Pursuing a Just Transition in the power sectors of Poland and South Africa: identifying barriers and drivers using System Dynamics

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TU/e Technische Universiteit Eindhoven University of Technology

Pursuing a Just Transition in the power sectors of Poland and South Africa: identifying barriers and drivers using System Dynamics

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with identity number 1567853

in partial fulfillment of the requirements of the degree of

Master of Science

in Sustainable Energy Technology

at the

Technology, Innovation & Society Research Group

Department of Industrial Engineering & Innovation Sciences

Eindhoven University of Technology

publicly defended on 7 July 2021

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Eindhoven University of Technology

Master Sustainable Energy Technology (SET)

Mastertrack SELECT – EIT InnoEnergy

Industrial Engineering and Innovation Sciences (IE&IS)

Technology, Innovation & Society (TIS)

0SE36 Graduation Project SET (IE&IS) – 45 ECTS

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Title: Pursuing a Just Transition in the power sectors of Poland and South Africa: identifying barrier and drivers using System Dynamics.

Key words: Just Transition; Power Sector; Sectoral System of Innovation; System Dynamics; Poland; South Africa; Carbon Lock-in; Coal;

7 July 2021

Eindhoven, The Netherlands

This report can be cited as follows:

Gonella, S. (2021). *Pursuing a Just Transition in the power sectors of Poland and South Africa: identifying barrier and drivers using System Dynamics (Master thesis)*. University of Technology Eindhoven, Eindhoven, The Netherlands

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Acknowledgments

I would like to express my deepest appreciation to my thesis supervisor, Heleen de Coninck, for improving my research skills by sharing suggestions, knowledge and constructive criticism with me. I am deeply indebted to Louis Jestin and Artur Wyrwa for involving me in this project through which I gained a more mature understanding of the complex challenges accompanying the energy transition.

Many people have supported me in various ways during the course of this Master's thesis. I had the opportunity to discuss my project with several experts in the field, to whom I am grateful for their time, input and support, which often went beyond what could have been expected.

I cannot forget to mention my classmates, who contributed to make these two years of my Master's programme incredible, and some of the senior students for guiding and advising me based on their experiences.

Last but not least, a special thank you to my family and loved ones, for being my backbone in the difficult times and for sincerely sharing my happiness in the good ones.

Summary

The energy sector is responsible for most of the CO_2 globally emitted, thus its decarbonisation is fundamental to achieve the Paris Agreement's goals. The energy transition is a complex process involving different actors and intertwining technical, economic, and social challenges. In some countries, moving towards cleaner energy supply technologies will be particularly challenging, due to the strong reliance on fossil fuel-based systems.

The just transition framework aims to provide guidance and support on how to pursue a technological transition that is also inclusive and sustainable. The concept of just transition originated in the 1970s in the USA and was later integrated into the agenda of environment and climate policies. The just transition approach encourages the collaboration among different actors for the development of a holistic strategy and the fair distribution of benefits and burdens during any major socio-economic transformation. A significant portion of the literature on just transition focuses on theoretical concepts, principles, and aspirations (i.e. elements of Procedural, Distributional, Recognitional, and Restorative Justice), without providing a roadmap for engaging the stakeholders, planning and enacting a just transition. There is a need to develop more case studies to distil procedural elements of just transitions in different political, economic, and social contexts.

This research focuses on the power sectors of Poland and South Africa, both strongly dependent on domestic coal, investigates the obstacles and the enablers to just energy transition paths in the two countries, and makes recommendations on how to improve those processes. First, a literature review has been conducted to understand the main characteristics of the two power sectors: the information has been catalogued through the Sectorial System of Innovation, used in Transition Studies for a comprehensive description of an economic sector. Then, several stakeholders involved in the electricity systems of the countries have been interviewed: the interviews helped to understand the implications, as well as the main challenges, of a just transition approach applied to these two case studies. The information collected during the interviews has been coded to obtain one qualitative System Dynamic Model per country: the models depict the interactions between different elements of the systems, highlighting lock-in factors that hamper the transition and leverage points for possible policy interventions.

The output of the study uncovers the similarities and differences between the two countries, which require different interventions to unlock a just transition in their power sectors. In South Africa, the discussion on just transition has been carried on for a while: the stakeholders can engage and dialogue through different platforms. The national economy has been negatively impacted by a power supply crisis for more than 10 years: due to the increasing cost of electricity from coal and as a result of the commitment made by signing the Paris Agreement, the new capacity should be made up of clean energy technologies. The South African utility company Eskom is unsustainable from any point of view, and there is a strong push for major changes in its business model: the challenge is that the country needs more qualified people to carry out the transition and a plan to finance it, while the advantage is that South Africa has great wind and solar power potential.

In Poland, the discussion on just transition started more recently: the Polish authorities have a long time denied the need for a transition, slowing it down, also due to the influence of actors like the coal trade unions. The ruling style of the Government, as a legacy of the Communist era, is to manage decision-making with little consultations of the interested parties. Exception made for the positive case of some regions, the engagement of the stakeholders in the social dialogue has been limited so far. The main uncertainty in Poland comes from the lack of clear direction from the Government: however, as soon as a national plan – aligned with the EU goals – will be defined, the country will likely have access to more funding opportunities for supporting the implementation of a just transition for all. Economic factors like the cost of Carbon, the increasing cost of coal mining, and the inability of many coal power plants to self-sustain will drive future investments towards cleaner technologies.

Table 1 reports some suggestions that could help to overcome the barriers hindering the transition in the power sectors of the two countries. In Poland, the coal workforce has long time benefitted from advantageous working conditions thanks to the great influence of trade unions, thus it is important to involve them in planning a just transition. The average age of the coal workers is about 50 years, thus many of them might prefer to receive financial compensation and access to early retirement. However, the coal workforce would perceive the transition as fairer if they were given a few concrete options to choose from. The coal workers in South Africa might prefer to be trained for new employments, although the unemployment rate in South Africa is one of the highest in the World: reserving the new job places generated by the transition to the former coal workers might not be fair towards the remaining unemployed workforce. There is a strong need to diversify and boost the national economy.

Table 1 - Dimensions of Just Transition in Poland and South Africa

	Poland	**South Africa**
Procedural justice	Greater involvement of the stakeholders could benefit the social dialogue	More communication about what discussed in each platform/sector
	More transparency, clarify roles and procedures	
Distributional justice	Support energy poor households	Support energy poor households
	Offer more than one option to the coal workers	Coal workers should be reskilled
	Many coal workers are close to retirement and would prefer a gold handshake rather than a reskilling program	New job opportunities should come from every economic sector and should be offered to both coal workers and other unemployed people
Recognitional & Restorative justice	Address the environmental issues caused by coal (e.g. Impacts on agriculture)	Diversify economy in coal regions
	Diversify economy in coal regions	New business models are needed for a more sustainable power sector and a more dynamic economy

1. Introduction

In December 2015, 196 states gathered at the Paris Climate Conference (COP21) and set a common goal: to contain the global temperature rise well below 2°C above pre-industrial levels, and strive for limiting warming to 1,5 °C (UNFCCC, 2015). The greenhouse gas emissions should therefore reach their peak as soon as possible (Rogelj, 2018) and decline rapidly thereafter, an objective that will require a huge effort and strong cooperation from each country and sector (UNFCCC, 2015).

One of the sectors that will be impacted more by the shift towards a more sustainable economy is the energy sector. "Energy transition" is the expression used to describe a significant structural change in an energy system. The term generally describes the pathway towards the transformation of the global energy sector from fossil-based to zero-carbon before the end of this century (Berkhout et al., 2012; IRENA, 2018). The reason for undertaking this path is that the energy sector is the largest global emitter of greenhouse gases (European Environment Agency, 2016; Olivier & Peters, 2020; Ritchie, 2020; Yoro & Daramola, 2020): tackling the emissions in the energy sector is key to fulfil the Paris Agreement's goals (Muttitt & Kartha, 2020).

In the past decades, awareness has been raising in the international community that not only the energy transition is needed, but it should also be inclusive and sustainable: transitions in history have often generated winners and losers since the burdens and the gains of a transition are often not equally distributed (Cahil & Allen, 2020; ILO, 2015; Jasanoff, 2018; TNI, 2020). This might happen in the case of the energy transition as well: from one hand, a renewable-based energy system would improve the air quality, would reduce premature deaths, would contribute to tackling the climate crisis, and would generate more jobs than those existing in the current energy regime (Semelane et al., 2018; Singer, 2013; Strambo et al., 2019). On the other side, those people who will lose their job might not have the required skills to access the newly created ones, or might have to move to access them (Semelane et al., 2018; Singer, 2013; Strambo et al., 2019): some countries and some regions will need to completely transform their economy and their infrastructures (Cahil & Allen, 2020; European Commission, 2019b; Jasanoff, 2018). The transition might require a different level of effort from different people. Similarly, if no action is taken to face the climate emergency, its consequences will have a greater impact on some countries and on some social classes rather than on others (Dryzek et al., 2012; Henry et al., 2020; Islam & Winkel, 2017; Jasanoff, 2018). These concepts have been developed and spread by the so-called Just Transition movement, which originated in the U.S. labour movement in the 1970s (Cahil & Allen, 2020). At the time, the disarmament during the Cold War threatened several atomic workers to lose their jobs. The Oil, Chemical, and Atomic Workers Union argued that the government should support the workers, just like it was doing for World War II veterans (Cahil & Allen, 2020; Smith, 2017). The concept was later adapted in response to a wave of new environmental protection policies: the Trade Union acknowledged that the activities associated with their industries were damaging the environment, and advocated for the environmental policies, but also pointed out the need to guarantee the workers a helping hand to make a new start in life (Smith, 2017). This approach encouraged collaboration between organised labour and environmental justice groups for a more holistic strategy, which was later described as "just transition" (Smith, 2017).

The concept of just transition was reinterpreted within the environmental and climate justice communities: the International Trade Union Confederation pushed for the inclusion of social and employment impacts of climate policy in the agenda of UN processes and agreements (UNFCCC, 2016). The UN Sustainable Development Goals lunched in 2015, are an expression of the agenda of just transition, particularly the goals of *Decent work and economic growth for all* (Goal 8), *Affordable and clean energy* (Goal 7), *Climate action* (Goal 13), and *No poverty* (Goal 1) (ILO, 2015). The Paris Agreement itself states the need to "*taking into account the imperatives of a just transition of the workforce and the creation of decent work and quality jobs in accordance with nationally defined development priorities*" (UNFCCC, 2016, p. 2) while pursuing the goal of limiting global warming (Cahil & Allen, 2020; ILO, 2015). The main reference adopted by the UNFCCC has

been the guidelines for just transition and sustainable development published by the International Labour Organization: a framework that aims to support the decision-makers in looking at energy transitions more holistically. However, the concept of justness itself is to some extent abstract and vague: the Just Transition framework does not provide a list of specific actions and interventions to be followed, since JT is always context-dependent (Strambo et al., 2019).

The guidelines provided by ILO, as well as a significant portion of the literature on JT, focus on theoretical concepts, principles, and aspirations, without providing a roadmap for implementation. There is a need to develop more case studies to distil procedural elements of just transitions in different political, economic, and social contexts (Biresselioglu et al., 2020): some States have already started their path in this direction.

In December 2019, the European Union has declared the intention to become the first carbon-neutral continent by 2050 and has launched the Green Deal, an action plan designed to reach this goal (European Commission, 2019a). The set of policies also include a tool called Just Transition Mechanism: 65-75 billion euros will be mobilized over the period 2021-2027 to support the most affected regions in Europe, to alleviate the socio-economic impact of the transition (European Commission, 2019b). The State that is expected to benefit the most from the JTM is Poland (European Commission, 2020f): although the Government had initially refused to sign the proposal (Boffey, 2020; European Commission, 2020c), it eventually committed to reducing its energy-related emissions by phasing-out coal. Undertaking this path implies a deep transformation in the Polish energy sector, and will influence its whole economy: the JTM aims to ease this process and to favour its acceptance by society.

The topic of just transition has been raised and explored in several non-European countries as well. A notable example is South Africa: this developing country signed the Paris Agreement in 2016 (Modise, 2016), although its economy still heavily relies on domestic coal. South Africa is currently facing different challenges from the social and economic points of view (TIPS, 2020a, 2020b), and while undergoing the energy transition, it will not benefit from external support as it could be the European Just Transition Mechanism. It appears clear that, besides the aspect of justness, any energy transition is strongly context-dependent: any country, sector, or industry will face different challenges and will have different resources (both human and natural) to address them. On the other hand, the energy transition is a worldwide shared challenge: it might be helpful to share knowledge and strategies among different countries, to be aligned in this challenge.

An energy (just) transition process might take place at very different paces according to the influence and interactions of several drivers, which can be distinguished as motivators and barriers (Janipour et al., 2020; Unruh, 2000).

Motivators are agents that initiate, facilitate, and support the execution of steps undertaken throughout the transition process: they might be of economic, personal, social, or storytelling nature. For instance, dissemination and communication of information to citizens affects the level of social support and acceptance for the energy transition. Incentives and the use of clean energy as a brand-marketing tool also support energy transition efforts (Unruh, 2000).

Barriers are, instead, obstacles to the transition: a specific type of barriers are carbon lock-in factors, path-dependent processes whereby initial conditions, increasing economic returns to scale, and social and individual dynamics act to inhibit innovation and competitiveness of low-carbon alternatives (Unruh, 2002). Carbon lock-in factors have a systematic nature that involves both technical and institutional aspects and which tends to inhibit the success of policies or any initiative aiming for a change (Unruh, 2000, 2002). This phenomenon affects several large technological systems, such as electrical systems, since a complex set of technologies is embedded in a powerful conditioning social context of public and private institutions. Although carbon lock-ins create systemic barriers to alternative solutions, it is not conceptualised as a permanent condition: technological and institutional changes have occurred repeatedly in history. Escaping

carbon lock-in might require the intervention of forces external to the system, and usually, it is necessary to build consensus towards the alternative proposal among the different actors involved (Unruh, 2002). Doing so implies a clear understanding of lock-in dynamics: otherwise, an action aiming for a change in the system might even unintentionally reinforce the lock-in situation (Janipour et al., 2020). When an issue is identified in an existing regime or system, the first solutions adopted usually are those that minimize the change to the system itself (Cahil & Allen, 2020; ILO, 2015): for instance, investing in energy efficiency optimization of an existing installation can present a carbon lock-in situation, since it incentivizes to continue running the current infrastructure, and it deters investing in renewable energy technologies (Cahil & Allen, 2020; ILO, 2015).

2. Aim, scope, and research questions

Most of the literature available on just transition focuses on theoretical concepts and principles. There is a need to develop more case studies of just transitions in different political, economic, and social contexts (Biresselioglu et al., 2020; Carley & Konisky, 2020). This thesis aims to contribute to this task by studying the case of Poland and South Africa, which power sectors share some similarities: they are both heavily reliant on domestic coal, and they are both experiencing pressure to undergo a transition. Looking into both Poland and South Africa would allow for comparing experiences and perspectives, and, where relevant, facilitate the two countries in learning from each other. The research provides an overview of the carbon lock-in factors and barriers that obstruct a just transition to take place in the two power sectors, highlighting the possible interventions that could defuse these feedback mechanisms.

The project has been developed in cooperation with the University of Cape Town (Cape Town, South Africa) and the AGH University of Science and Technology (Krakow, Poland). The contact persons in these two locations provided support in determining the scope of the research, data collection, and getting in touch with the stakeholder involved in the study.

The research question that this paper aims to address is "*How can South Africa and Poland overcome the carbon lock-in factors and the barriers in their electricity systems while pursuing a just transition?*".
This main research question has been investigated by splitting it into several sub-questions:

1) *What does the Sectoral System of Innovation of the electricity supply sector in South Africa and Poland look like?*

The first step of the project was to gain a good understanding of the current electricity system's state of play in the two countries. This was tackled by applying the Sectoral System Innovation (SSI) framework, used in Transition Studies to fully describe a specific sector (Carley & Konisky, 2020): a deeper description of the tool will be provided in the *Theoretical frameworks* chapter. With the guidance of the SSI framework, chapter 5 of the thesis includes a description of the main aspects characterising the sector: actors involved, the role they play, their interactions; electricity mix, cost of electricity; infrastructures, level of reliability and efficiency of the electricity grid; knowledge basis, main technologies; rules and norms; etc (Carley & Konisky, 2020).

2) *What are the carbon lock-in factors and the barriers hampering the just transition in South Africa and Poland?*

According to Elzen and Wieczorek (2005), "a transition denotes a long-term change in an encompassing system that serves a basic societal function (e.g. food production and consumption, mobility, energy supply and use, communication, etc.). In a transition, both the technical as well as the social/cultural dimensions of such a system change drastically. This emphasis on the co-evolution of technical and societal change distinguishes transitions from incremental processes, which are primarily characterised by technical change (through successive generations of technologies) with relatively little alteration of the societal embedding of

these technologies.". This definition of transitions depicts the complexity of the phenomenon: being a transition a radical change, it is expected that many elements of the incumbent system will constitute an obstacle. We can distinguish two main types of obstacles to the energy transition in the two analysed cases (Unruh, 2000, 2002):

- Carbon lock-in factors: path-dependent processes whereby initial conditions, increasing economic returns to scale, and social and individual dynamics act to inhibit innovation and competitiveness of low-carbon alternatives. Interdependent and systemic problems that inhibit low-carbon transition.
- Barriers: they are obstacles to the clean energy transition, but they do not have a self-reinforcing character.

A description of these dynamics is necessary to understand how to defuse any vicious cycles. The analysis was conducted utilising System Dynamic Modelling: this technique can also be used for the description of virtuous feedback cycles (i.e. motivators or drivers of the transitions).

3) What would a just approach imply in these two power system transitions?

The Just Transition movement has identified a few core principles to be followed for a transition to be just (Henry et al., 2020):

- Procedural justice: the decision-making processes should be fair, equitable, and inclusive for all who choose to participate.
- Distributional justice: benefits and burdens of the transition should be distributed across the population. The objective is to avoid some populations receiving an inordinate share of the burdens while being denied access to the benefits.
- Recognitional justice: understand historic and ongoing inequalities, together with their roots. Prescribe efforts to seek to reconcile these inequalities.
- Restorative justice: governments and other decision-makers should intervene to either avoid or correct procedural, distributional, or recognitional injustices.

Furthermore, an energy justice framework should include energy availability and access, affordability, due process, accountability and transparency, and both inter- and intra-generational equity (Elzen & Wieczorek, 2005). Just Transition is a framework that will lead to different results when applied to different contexts: there isn't a single way to follow these principles, since the concept of justness is to some extent subjective and abstract. Although there is not an exact just transition path universally recognised, three main phases can be outlined (Henry et al., 2020):

- Engagement phase: community goals development, economic development planning, creation of policies in support of transition efforts, establishment of financial programs, economic impact analysis;
- Planning phase: retraining of workers, investment in economic development, scaled implementation of emissions reductions and investments in renewables, investment in community energy savings.
- Enactment phase: enact worker and social protection programs, implement wide-ranging apprenticeship and entrepreneurship training, repurpose and remediate properties, invest in regional green technology research and development.

It is important to understand what are the expectations and values of the involved parts to properly apply the framework to the case. Entities in both South Africa and Poland have expressed an interest in undertaking a just transition path: the two countries, though, have been approaching this process in different ways. Comparing the two experiences, the stakeholders in South Africa and Poland might learn from each other and be facilitated in planning the steps forward.

The thesis will result in:

(1) An improved understanding of the aspects to be considered for a just energy transition in the electricity sector of Poland and South Africa;
(2) An understanding of the obstacles and enablers to just energy transitions in the electricity sector in Poland and South Africa, and their dynamic interaction;
(3) Suggestions of possible interventions that could defuse the vicious cycles induced by carbon lock-in factors and barriers.

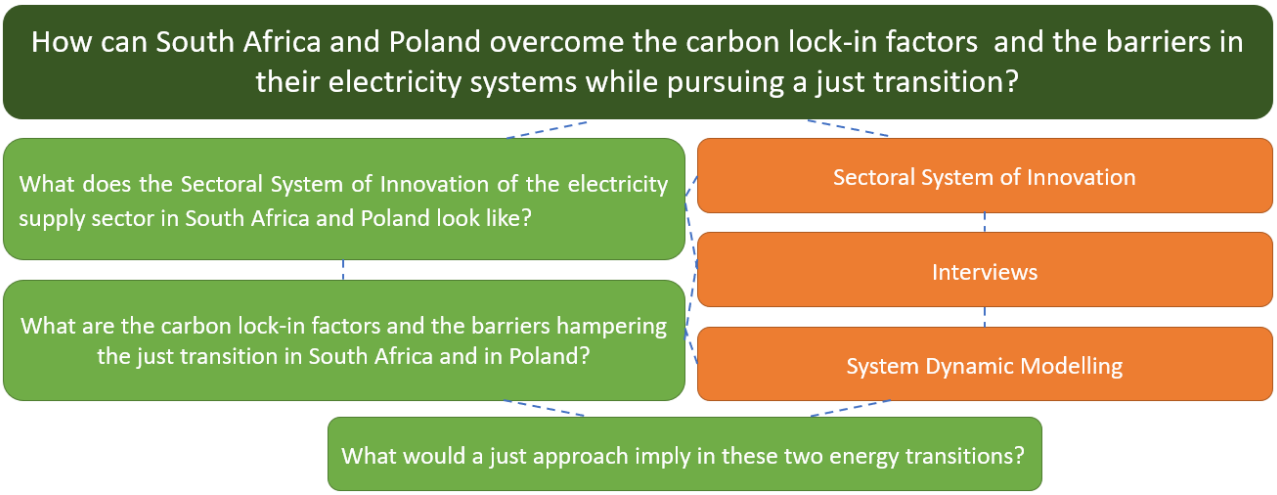

Figure 1 - Research questions and methods – Summary. (Green: Research questions; Orange: Theoretical frameworks and Methodologies).

3. Theoretical framework

Two frameworks have been combined for tackling this research. The Sectoral System of Innovation was used to guide the literature review and collect information on the two energy sectors in an organised way, thus its main purpose is to gain a comprehensive understanding of their characteristics. The System Dynamic Models depicts the dynamics ruling the power sectors as perceived by the agents involved in them. This methodology is used to highlight possible sources of policy resistance when planning a major transformation of the system.

3.1. Sectoral System of Innovation

The Sectoral System of Innovation (SSI) is a framework proposed by Malerba for describing an economic sector and its evolution in time. The framework has been developed with the intent of complementing other concepts within the innovation system literature, such as National Systems of Innovation (NSI), Regional/Local Innovation Systems (LIS), and Technological Systems (TS) (Edquist & Charles, 1997; Schrempf et al., 2013). National and regional/local boundaries matter to varying degrees depending upon the specific sector under consideration (Edquist & Charles, 1997). Both NSI and LIS perspectives do not focus on specific industries or technologies, rather they focus on the whole set of industries active in a specific country or region and on the institutions supporting them (Edquist & Charles, 1997). TS, on the contrary, is more technology and industry-specific (Malerba, 2003). Considering solely the technology perspective might be reductive though, while it might be more instructive to merge it with the correlated economic activities processes (Malerba, 2002, 2005; Malerba & Mani, 2009). SSI taps into Evolutionary Theory, which places a key emphasis on dynamics, process, and transformation: learning and knowledge are key elements in the change of the economic systems; agents act in uncertain and ever-changing environments; agents' beliefs, objectives, and expectations are emphasized (Malerba & Mani, 2009).

Malerba argues that broadly speaking, innovation systems frameworks do not emphasize enough the role of non-firm agents (Geels, 2004) and overlook institutions (Malerba, 2002). The latter point is deepened by Geels (Geels, 2004) as well, stressing the need to open up this "black box" and not consider it as a "leftovers" category. Malerba defines a sectoral system of innovation as a set of products for specific uses and the set

of agents carrying out market and non-market interactions for the creation, production, and sale of those products. A sectoral system has a knowledge base, technologies, inputs, demand. The agents might be organisations or individuals and are characterised by specific learning processes, competencies, beliefs, objectives, organisational structures, and behaviours. They interact through processes of communication, exchange, cooperation, competition and command, and their interactions are shaped by institutions (rules and regulations) (Malerba, 2002, 2005). The Sectoral System of Innovation (SSI) framework proposed by Malerba provides a multidimensional, integrated, and dynamic view of sectors (Malerba, 2005). The purpose of the framework is to support the researcher not only in a static analysis of the sector but also in understanding how the sector evolves and innovates.

The basic elements identified within a sectoral system are (Malerba, 2002):

- Product(s): in this case, the electricity;
- Agents: firms and non-firm organizations, individuals;
- Knowledge and learning processes;
- Basic technologies, inputs, demand, and the related links and complementarities: there might be links and complementarities among vertically or horizontally related sectors. They define the real boundaries of a sectoral system;
- Mechanisms of interactions both within firms and outside firms;
- Processes of competition and selection;
- Institutions: standards, regulations, labour markets, and so on.

The SSI framework gathers and describes these basic elements in three main blocks (Malerba, 2005):

- Knowledge and technologies: knowledge plays a central role in innovation and production. This block includes the specific scientific and technological field knowledge (supplier's side), as well as the application, the demand for the sector's products (user's side). The most relevant dimensions to analyse knowledge are accessibility, opportunity, and cumulativeness (i.e. degree by which the generation of new knowledge builds upon current knowledge), and can be evaluated at the local, firm, or technical level. In addition to basic technologies and demand, links and complementarities among artifacts and activities affect the real boundaries of a sectoral system – they impact firms' strategies, organisation and performance, the rate and direction of technological change (Malerba, 2002).
- Actors and networks: sectorial agents can be organizations and individuals. Organisations might be firms, non-firms (e.g. universities, government agencies, trade unions, ...), as well as sub-units of larger organisations (e.g. R&D) or groups of organisations (e.g. industry associations) (Malerba, 2005). A key sectorial feature is the higher or lower degree of agents heterogeneity in terms of types, beliefs, competencies, behaviour, goals, learning processes, and organizations. Heterogeneous agents are connected in various ways, through market and non-market interactions: processes of exchange, competition, and command; formal or informal cooperation (Malerba, 2002). From a sectorial system perspective, innovation is considered a process that involves systematic interactions among a wide variety of actors for the generation and exchange of knowledge relevant to innovation and its commercialisation (Malerba, 2005).
- Institutions: they shape agents' cognition, actions, and interactions. Institutions include norms, common habits, established practices, rules, laws, standards, and so on. They might be formal or informal, national or sectorial. Institution concerns both the supply and the demand side of a sectoral system (Malerba, 2002).

As mentioned above in the text, SSI is not a tool to provide a mere snapshot analysis, but also to understand how changes take place within a sector. Changes might be incremental (a quantitative growth of the variables of a sectoral system) as well as radical (innovative transformations). The push for a change might come both from the supply or from the demand side. It is possible to identify two basic evolutionary processes:

- Processes of variety creation: they refer to products, technologies, firms, institutions, strategies, behaviours. They involve several mechanisms such as entry, R&D, innovation, and they increase the heterogeneity in the sector. E.g. the emergence of new specialised departments within universities; the creation of new agents.
- Processes of selection: they reduce heterogeneity within the sectorial system in terms of firms, products, activities, technologies, and so on. They might be both market or non-market processes.

Some of the key questions that might guide the analysis over the sectoral system's dynamics are (Geels, 2004):

- How do new agents come into being and what are the rate, type, and determinants of entry?
- Do new competencies, organisational forms and strategies radically differ from the old ones?
- Do relationships among agents and networks show great stability, or do they change over time?

It is worth noticing that the boundaries of a sectorial system are, to some extent, subjective: the delimitation of the system should be driven by the aim of the analysis (Malerba, 2003, 2005; Malerba & Mani, 2009).

SSI, however, has not been exempt from criticism. Geels refers to (Malerba, 2002) and identifies some aspects of the framework which might still be improved, providing his contribution to addressing these open issues (Geels, 2004). One of his comments is that the SSI framework could put more emphasis on the demand side of the system: while SSI strongly focuses on the development of knowledge from the supply side, it pays less attention to the diffusion and use of the technology, and the consequent impacts and societal transformations. In his later publications, Malerba stresses more the role of the demand in a sectoral system (Geels, 2004, 2006), perhaps addressing Geels' comment: "Demand is made up of individual consumers, firms and public agencies, each characterised by knowledge, learning processes, competencies, and goals, and affected by social factors and institutions. Thus, in sectoral systems demand is not seen as an aggregate set of similar buyers, but as composed of heterogeneous agents whose interactions with producers are shaped by institutions. The emergence and transformation of demand play a major role in the dynamics and evolution of sectoral systems." (Malerba, 2005, p. 67)

A second observation is that the elements of a system might be more carefully distinguished and analysed: the SSI groups together heterogenous elements, making it somewhat unclear how they are linked (Geels, 2002, 2006; Geels & Schot, 2007). Finally, Geels suggests that SSI might make use of the concepts of niche and landscape as expressed in the Multi-Level Perspective (MLP) framework to depict how one system (regime) switches to another (Geels, 2002, 2006; Geels & Schot, 2007).

The SSI is useful to thoroughly analyse an economic sector, from its agents' behaviour to the rules governing it, thus it has been evaluated appropriate for supporting this research: in this project, the SSI framework has been combined with some elements of the MLP framework, as suggested by the criticisms, since it is recognised that the dynamics inside the power sectors of Poland and South Africa cannot be fully understood if not inserted in the current national and international contexts. MLP analyses reality from three different perspectives: meso, micro, and macro (Geels, 2002, 2006; Geels & Schot, 2007). The meso level, commonly called "regime", describes the status quo of a selected sector (Dangerfield, 2014; Forrester, 1961). This level matches with the focus of the Sectoral System of Innovation: however, the MLP alone provides fewer guidelines on how to analyse a sector, therefore the decision to rely on SSI. The micro-level, also known as "niche(s)", is the locus for innovations (Dangerfield, 2014; Forrester, 1961): in the SSI framework, innovation and variation are covered by the "Processes of variety creation" and the "Processes of selection". The macro level, the "landscape", refers to aspects of the wider exogenous environment, which affect the stability and the development of the sector (Awan, 2020; de Gooyert et al., 2016). The concept of "landscape" has been borrowed from MLP to guarantee the completeness of the analysis conducted by this research.

3.2. System Dynamic Modelling

System Dynamics (SD) is a method to represent complex, systemic problems in the form of diagrams and feedback loops. This field was invented in the 1950s by J.W. Forrest, professor at Massachusetts Institute of Technology (MIT), and was first known as Industrial Dynamics (Forrester, 2007). Originally, it was a branch of Operational Research and was used for simulating industrial supply chain problems (Forrester, 1996, 2007, 2009). The methodology has then been further developed and applied in many different fields, such as urbanisation, dynamics of growth, environmental studies, policy resistance, and economics (de Gooyert et al., 2016; Hayden, 2006; System Dynamics Society, n.d.). Particularly, de Gooyert argues that SD can effectively complement commonly used frameworks like Multi-Level Perspective to analyse and tackle cases of policy resistance (de Gooyert et al., 2016).

Nonetheless, 50 years after the ideation of SD, Forrest wrote that the methodology is yet to exploit its full potential (Radzicki & Tauheed, 2009). He argued that the value of SD has not been completely understood yet, therefore it is mastered by a small community of experts, mainly in the academic and research world. According to Forrest, mastering SD should be considered a profession, same as engineering or medicine, due to the complexity of thinking in a non-linear way and relying on multi-loop feedback systems. Forrest promotes the idea of teaching System Dynamic thinking starting from elementary school when "students have much less to unlearn than they do later after years of being conditioned by linear and unidirectional cause-to-effect education". The MIT has therefore launched the "System Dynamic for Education" project, which involves hundreds of pre-college teachers and promotes the use of the SD methodology in different subjects, even the non-scientific ones, such as Literature: an application of SD on the analysis of the Hamlet drama is reported as an example in the material provided by MIT. (MIT University, n.d.; Radzicki & Tauheed, 2009)

System Dynamics has not been exempted from criticism. Hayden argues that Forrest's methodology shows more than one weakness: it fails to integrate the concept of hierarchy; it fails to describe the real complexity of a feedback loop; it doesn't take into account the interactions between the system and the environment (Hayden, 2006). These comments have later been addressed by Radzicki and Tauheed (Radzicki & Tauheed, 2009). For what concerns hierarchy, the two authors explain that the behaviours of non-linear systems are due to both the behaviour of its parts and the particular connections and interactions among its parts. As such, non-linear systems do not consist of top-down hierarchies, but are categorised as complex interactive processes. Radzicki and Tauheed argue that Hayden might have an incomplete knowledge and understanding of feedback loops, also contesting his claims over the origins of the concept. The authors disagree with Hayden's observation on the openness of an SD model and provide some examples to demonstrate how system dynamic models can represent an open system. They also point out that Hayden seems to confuse two different concepts: a materially closed system is a system that does not exchange information, energy, materials, or ideas with its environment; a causally closed feedback loop is a model that describes a system's problematic behaviour due to endogenous forces. However, they cut him a little slack, recognising that this mistake has been done by several authors writing on SDM. (Radzicki & Tauheed, 2009)

The primary elements of the System Dynamics framework are (Meadows, 2009; J. Sterman, 2014):

- Stocks: a store, a quantity, an accumulation of material or information that has built up over time. It does not have to be physical.
- Flows: stocks change over time through the actions of a flow. Flows are filling and draining, births and deaths, purchases and sales, …
- Causal loop/Feedback loop diagrams: a feedback loop is formed when changes in a stock affect the flows into or out of that same stock. Feedback loops can cause stocks to maintain their level within a range or grow (positive or reinforcing feedback loops) or decline (negative or balancing feedback loops). The flows into or out of the stock are adjusted because of changes in the size of the stock itself. Whoever or

whatever is monitoring the stock's level begins a corrective, adjusting rates of inflow or outflow (or both) and so changing the stock's level. Not all systems have feedback loops.

Therefore, an SD model depicts the internal dynamics of a system and the evolution of the system's status over time. A model can be more or less complex: in many cases, different causal loops are interconnected and there is no one single cause for the positivity or the negativity of feedback. According to the nature of the data available on the observed dynamics, an SD model might be based on qualitative or on quantitative relationships (Coyle, 2001; de Gooyert et al., 2016; Janipour et al., 2021; Kim & Andersen, 2012; Wolstenholme, 1985): in some cases, quantification might be fraught with so many uncertainties that the model's output could be misleading (Coyle, 2001). Thus, a qualitative model is sometimes preferable to depict the dynamics of a system (Coyle, 2001; Wolstenholme, 1985).

While the SSI will be adopted to describe the state of play of the electricity generation system in Poland and South Africa, the SD method will be used to describe the obstacles and the drivers that are affecting the just transition in the two electricity sectors. The model developed for each country aims to ease the comprehension of these dynamics and highlight where an intervention would be needed to favour a just energy transition.

4. Methodology

To answer the research questions, the methodology consists of three parts: first, a document analysis has been carried out to fill the Sectoral System of Innovation framework for both the Polish and the South African power sectors. Second, interviews have been conducted with experts and practitioners from both South Africa and Poland. Finally, their interview transcripts have been coded in the form of two System Dynamic Models (one per country), which gives insight in changes and interconnections in a complex transition.

4.1. Document analysis

A literature review has been conducted at the beginning of this study to familiarise with the power sectors of Poland and South Africa. The information has been catalogued following the guidelines if the SSI framework. After completing the interviews, a document analysis was also completed to supplement and clarify some of the statements made by the respondents of the investigation.

4.2. Interviews

17 interviews have been conducted (8 for South Africa, 8 for Poland, and 1 which is relatable to both) (Table 2). The interviewees have been reached by email: the interviews were conducted online, and lasted between 45 and 60 minutes. The interview guide available in Appendix 1 constituted the basis of the conversations. The interviews have been recorded and transcribed, and the transcripts were sent to the interviewees for their approval: in several cases, the interviewees provided further information and clarifications. Subsequently, the interviews were coded.

Table 2 - List of interviewees

Code	Type of stakeholder	Role of interviewee	Country
1-PL	Research centre/consultancy	Researcher	Poland
2-PL	Utility company	Former high-level manager	Poland
3-PL	Consultancy	High-level manager	Poland
4-PL	Coal manufacturer	Market analyst	Poland
5-PL	Research centre/consultancy	Senior expert (Energy)	Poland
6-PL	Research centre/consultancy	Senior expert (Just Transition)	Poland
7-PL	Utility company	High-level manager	Poland
8-PL	Academy	Researcher	Poland
1-SA	Consultancy	Senior advisor	South Africa
2-SA	Government (National Planning Commission)	Commissioner	South Africa
3-SA	Organised business	Senior expert	South Africa
4-SA[1]	Trade union; NEDLAC	High-level manager; Member of NEDLAC	South Africa
5-SA	Academy	Researcher	South Africa
6-SA	Utility company	Former high-level manager	South Africa
7-SA	Organised business	High-level manager	South Africa
8-SA/9-PL	Utility company	Energy and Climate Policy expert	South Africa; Poland

4.3. System Dynamic Modelling

The transcripts of the interviews have been coded to obtain one System Dynamic Model per country. The procedure adopted has been the one described by Kim and Andersen (Kim & Andersen, 2012) and also applied by (Janipour et al., 2021).

The following four-step procedure (Figure 2) has been followed to obtain an SD model from a text (Kim & Andersen, 2012):

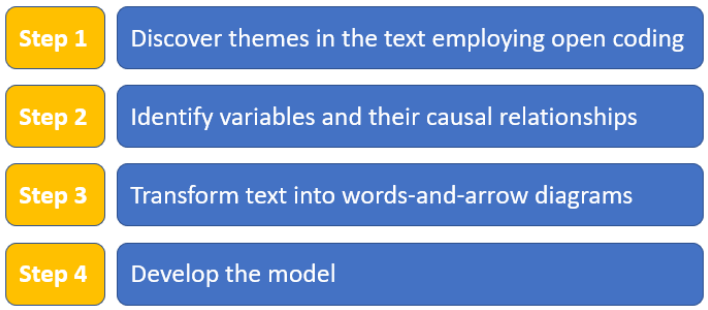

Figure 2 - Four-step coding procedure (Kim & Andersen, 2012)

[1] Two people have been interviewed at the same time: both are members of a trade union, and one of the two also sits in NEDLAC (see chapter *Agents*). Since their opinions were quite aligned, their interview has been coded as if they were one single interviewee.

1. Discover themes in the text employing open coding.

The transcripts have been analysed to identify the main opinions and supporting arguments reported by the interviewees. The codes found in each interview's transcript have been collected in a table (one per country), keeping track of the interviewees associated with the code. Subsequently, the codes have been summarised in a shorter table, since it has been noted that several codes were repeated more than once. The interview transcripts and the first table have not been attached to this report to safeguard the anonymity of the interviewees. The second table, which summarises the previous one, can be found in Appendix 2. To guarantee the coding process to be linked to the original text, the table initially had a column to record the interviewees who supported each claim: to guarantee the anonymity of the respondents, this column was deleted and the table in Appendix 2 only records the number of interviewees who supported a given claim. Every code (or claim) has been assigned an identification number, for being tracked in the following steps of the coding procedure.

2. Identify variables and their causal relationships.

The information gathered in Step 1 has been analysed to identify relationships of cause and effect among the different topics. The codes identified in Step 1 have been used to fill a few tables as the one here reported (Table 3):

Table 3 - Step 2, South Africa: Example. Argument #1: The current power sector is coal-dominated, aged, unreliable

#1	Argument:	The current power sector is coal-dominated, aged, unreliable				
Causal Structures		Causal variable	Maintenance	Power plants efficiecy	Capacity availability	Load-shedding
		Effect variable	Power plants efficiency	Capacity availability	Load-shedding	Local economy (GDP)
		Relationship type	(+)	(+)	(-)	(-)
		Reference code (from Codes - Step 1)	1,2	1,2	1,2	1,3

Starting from Step 1, the codes have been gathered in a few different Arguments (as it can be noticed in the heading, Table 3 contains *Argument #1: The current power sector is coal-dominated, aged, unreliable.* The complete table can be found in Appendix 3 together with the tables on the other arguments identified). In the third line of the table, it has been specified whether the two variables have a positive or a negative relationship. If the relationship is recognised to be positive when the *Causal variable* increases in value so does the *Effect variable*. On the contrary, if the relationship is negative, when the *Causal variable* increases in value or intensity, the *Effect variable* decreases.

Kim and Andersen add two further lines to the cause/effect tables: the *Variable behaviour* of both *Cause* and *Effect variables* (see Table 4). These two parameters have not been included in the tables of this study: in more than one case, the information available was not sufficient to establish a variable behaviour without the risk of assigning a biased and inaccurate value.

Table 4 - Table (Step 2) from literature (Kim & Andersen, 2012, p. 318)

Speaker name: Mr Boehne; *Transcript page*: 12–13; *CIN*: *12-06*
Main argument: There is a slow-down in economic growth due to supply constraints

Causal Structures	*Cause variable*:	Labor market	Production (inventory)	Production (inventory)	Production (inventory)	Production (inventory)	(Inventory)
	Effect variable:	Production	Delivery times	Industry friendliness	Shipment	Unfilled Orders	Concern about inventory buildup
	Relationship type:	Positive	Negative	Positive	Positive	Negative	Positive
Variable behavior	*Cause variable*:	Tight	Slower growth	Slower growth	Slower growth		
	Effect variable:	Slower growth	Slower	Not as friendly	Slower	Some cases	No excessive concern
Information source:		Comments heard from manufacturing and steel industry					

Note: "Inventory" concept is implicit and thus shown in parentheses. "Economic activities" are interpreted as "production" after examining the context.

The variables' names have been chosen respecting the conventions of SDM: their normal sense of direction should be positive; negatives prefixes should be avoided (J. D. Sterman, 2000). Thus, instead of writing:

"*Poor maintenance –(+)-> Old and inefficient coal fleet*"

it is better to write:

"*Maintenance –(+)-> Coal fleet's efficiency*".

3. Transform text into words-and-arrow diagrams.

The variables identified in Step 2 are re-written in the form of words-and-arrow diagrams (see Appendix 4). While completing this task, Kim and Andersen recommend reflecting on the variables' behaviour to identify which one of them are stocks, which ones are flows, and which ones are auxiliary variables. In this research, the distinction between stocks, flows, and auxiliary variables has been finalised while merging the words-and-arrow diagrams to create an SD model: when completing the last step of the procedure, it is easier to understand how the variables relate to each other.

While completing Steps 3 and 4 of the methodology, a list of variables has been compiled, including a short description of each and the unit of measurements (Appendix 6).

4. Generalise the structural representation and develop the System Dynamics Model

The words-and-arrow diagrams are merged into a System Dynamics Model: as also Kim and Andersen report, while completing this step the researcher might require to add or delete some variables, for a better understanding of the dynamics and to avoid redundancies. After completing this part, the balancing and the reinforcing feedback loops can be identified, looking at the polarity of the arrows composing each loop.

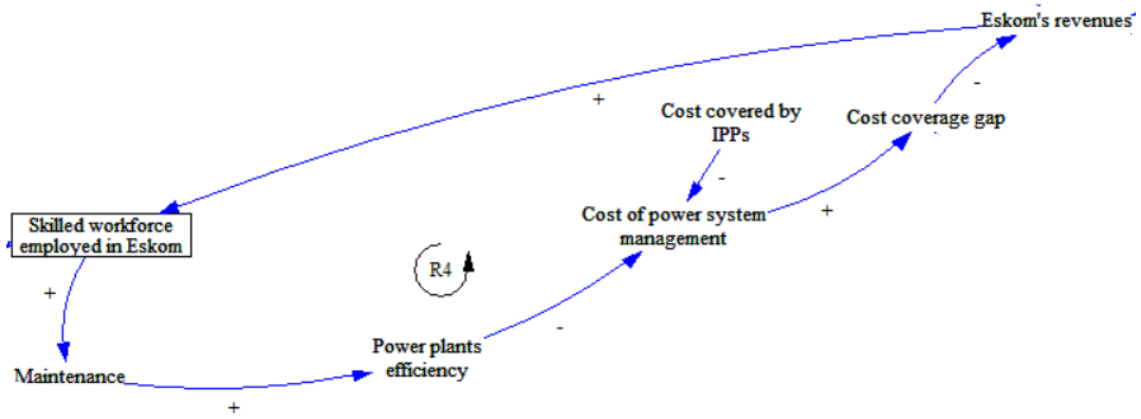

Figure 3 - Reinforcing Loop N.4, South Africa

A fast way to verify the polarity of a loop is to count the number of negative arrows: an even number of negative arrows makes a positive (reinforcing) loop, while an uneven number of negative arrows makes a negative (balancing) loop (J. D. Sterman, 2000). For instance, the loop in Figure 3 has an even number of negative arrows and is a reinforcing loop. Although this rule stands generally true, it is recommended to go through the loop and determine whether this is a balancing or a reinforcing loop according to the dynamics it describes (J. D. Sterman, 2000).

When it was deemed helpful to understand the behaviour of a variable, it has been specified whether the variable is a stock or a flow (see *3.2. System Dynamic Modelling*). The models have been designed in Vensim PLE: graphically, the stocks are represented by boxes, while the flows are represented by thick arrows that either originate or end in a cloud (Figure 4). The clouds stand for the boundaries of the system.

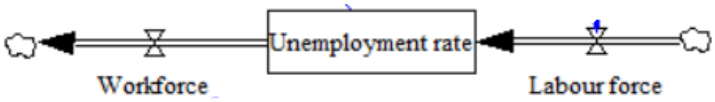

Figure 4 - Stocks and flows

The two models obtained (one for Poland and one for South Africa) are shown in Appendix 5 and discussed in Chapter 6.

5. Sectoral System of Innovation for electricity generation in Poland and South Africa

This chapter focuses on the electricity generation sectors in Poland and South Africa, and describes their current status, taking into account all of their main elements, following the SSI framework. The chapter also includes an overview of the national and international contexts in which the two power sector are embedded: the concept of "landscape" is adopted from the MLP framework (see the *Theoretical framework* chapter). A more extensive description of the Sectoral System of Innovation for the two power sectors can be found in Appendix 7.

5.1. Poland

5.1.1. Landscape

The landscape or macro-level describes aspects of the wider exogenous environment, which affect the stability and the development of the power sector. Particularly, the economy and the politics of Poland are influenced by being a Member State of the European Union. The key elements of the landscape are summarised in Table 5 and more detailed explained in Appendix 7.

Table 5 - Landscape, Poland

Political framework	Governed by a Communist administration until 1989
	Member of the EU since 2004
	National elections in 2019: Law and Justice (PiS) party, right-winged, conservative, Eurosceptic. PiS has often shown its support to the coal sector and its antagonism towards several EU directives (The World Bank, 2018b, 2019d). It is still the most favoured party in Poland with the support of 37,4% of the population as of February the 13th, 2021 (Ewybory, 2021).
Economic state of play	GDP (2019): 532'329 M€ or 631'833 US$ million (Eurostat, 2020a)
	GDP per capita (2019): 13'870 € or 16'463 US$ (Eurostat, 2020a)
	EU average GDP per capita (2019): 31'160 € (Eurostat, 2020a)
	GDP growth (2019): 4,1% (The World Bank, 2019b)
	GDP contraction (COVID-19): -4,5% (European Commission, 2020b) to -9,5% (OECD, 2020)
	Gini coefficient: 0,3 (The World Bank, 2018a)
	Unemployment rate: 6% (Sas, 2021; Statistics Poland, 2021)
	Energy poor households[2]: 12% (Joas et al., 2018)
Pressures on the power sector	*External cost*
	Emissions (2018): 150 Mt of CO2 (Baran et al., 2018; Szpor & Ziółkowska, 2018) (50% CO2 emissions in Poland)
	External cost: 7-13 US$ billion/year[3]
	Coal sector
	Mining activities: 1,5% GVA[4] (Poland) (Baran et al., 2018), 6,9% GVA (Region of Silesia) (DG Climate Action, 2017; European Commission, 2015; ICAP, 2021)
	Employment: 0,36% (Poland) (European Commission, 2020i), 4,9% (Region of Silesia) (PGE S.A., 2010)
	Financial results (2015): 1,1 billion € loss (Baran et al., 2018; European Commission, 2020d)
International pressure	2015: Paris Agreement (Rutkowski et al., 2018)
	2019: European Green Deal, carbon neutrality by 2050
	Just Transition Mechanism: €150 billion, €40 billion of which constitute the Just Transition Fund, that will be distributed among the Member State according to the entity of the challenges they will need to face for undergoing the energy transition (European Commission, 2020f, 2021)
	2021: Reform of the EU Emission Trading System (ETS) (Ministry of Climate, 2020; Paska et al., 2020)
	More sectors will be included in the fourth ETS phase (2021-2030)
	Stricter rules. Probably, the number of allowances available in the market will yearly decrease by 2,2%, instead of by 1,74%/year as it has been for round three (Ministry of Climate, 2020; Paska et al., 2020)

[2] Households are defined as energy poor when spending 10% or more of their income on energy (either for heating, electricity, fuels...) (Joas et al., 2018)

[3] Electricity Generated x External Cost due to Electricity Generation = (164 x 10^9 kWh) x (0,041 to 0,082 US$/kWh) (Szpor, 2018)

[4] GVA: Gross Value Added. GVA is a measure of the contribution to GDP made by an individual producer, industry or sector. GVA= GDP + Subsidies on products – Taxes on products.

5.1.2. Product

Referring to the SSI terminology, the "Product" is the electricity generated and sold in the Polish power sector. The electricity demand has been growing in the past decade, but it slightly decreased in 2020 due to the pandemic. However, the electricity generation decreased even more, thus the electricity import has increased by 25% compared to the previous year, accounting for 7,8% of the consumption (Jedra, 2021). The electricity tariffs in Poland are below the EU average (Eurostat, 2021), but are expected to increase (Gawlikowska-Fyk et al., 2019).

Table 6 - SSI Product, Poland

Electricity demand (2019)	174,6 TWh (2019) (Macuk, 2019), 171,1 (2020) (Jedra, 2021)
- Generated in Poland	164 TWh (Macuk, 2019), 157,7 TWh in 2020 (Jedra, 2021)
- Imported	10,6 TWh (2019) (Macuk, 2019) 13,3 TWh (2020) (Jedra, 2021)
Average demand growth (10 years)	1,1% (Macuk, 2019)
Utility companies	(Statista, 2019)
- PGE Polska Grupa Energetyczna SA	41% of domestic production
- ENEA SA	18%
- Tauron Polka Energia SA	8%
Price of electricity	(GlobalPetrolPrices, 2020)
- Households	0,19 US$/kWh
- Business	0,148 US$/kWh

5.1.3. Agents

There are different actors involved in the electricity sector of Poland, covering different roles. In this chapter, they are divided into Authorities, Utility companies, Transmission and Distribution System Operators, and Trade Unions.

5.1.3.1. Authorities

The following scheme shows the main Polish authorities involved in the electricity system:

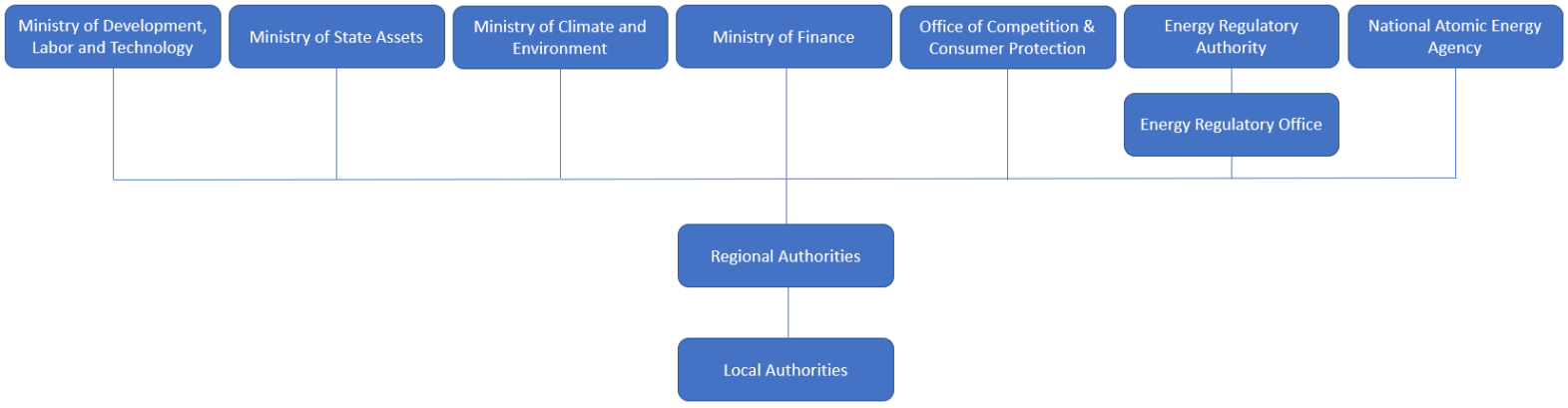

Figure 5 - Power sector in Poland – Authorities[5]

The **Ministry of Development, Labour, and Technology** is the administrative authority responsible for matters concerning energy policy (Ciolcowski, 2015; European Committee of the Regions, n.d.). The **Ministry of State Assets** includes an Energy and Mining division, which task is to restructure public energy companies (Ciolcowski, 2015) (Bartkowska & Wojciechowski, 2020). The **Ministry of Climate and Environment** is in charge of creating and implementing Poland's Climate policy, creating inventories of greenhouse gas emissions and sinks, verify the correct implementation of these regulations (Ciolcowski, 2015; European

Committee of the Regions, n.d.). This is also the Ministry that will prepare the define a plan on how Poland should use the funding coming from the Just Transition Mechanism[5]. The **Ministry of Finance** prepares, executes, and controls the implementation of the state budget: it determines and manages taxes and subsidies (Pawlik, 2019); for what concerns the power sector, it determines the electricity tariffs for the end-users (European Committee of the Regions, n.d.).

The **Energy Regulatory Authority** (ERA) issues and withdraws licences for generation, transmission, distribution, and trading in electricity; it approves grid codes, it issues green and other certificates (Ciolcowski, 2015; European Committee of the Regions, n.d.). Since the reform of the Polish electricity sector in 1997, the ERA is supported by the **Energy Regulatory Office**, which deals with coordinating the energy sector and its prices, issuing operating licenses, promoting energy efficiency (European Committee of the Regions, n.d.). The **Office of Competition and Consumer Protection** (UOKiK), instead, acts independently of the ERA President. It is responsible for the supervision of companies that are natural monopolies, such as grid companies (Ciolcowski, 2015).

The **Regional Authorities** participate in the planning of energy and fuel supply in the region and coordinate the planning of municipalities. They test the compliance of the energy and fuel supply planning with the state energy policy (Ciolcowski, 2015; European Committee of the Regions, n.d.). The **Local Authorities** take part in planning activities aimed at achieving energy efficiency, as well as promoting the reduction of energy consumption (Ciolcowski, 2015; European Committee of the Regions, n.d.).

The **National Atomic Energy Agency** is competent for nuclear safety and radiological protection issues. It operates under the administrative supervision of the Minister of Environment. To date, no nuclear power plants are operating in Poland: however, the Government intends to start operating the first ones between 2030 and 2040 (Brauers & Oei, 2020; Şahin, 2018; Szulecki, 2018).

5.1.3.2. Utility Companies

The Polish electricity market is dominated by a few utility groups which are partially State-owned (the Ministry of State Assets is their main shareholder), which means that they are strongly influenced by the Polish Government.

Table 7 - Utility companies, Poland

Utility company	**State-owned shares**
PGE SA	57,39% (Brauers & Oei, 2020; Szulecki, 2018)
ENEA SA	51,5% (Szulecki, 2018)
TAURON Polska Energia SA	30,06% (Stooq, 2020b)
Energa	0%[6] (Stooq, 2020a)
Innogy	0%

The Polish energy sector seems to be affected by the "revolving door phenomenon", which means that the same people are involved both in politics and in relevant managerial roles in the main utility companies or large coal firms (Brauers & Oei, 2020; Şahin, 2018; Szulecki, 2018). To avoid a conflict of interest, the Polish law requires that any civil servants, Ministers, or politicians, after leaving their role should wait one year before joining the private sector. In practice, this restriction rarely applies, since a special Commission operating under the Prime Minister's Chancellery has the faculty to shorten the period. There have been several cases of people passing through the revolving door more than once, switching between politics,

[5] This information was provided by an expert of the Polish energy sector. This interview is not among those included in the chapter *Interviews*.

[6] The multinational energy group PKE ORLEN has recently acquired over 90% of Energa's shares. However, the State of Poland is the main shareholder of this group and owns 27,52% of its shares. (Czyżak et al., 2020; PKN Orlen, 2020; Stooq, 2020a)

administration, and business (Brauers & Oei, 2020; Szulecki, 2018). Completely private energy companies, such as Innogy Poland, do not seem to attract employees with public administration or political backgrounds and are managed exclusively by energy and business professionals (Szulecki, 2018).

The Polish utility companies are vertically integrated and deal with mining, electricity generation, electricity distribution, and each one of them covers a different geographical area in Poland, as shown in Figure 6. The five companies are discussed under the next subheadings.

Figure 6 - Map of utility companies in Poland (Joas et al., 2018, p. 12)

a. PGE Polska Grupa Energetyczna S.A.

PGE is one of the main electricity utility companies in Poland and one of the largest in Central and Eastern Europe; it produces about 40% of the electricity consumed in the country (PGE GiEK SA, n.d.; Statista, 2019). Overall, the energy mix of the **PGE Group** is strongly dominated by coal and lignite: however, the company is increasing its investments in renewables, particularly in wind power. As for 2019 (PGE GiEK SA, n.d.):

Table 8 - PGE SA, Poland (PGE GiEK SA, n.d.)

Power installed	17,78 GW
• *RES installed capacity*	*3,22 GW (18%)*
Electricity produced	58,32 TWh
• *Electricity produced from RES*	*2 TWh (3,4%)*
Electricity distributed	42,91 TWh
Lignite extracted	43,29 million tons
Number of customers[7]	5,33 million customers (33% of the market)
Number of employees	42'000 employees[8]

b. ENEA SA:

ENEA SA produces and sells to householders and businesses about 18% of the electricity consumed in Poland (ENEA SA, n.d.-b; Statista, 2019). The electricity mix is largely dominated by coal and heating oil: only around 1% of the electricity mix (ENEA Group, 2018) comes from hydropower and wind power together. In 2019 (ENEA SA, n.d.):

[7] Including individual consumers, small and medium-sized companies, as well as large industrial plants
[8] PGE is one of the largest employers in the country

Table 9 - ENEA SA, Poland (ENEA SA, n.d.)

Power installed	6,3 GW
• *RES installed capacity*	*0,44 GW (6,9%)*
Electricity produced	25,9 TWh
• *Electricity produced from RES*	*0,29 TWh (1,1%)*
Electricity distributed	20 TWh
Coal extracted	9,5 tons
Number of customers[9]	2,4 million (15% of the market)
Number of employees	10'000

c. Tauron Polska Energia SA:

TAURON owns 3 mining plants covering about 29% of the national balance energy resources of hard coal. Although the group generates only 8% of the Polish electricity, it is the main distributor in the country. The electricity is produced by conventional sources, including cogeneration, as well as from renewable sources, including combustion and co-firing of biomass, hydro, and wind power plants. (TAURON, 2020)

Table 10 - TAURON Polska Energia SA, Poland (TAURON, 2020)

Power installed	5,3 GW (IEEFA, 2019; Osička et al., 2020)
• *RES installed capacity*	*0,62 GW (11,7%)* (TAURON, 2019)
Electricity produced	13,9 TWh
• *Electricity produced from RES*	*1,4 TWh (10%)*
Electricity distributed	51,7 TWh (TAURON, 2020)
Coal production	3,8 million tons
Number of customers[9]	5,6 million (34,7% of the market. Tauron is the largest electricity distributor in Poland)
Number of employees	25'000 (TAURON, 2018)

d. ENERGA

Its activities include the generation, distribution, and trading of electricity, heat, and gas. Unlike its main competitors, Energa does not include coal mining and coal refinery in its business lines. Energa's electricity mix has a share of renewables equal to 40%, much higher compared to the other main utility companies in Poland (ENERGA, 2020b).

Table 11 - ENERGA, Poland (ENERGA, 2020b)

Power installed	1,34 GW
• *RES installed capacity*	*0,56 GW (40%)*
Electricity produced	1,4 TWh
• *Electricity produced from RES*	*0,5 TWh (36%)*
Electricity distributed	22,2 TWh
Number of customers[10]	3,1 million (of which 2,6 million are households) (ENERGA, 2020a).
Number of employees	9'900

[9] Including individual consumers, small and medium-sized companies, as well as large industrial plants
[10] Including individual consumers, small and medium-sized companies, as well as large industrial plants

e. Innogy

Innogy is a European energy company that operates in Poland too. It recently joined the energy group E.ON (Innogy, n.d.). It covers a smaller share of the electricity market compared to its Polish competitors, it mainly serves the city of Warsaw (Innogy, n.d.).

Innogy Polska SA is responsible for supporting the development of the concern in Poland. In 2019, about 24% of the electricity sold had been generated from renewable energy sources (Innogy, n.d., 2019a). The company manages the Warsaw electricity network (6% of the Polish market) since 2007 (Innogy Polska Solutions, n.d.). In Poland, the Innogy Group operates wind farms with a total capacity exceeding 240 MW and a solar park of 600 kW. The company has recently won an auction launched by the Polish government for the installation of 42 MW of PV panels (IEEFA, 2020; Renewables Now, 2021).

Table 12 - Innogy, Poland (Innogy, n.d.)

Power installed[11]	240,6 MW (IEEFA, 2020; Renewables Now, 2021)
• *RES installed capacity*	*240,6 MW*
Electricity produced	700 GWh
• *Electricity produced from RES*	*700 GWh* (Baran et al., 2018)
Electricity distributed	8,24 TWh[12]
Number of customers	1 million (6% of the market)
Number of employees	790 (D&B Business Directory, n.d.)

5.1.3.3. Transmission System Operator & Distribution System Operator

PSE Operator is the sole Transmission System Operator in Poland and it is 100% State-owned (Ciolcowski, 2015; Joas et al., 2018). The electricity distribution is managed by the same utility companies mentioned in the previous section (Joas et al., 2018).

5.1.3.4. Coal mining companies

The Polish coal market is dominated by a few companies (see Table 13). The coal sector is strongly connected with the power generation of Poland. The hard coal mining reserves are mainly located in Upper Silesia and Lublin Basin, while lignite is mainly located in the central area of the country (Euracoal, 2018).

Figure 7 - Coal and lignite reserves in Poland (Kociuba & Acosta, 2020, p. 4)

[11] In Poland

[12] It has not been possible to find this information, therefore this value has been estimated looking at the data available on electricity distributed and customer served for the other utility companies

Table 13 - Coal mining companies, Poland

PGG	The largest employer in Silesia
	2016: the group integrated Kompania Weglowa (KW) and Katowicki Holding Weglowy (KHW), two coal mining companies in a difficult economic situation. This operation was directed by the Government to contain the debt of the coal sector (Euracoal, 2018; Szpor, 2018).
	Today PGG is mostly owned by the State (Euracoal, 2018; Szpor, 2018)
JSW	One of the main employers in Silesia
	The largest European producer of high-quality hard coal (Euracoal, 2018; JSW SA, 2019)
	State-owned by 55% (JSW SA, 2019; Trappmann, 2012)
LW Bogdanka	Located in Lublin Basin
	A single, large coal mine that supplies about 20% of the total power coal sales in Poland (Gardawski et al., 2012).
	It is 66% owned by the utility company Enea SA (Gardawski et al., 2012)
TAURON Wydobycie SA	The TAURON Group manages 29% of the coal reserves of the country (TAURON, 2020)
PGE GiEK	The most importnat mines are located in Belchatòw and in Turòw
	It dominates 87% of the Polish lignite mining industry (Euracoal, 2018)
	State-owned by 60% (Euracoal, 2018; Gardawski et al., 2012)

5.1.3.5. Trade Unions

Trade Unions are a fragmented reality in Poland: they usually do not cooperate one with another; there aren't many statistics available about Trade Union members (Mrozowicki, 2016). The most important Trade Union groups are shortly listed in the Table, and a more extensive description can be found in Appendix 7.

Table 14 - Trade unions, Poland

NSZZ Solidarnosc (Solidarity)	Founded in 1980
	1981: martial law; the trade unions should have stopped their activities, but NSZZ was favoured by the international public opinion
	722'000 workers (4,35% of the total unionisation workforce in Poland, 12 to 14% of the total workforce) (Solidarnosc, 2018)
OPZZ (All-Poland Alliance of Trade Unions)	Founded in 1982, to be the only legal trade union. Part of the pro-government Patriotic Movement for National Revival and tied very closely to the Polish United Worker's Party (Trappmann, 2012)
	550'000 members in all branches - Mining, chemical & energy in one of the most popular (Trappmann, 2012)
FZZ (Trade Unions Forum)	Founded in 2002
	420'000 members

NSZZ, OPZZ, and FZZ were all admitted to the European Trade Union Confederation in early 2000. Only 50% of the workers who could be organised are members of a trade union group: the percentage changes according to the branches, and it's almost 100% among miners (Baran et al., 2018). Although the trade union reality in Poland is still quite fragmented, in September 2020 the main trade union groups signed an agreement with the Polish Government to phase out coal by 2049 (Farand, 2020; Husen-Bradley & Zierold, 2020). This agreement concerns hard coal and will imply a major transformation in one of the most important industries of Poland. The trade unions and the government now need to define a strategy to guarantee protection to the workers: a plan will be defined by February and integrated with the Just Transition Mechanism plans[13] (Farand, 2020; Husen-Bradley & Zierold, 2020).

[13] This information was confirmed by an expert of the Polish energy sector. This interview is not among those included in the chapter *Interviews*.

5.1.4. Technology & Knowledge

5.1.4.1. Electricity mix

The power capacity in Poland is 47 GW (U.S.A. Department of Commerce, 2020), of which 50,4% from hard coal and 19,6% from lignite (Figure 8) (year 2019) (Forum Energii, 2019). The electricity generated in the same year was 164 TWh, distributed by source as showed in Figure 10 (European Commission, 2020d).

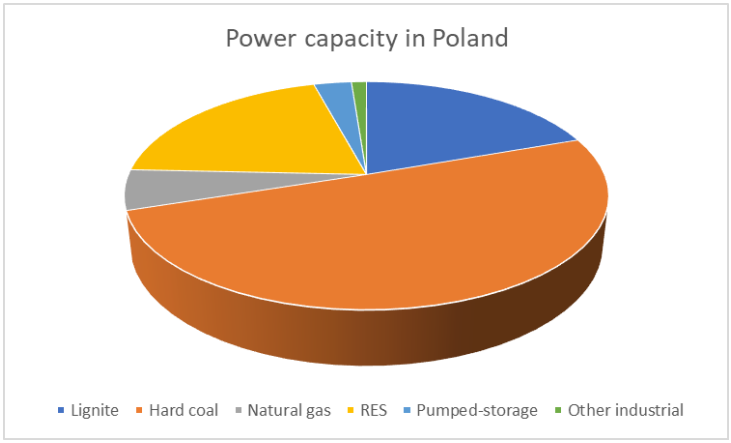

Figure 8 - Power capacity, Poland, 2019 (Forum Energii, 2019)

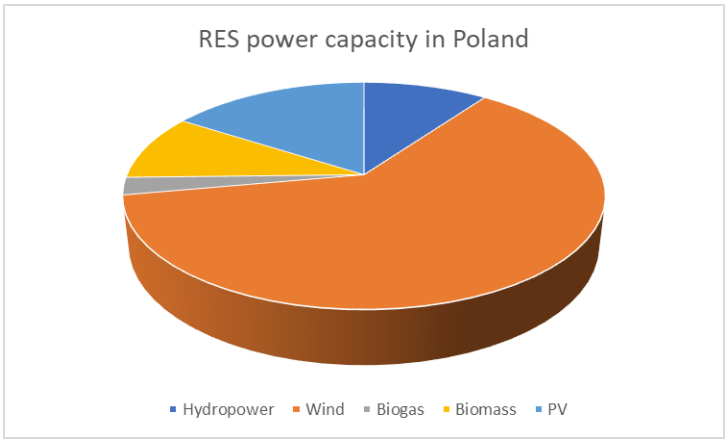

Figure 9 - RES power capacity, Poland, 2019 (Forum Energii, 2019)

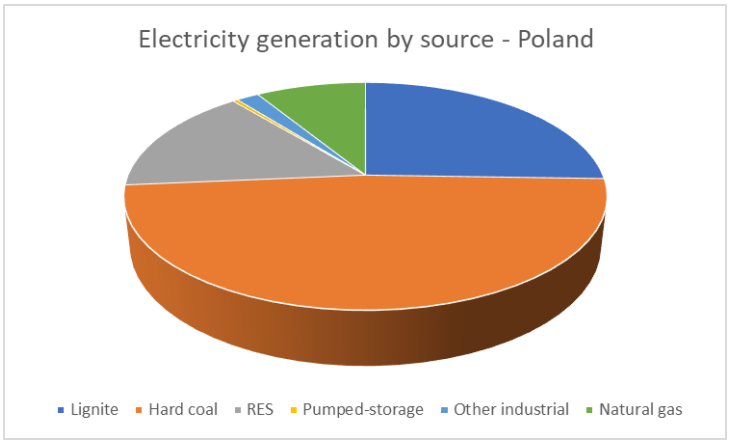

Figure 10 - Electricity generation by source, Poland, 2019 (Macuk, 2020)

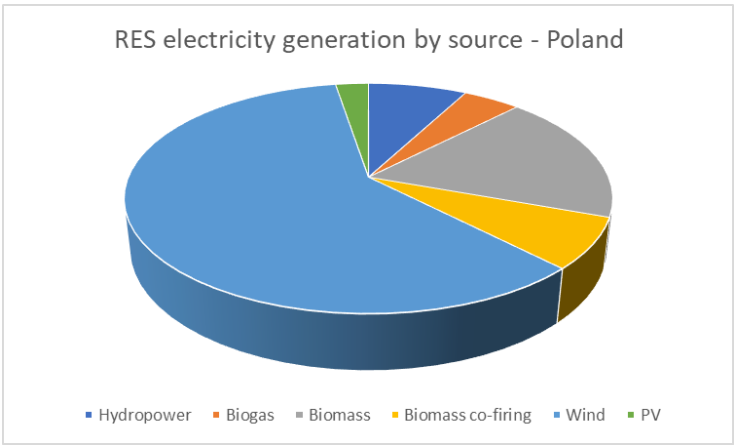

Figure 11 - RES electricity generation, Poland, 2019 (Macuk, 2020)

a. Coal & Lignite

In the 20th century, Poland was among the top five global producers of coal, together with the USA, URSS, United Kingdom, Germany (Baran et al., 2018) (Figure 12). From 1945 to 1989, the Polish coal production became unavailable because Poland was included in the Eastern Block (Baran et al., 2018). The absence of a free market caused the inefficiency of the sector: the production could not access the international market and there were no price signals to regulate the production (Baran et al., 2018). After the fall of the Berlin wall in 1989, the Polish government realised that the coal production was excessive and the production costs too high (Schwartzkopff & Schulz, 2017). In the subsequent years, the least profitable mines were closed and employment was reduced. Although the coal mining sector improved its score in efficiency indicators after 1989, the production costs are still quite high and the sector is again unprofitable: the sector has been achieving negative financial results since 2013, reaching a 1,1 billion € loss in 2015 (Schwartzkopff & Schulz, 2017). The domestic production of hard coal in Poland declined, the exports decreased, and the internal demand began to be supplemented with imported coal – mainly from Russia (Nyga-Lukaszewska et al., 2020).

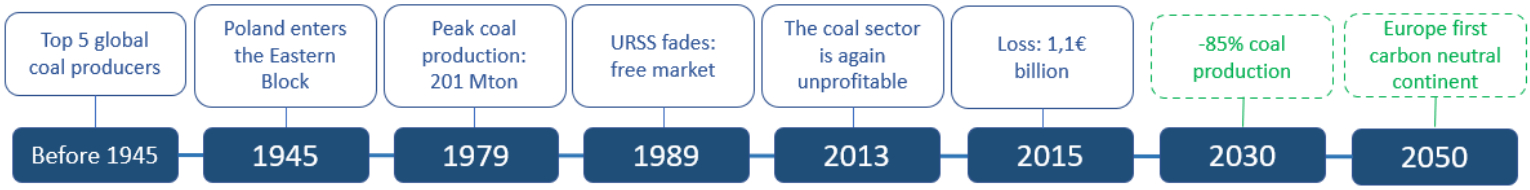

Figure 12 - Coal sector in Poland: Timeline

The energy sector is the biggest consumer of coal domestically. It is responsible for 59% of coal consumption, while industry and buildings consume 23% and the residential sector 13% (Schwartzkopff & Schulz, 2017). There are strong ties between the coal industry and the national government. The energy sector is an oligopoly, and the main coal mining companies are fully or partially owned by the Polish state (Baran et al., 2018).

Hard coal mining is restricted to three regions: Śląskie, Lubelskie, and Małopolskie. Śląskie (Silesia) hosts 90% of the hard coal employment. For lignite, there are five main mines: Bełchatów (the largest one), Turów, Konin, Adamów, and Sieniawa, located in the regions of Łódzkie, Wielkopolskie, Dolnośląskie and Lubuskie. Lignite is less labour intensive than hard coal mining, the sector counted around 10 thousand employees in 2015. It is commonly believed that lignite mines will run out by the 2030s. The employment in the two sectors shares some similarities: highly masculinised, rather low-skilled. However, due to more spatial dispersion of lignite, the transition is likely to have different implications compared to the transition in hard coal mining. (Ministry of National Assets - Poland, 2019)

b. Natural gas

Poland consumed 720 bcf[14] (20,4 bcm[15]) of natural gas in 2019: the country is strongly dependent on imports, about 80% of the gas consumed is imported (U.S. Energy Information Administration, 2020). Most of the gas consumed today is imported from Russia, but Poland is trying to reduce this dependence: in May 2020, a long-term natural gas transit contract with Russia was let expire. Russia can still move smaller volumes via short-term capacity booking at reduced transit rates, though. Another long-term natural gas import contract with Russia is expected to expire in 2022, and Poland plans not to renovate it (U.S. Energy Information Administration, 2020). The purchases of sea-borne liquefied natural gas from Norway will be increased: a Baltic Pipe is being constructed and expected to be completed by October 2022. A gas interconnection with Lithuania will be completed in December 2021 (U.S. Energy Information Administration, 2020). According to the Polish Geological Institute, the recoverable resources of natural gas amounts to 120 bcm (4236 bcf) as of 31 December 2016 (Flanders Investment & Trade Market Survey, 2019).

c. Renewable energy sources

The percentage of electricity coming from renewable sources has been increasing in the past years, although being still quite below the European average. The electricity coming from RES in Poland is about 15% (Forum Energii, 2019). Among the renewable energy sources, the one which is more exploited and which is receiving the largest investments is wind power, followed by biofuels (2018). In the time frame from 2013 to 2019, wind energy technologies and projects have been entitled to about 62% of the total investments in renewables supported in Poland. Wind power could provide as much as 27% of the country's energy by 2050. Solar and geothermal together could sum up to 20% of the national energy demand: about the same as biomass. To date, only 1-2% of the potential solar and geothermal sources have been exploited so far (Ministry of National Assets, 2019a; SolarPower Europe, 2019).

Domestic legislation isn't always favourable to renewables. New wind power projects, for example, have been limited by a "10H regulation", meaning that wind farms must be built at a distance from housing of at

[14] Bcf: billion cubic feet
[15] Bcm: billion cubic meters

least 10 times the height of the turbine. This blocks around 98% of the country's land for wind power development. On top of that, the legislative framework is unstable. In 2015, Poland adopted the Renewable Energy Sources Act to subsidise very small renewables installations (3-10 kW). However, this law was amended in June 2016: feed-in-tariffs for wind and solar energy were lowered substantially, while more support for biomass, biogas, and co-firing was created. (Ministry of National Assets, 2019a)

5.1.4.2. Research & Development

In the last National Energy and Climate Plan submitted by the Polish government, it is stated that Poland plans to increase investments in sustainable initiatives. This will indeed be needed to reach the goals set to fulfil the European Union's requirements (Ministry of National Assets, 2019a).

R&D intensity in eco-innovation was 1% of the Polish GDP in 2015 and 0,97% in 2016: lower than the EU average of 2,03% (Baran et al., 2018). Poland aims to increase the R&D intensity to 2,5% of the GDP by 2030 (Kubicka, 2018). Although the R&D intensity is relatively low, the domestic expenditure on R&D is complemented by the EU and foreign funds which are an important source of funding. In 2019, the European Commission proposed the European Green Deal: an action plan to boost the circular economy and to cut pollution. The Green Deal will mobilize at least €1 trillion (European Commission, 2019a).

Besides the several research centres working on sustainability and renewable energy sources, the research is still active in the coal sector too. For instance, the Clean Coal Technology Centre was created by the joint initiative of the Central Mining Institute (GIG) in Katowice and the Institute of Chemical Processing of Coal (IChPW) in Zabrze (CCTW, 2013). The laboratory was created in 2013 in Silesia and funded by the EU to research how to reduce the negative impact on coal used for energy purposes (CCTW, 2013).

5.1.4.3. Workforce

The unemployment rate in Poland is about 6%: it has been decreasing during the past years, although the COVID-19 pandemic is reversing the trend (Sas, 2021; Statistics Poland, 2021). It is a common opinion in Poland that coal is the "Polish gold" and that termination of coal mining would lead to tragic consequences for employment: however, only 0,36% of the Polish population is employed in the mining and extraction industry. 90% of them, though, are concentrated in Upper Silesia (or Slaskie Voivodeship) (Baran et al., 2018). The employment in the coal sector has been declining by 4% yearly on average (by 0,6% in the sector specializing in generation and supply of electricity, gas, steam, hot water) (Baran et al., 2018). Other industrial sectors have instead experienced deficiencies of employees – e.g. construction, transport, catering, processing industries, health care (Baran et al., 2018).

Workers in the coal mining sector are less educated compared to an average in the Polish economy: 16% of coal miners have tertiary education, 41% have secondary education, 37% have basic vocational education, and 6% have primary education (Baran et al., 2018). The low education level worsens their prospects in finding a new job in a different sector: however, the skills gap is lower with job places in industrial processing, transport, or construction (Baran et al., 2018).

Coal mining is the most unionised sector of the Polish economy. In 2015, the unionisation rate of the coal mining sector was 72%, compared to only 11% of the average for the total economy (Wierzbowski et al., 2017). Despite coal miners are low-skilled, the earnings in the coal mining sector are much above the nationwide average. The average monthly wage in the hard coal and lignite sector was 6559 PLN (€1460) in 2014, whilst the average wage in manufacturing was 2907 PLN (€647) (Wierzbowski et al., 2017). Besides, the underground coal miners, which constitute on average 76% of workers in collieries, are covered with early retirement provisions (Wierzbowski et al., 2017). They can retire at age of 50 if they worked at least 25 years, including 15 years of working underground. The regular retirement age for males is 65, which means that underground miners can retire 15 years earlier than the majority of men (Wierzbowski et al., 2017).

In 2014, the average age of workers was 39 years. The age distribution reveals that a large share of workers was in the age of 40-45, constituting ¼ of employment in hard coal mining (Şahin, 2018). In 2014 they were still below retirement age, but soon they will be eligible for early retirement age, at least some of them who have worked underground for a sufficiently long period (Şahin, 2018).

5.1.5. Infrastructures

5.1.5.1. Power plants

The recent inspection carried by the Polish Supreme Audit Office released a report on the current situation of the Polish energy sector and the forecasts on future energy security (Wierzbowski et al., 2017). The main problem of the Polish energy sector is the impending decommissioning of old units. The predicted lifetime of coal power plants is 40–45 years. 59% of turbo generators are over 30 years old, 16% are between 20 and 25 years and only 25% of units were built in the recent 20 years (Wierzbowski et al., 2017). Even more alarming situation can be observed for the boilers of which over 63% is over 30 years old and only 20% is less than 20 years old (Wierzbowski et al., 2017). The government aims to replace existing, low-efficiency generation units with new, high-efficiency plants to decrease air pollution and GHG emissions, making Poland one of the few countries in Europe that still builds new coal power plants (Paska et al., 2020).

5.1.5.2. Transmission lines

70% of transmission lines are over 30 years old, and 47% over 40 years old (Paska et al., 2020). However, the maintenance processes prolonged the period of the efficient functioning of transmission lines to 70 years, so the problem of old lines has been postponed. Almost 66% of transmission and distribution lines are the overhead lines that are subjected to severe weather conditions (typical to Polish climate) that often cause damages (Paska et al., 2020). The grid's density is not equal on the Polish territory - it is more expanded on the south and less in the north. The uneven structure causes that the grid operates in the "open" configuration instead of the meshed one and the possibilities of reconfiguration are limited (Paska et al., 2020). The Polish grid allows for only one-way electricity flows and limits the potential of distributed generation (Paska et al., 2020). The frequent thefts of the infrastructure constantly increase the expenses of the operators. The transmission losses are very substantial in the Polish energy sector: the total loss of electricity transmission in 2011 reached 10,774 GWh (7.3% of total electricity produced) which represents the loss of almost €0.5 billion (Paska et al., 2020).

5.1.6. Institutions

In the SSI framework, “Institutions” include laws, policies, rules, as well as informal norms and established practices (Malerba, 2002, 2005).

5.1.6.1. Energy Policy

This section presents the latest key policies and directives affecting the power sector of Poland, also reported in a timeline (Figure 13).

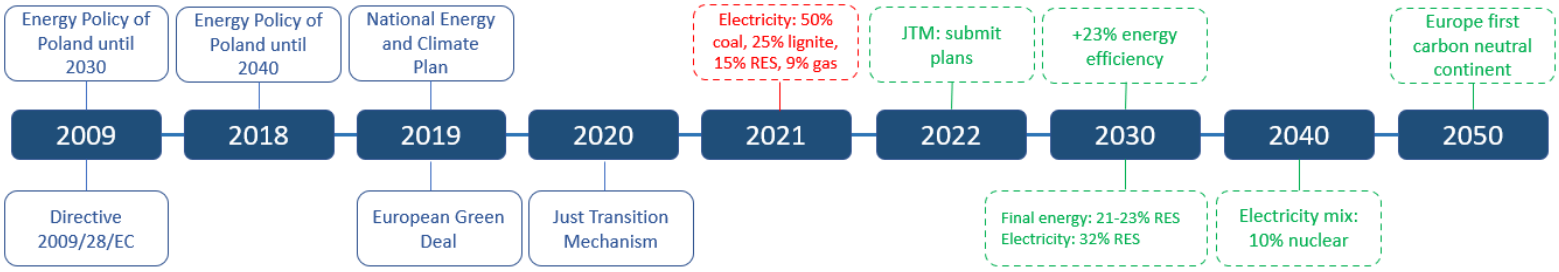

Figure 13 - Energy policies in Poland: Timeline

a. Energy Policy of Poland until 2030

Poland adopted the Energy Policy of Poland until 2030 to fulfil the EU's obligations, especially on the reduction in CO_2 emissions. In 2009, Poland estimated that the electricity demand would have quite increased (from 9 Mtoe to 14,8 Mtoe estimated in 2030). Also, the share of renewables was expected to almost double, from 9,4% to 16%. The document recognises the greatest potential for energy in biomass, biogas, wind power and hydropower, due to the Polish climate and the mechanisms of financial support. This strategic document has not been revised, even though the Polish government has prepared and published several drafts of a new energy policy and there have been changes in the conditions in which energy entities operate. (Paska et al., 2020)

b. Energy Policy of Poland until 2040

The Energy Policy of Poland until 2040 was published in February 2021. Poland will strive to cover the demand for energy with its internal resources (Ministry of Climate and Environment, 2021; Paska et al., 2020). Domestic coal resources will remain the main source of Poland's energy security and the core of its energy balance. The use of coal by the power plants will continue to be stable, but the share of coal in electricity production will decrease to 56% in 2030 (Ministry of Climate and Environment, 2021). Investments in new coal-based power plants undertaken after 2025 will be based on highly efficient cogeneration units, or other technology meeting the emission standard of 450 kg CO_2 per MWh of generated energy (Paska et al., 2020).

Renewable energy sources will play an increasing role in power systems. Their level in the structure of national electricity consumption may amount to about 32% (Ministry of Climate and Environment, 2021). The main instrument to reduce emissions from the energy sector will be the implementation of nuclear energy in 2033. It has been assumed that by 2043, six nuclear units, with a total capacity of 6–9 GW, will be built (Ministry of Climate and Environment, 2021; Ministry of Energy, 2018). This means that in 2040 the share of this energy in electricity generation could be about 10%. Poland has declared it will achieve a 23% share of renewables in final energy consumption by 2030, saying that this level of renewable development is in line with the requirements of the 15% 2020 target (Ministry of Climate and Environment, 2021). Photovoltaic installations and offshore wind power plants are presented as the most promising routes for development in Poland in the next decade (Ministry of Climate and Environment, 2021; Ministry of Energy, 2018). In the case of onshore wind power, the Ministry intends to phase out existing wind power capacity from the second half of this decade: several new technologies are scheduled to be installed (Ministry of National Assets, 2019a; Paska et al., 2020).

c. Directive 2009/28/EC

Under Directive 2009/28/EC of the European Parliament and the Council of April 23rd, 2009 on the promotion of the use of energy from renewable sources, Poland was obliged to derive a minimum 15% share of energy from renewable sources in its gross final energy consumption by 2020 (Ministry of National Assets, 2019a). Partial goals have been defined for district heating and cooling (17.05%), electricity generation (19.13%), transport (11.36%) (Ministry of National Assets, 2019a; Paska et al., 2020). According to Eurostat data, the share of energy from renewable sources in the gross final energy consumption of 2017 was 10.96%, while in 2018 it was about 11.28% (Paska et al., 2020). The share of energy derived from RES in the gross final consumption of energy in 2018 did not reach the planned ratio (Ministry of National Assets, 2019a; Paska et al., 2020).

d. National Energy and Climate Plan

On 30 December 2019, the Minister of State Assets sent the European Commission the Plan for Energy and Climate for Poland. The main objectives of Poland's energy and climate policy outlined in the document and the means for providing a future measure of its implementation are (Şahin, 2018; Szpor & Ziółkowska, 2018):

- Reduction of greenhouse gas emissions in sectors not covered by the European Union Emission Trading Scheme (EU ETS)[16]. This target was set at –7% in 2030 compared to 2005. The EU ETS foresees a 25% reduction in greenhouse gases between 2005 and 2030.
- As part of the EU-wide RES target for 2030, Poland declares to achieve a 21–23% share of energy being derived from renewable sources in the gross final consumption of energy (total consumption for electricity, heating, and cooling, and transport purposes) by 2030[17]. It is estimated that by 2030, the share of RES in heating and cooling will increase by 1,1 percentage points on average annually. The share of renewable energy is expected to reach 32% in electricity generation by 2030.
- The national energy efficiency improvement target for 2030 has been set at 23% of primary energy consumption according to the PRIMES 2007 forecast, corresponding to the primary energy consumption of 91.3 Mtoe in 2030.

Cogeneration might give a significant contribution to reach the energy efficiency target as well as a reduction in greenhouse gases emissions: indeed Poland has a long tradition in CHP compared to other European countries and it plans to increase the investments in this technology (Brauers & Oei, 2020; Şahin, 2018; Szulecki, 2018).

e. European Green Deal

In December 2019, the European Union has declared the intention to become the first carbon-neutral continent by 2050 and has launched the Green Deal, an action plan designed to reach this goal (European Commission, 2019a). The European Green Deal aims to boost the efficient use of resources by moving to the circular economy, restore biodiversity and cut pollution. The plan outlines the investments needed and financing tools available (European Commission, 2019a). The EU would like to turn this political commitment into a legal obligation, transforming the Green Deal into a European Climate Law. If the law proposal will be approved, the Member States will be obliged to reach net-zero emissions by 2050 (European Commission, 2019a). In April 2021, a provisional agreement has been reached and the GHG emissions reduction target has been set to 55% by 2030 (McPhie & Rietdorf, 2021).

f. Just Transition Mechanism

The European Green Deal includes a Just Transition Mechanism that is expected to mobilise about €65-75 billion: €17,5 billion of which (in 2018 prices, or €19,3 billion in today's prices) constitute the Just Transition Fund, which will be distributed among the Member State according to the entity of the challenges they will need to face for undergoing the energy transition (DG for Communication, 2021b, 2021a; European Commission, 2020f). Poland will benefit most of all MSs from this program and will receive €3,5 billion (in 2018 prices, or €3,864 billion in today's prices), 20% of the total figure (European Commission, 2021). The Just Transition Fund is part of the funding mechanisms for the European recovery after the Coronavirus pandemic, and around €10 billion of its budget come from the NextGenerationEU initiative (European Commission, 2021).

The Just Transition Fund will support a series of measures for social support (training, employment policies, income support, etc), economic conversion, and land restoration. According to the European Parliament, the just transition should fulfil four criteria to be successful: it must be conducted at a local level; include targeted labour and welfare policies; be part of a long-term economic and decarbonisation strategy; and allow regular

[16] Non-ETS sectors include transport, construction, agriculture.
[17] Poland declared this target as conditional, it is attainable only if the country is granted additional EU funds, including those for a just transition (Wisniewska, 2016).

evaluations of its effectiveness, leading to changes during the year, particularly to grant it more resources (European Commission, 2020f; Pascale, 2020).

The preliminary Commission services' views on priority investment areas in Poland have identified that the transition will likely impact all coal mining regions, namely Silesia, Wielkopolska, Lower Silesia, Łódzkie, Lubelskie, and Malopolska (European Commission, 2020a). Silesia, the biggest mining region, extracts coal in 18 mines, located in Katowice, Bielsko-Biała, Tychy, Rybnik, Gliwice, Bytom, Sosnowiec (European Commission, 2020a). The European Commission suggests that Poland invests in SMEs, new firms, research and innovation, upskilling and reskilling of workers in these areas. While the JTM would like to favour small, new enterprises, in some regions it is not realistic to entirely offset the job losses in the coal sector without supporting large enterprises too (European Commission, 2020a).

The Member States must now prepare "Just Transition Territorial Plans" in consultation with all local stakeholders (trade unions, enterprises, NGOs, local authorities) (European Commission, 2020f). The plans should be consistent with the national goals set in the National Energy and Climate Plans (NECP) and the EU regulations and goals (Widuto & Jourde, 2021). The legal deadline by when the project proposals should be submitted is 2022, however, the Member States are encouraged to act as soon as they can (European Commission, 2020h). From the interviews, it emerged that the first interim deadline will be in summer 2021.

5.1.6.2. Public perception of the power sector

There is a mismatch between reality and perception over the Polish coal sector: the coal sector has been declining for many years, but Poland is still perceived as a "coal country" by at least part of the population (Baran et al., 2018). This is due to the long coal tradition experienced in Poland and to the partial information spread by the coal lobby: low-carbon transition initiatives are often framed as unacceptable and difficult to implement (Szpor, 2018). Poland has often tried to delay or obstruct low-carbon initiatives coming from the EU. Eventually, the country transposes the EU climate and energy directives with massive delays (Şahin, 2018). Polish politicians often use the EU as a scapegoat, diminishing its influence, albeit EU funds constitute 60% of total public investment in Poland and the country is the largest beneficiary of EU funding in net terms (Şahin, 2018). It seems that Poland would like to shape the EU more into an economic and security union, rather than a value-based liberal democratic union (Şahin, 2018).

Public opinion is raising concerns about the vulnerability of the country to climate change, particularly in the agricultural sector (Şahin, 2018). Farmers and municipalities are growing interest in renewable energy sources and oppose the opening of new mines: however, this has not led to political action at the national level (Şahin, 2018). The engagement of Polish society with politics is still relatively limited, which is typical within post-Communist societies, and energy issues are usually not a priority in the election discussions (Karkour et al., 2020).

5.1.7. Evolutionary and dynamic aspects

The electricity sector in Poland is dominated by a few huge utility companies, which usually are also coal mining companies, and control the whole electricity value chain. The companies are largely State-owned.

For a long time, domestic regulation has not eased the diffusion of renewable energy technologies, and the EU directives on climate and energy have often been delayed or challenged. The relationship between Poland and the EU is not always smooth: in 2020, the country spent several months vetoing the EU Recovery Fund proposed to face the post-COVID crisis, which also includes the Just Transition Fund. Poland and Hungary initially refused to sign the proposal, since they did not agree with the rule-of-law mechanism that could see a Member State losing EU subsidies if not fulfilling democratic standards (Boffey, 2020; European Commission, 2020c). Some actors point out the contrasts with the fact that Poland is one of the largest beneficiary of EU investments among the Member States (Buchholz, 2020; Golinowska & Jana, 2019; Kovacevic, 2019).

Although Poland has traditionally opposed the low-carbon energy transition, it seems that the trend might be about to change:

- Coal Trade Unions have long opposed any energy sector reform, to avoid job losses. However, last September the Polish Trade Union groups subscribed to the phase-out of coal by 2049 (Farand, 2020; Husen-Bradley & Zierold, 2020). Although a detailed strategy still has to be defined, this was a historical moment for Poland (Farand, 2020; Husen-Bradley & Zierold, 2020).
- It is spread in Poland the opinion that the EU wants the country to become greener despite the social and economic impacts that the transition would have (Osička et al., 2020). The Just Transition Mechanism aims to take charge of both social and economic perspectives, besides the environmental one. The proper management of this funding mechanism might positively influence the Polish public opinion on the green energy transition.
- In 2018, during the COP24, the Polish Government signed the Solidarity and Just Transition Silesia Declaration, acknowledging the need to tackle climate change while recognizing the specific needs of the most affected sectors and communities (United Nations, 2018). Drafting the NECP 2021-2030, Poland committed to doing its part to achieve the EU energy and climate targets (Ministry of National Assets, 2019b). Although being still quite locked in to coal, the Polish energy sector can no longer ignore the international pressures for a clean transition.

5.2. South Africa

5.2.1. Landscape

The power sector of South Africa cannot be understood without taking into account the socioeconomic environment in which it is embedded. Although South Africa is one of the most developed countries in the continent, a large share of its population is still affected by poverty, and the wealth is unequally distributed among the society. The key elements of the landscape are summarised in Table 15 and more details are explained in Appendix 7.

Table 15 - Landscape, South Africa

Political framework	1961: Republic
	1994: end of the Apartheid; every citizen can vote
	Since 1994, the African National Congress has kept being re-elected and has ruled the country (ANC, 2019; GCIS, 2019; Kirby, 2019; Santander, 2021)
	The country is a member of both the Commonwealth of Nations and of the Southern Africa Development Community – an inter-governmental organization among southern African countries to strengthen socio-economic, political and security cooperation (SADC, 2012).
Economic state of play	GDP (2019): 5291,91 R billion (351,4 US$ billion or 292€ billion) (The World Bank, 2019c)
	GDP per capita (2019): 90'272 R or 6000 US$ or 4985 €, constant since 2014 (The World Bank, 2020a)
	GDP growth (2019): +1% (Department: Statistics South Africa – Republic of South Africa, 2020)
	GDP contraction (COVID-2019) in the last 3 quarters of 2020: -0,8%, -1,4%, -2% (Department: Statistics South Africa – Republic of South Africa, 2020)
	< 1,90$/day (2015): 18,8% people (Macrotrends, 2020)
	< 5,50$/day (2015): 57,10% (Macrotrends, 2020)
	Gini coefficient (2015): 0,63 (The World Bank, 2020a)
	Unemployment rate: 29,1% (Statistics South Africa, 2019) or 28,2% (The World Bank, 2020b) in 2019, 32,5% in 2020 (Stats SA, 2021)
	Energy poor households[18]: 47% (Heinrich Boll Stiftung SA, 2016)
	Households without access to electricity: 10% (The World Bank, 2019a)
Pressures on the power sector	*External cost*
	Emissions (2018): 428 Mt CO2 (IEA, 2018b) to 433 Mt CO2-eq (Department of Environmental Affairs, 2015; South African Government, 2020)
	External cost (2018): 4,3 to 29 US$ billion/year[19]
	Coal sector
	Coal mining activities: 1,5% of the GDP (Minerals Council South Africa, 2018)
	30% of the annual production (250-260 Mtpa) is exported - Exports are more profitable than domestic sales, they amount to 45% of the total sales (2016) (Burton et al., 2018)
	The increasing cost of coal is affecting the energy security and affordability in South Africa (Burton et al., 2018)
International pressure	2016: Paris Agreement (Marquard & McCall, 2019; Modise, 2016)
	Post-Apartheid: re-admitted to the Commonwealth association. The Commonwealth Climate Finance Access Hub supports the most vulnerable states secure funding to tackle climate change: however, South Africa has not been involved in any of these projects so far. The Commonwealth does not impose biding regulations concerning climate and the environment (The Commonwealth, 2020a, 2020b).
	Southern Africa Development Community: 16 southern African countries gather to strengthen socio-economic, political, and security cooperation. The SADC intends to strengthen climate change resilience and mitigate climate change effects among its member states, but it has not developed any binding law on climate-related topics (SADC, 2020a, 2020b).

[18] Households are defined as energy poor when spending 10% or more of their income on energy (either for heating, electricity, fuels...) (Joas et al., 2018)

[19] Electricity Generated x External Cost due to Electricity Generation = (204 x 10^9 kWh) x (0,021 to 0,144 US$/kWh) (Szpor, 2018)

5.2.2. Product

Referring to the SSI terminology, the "Product" is the electricity generated and sold in the South African power sector. Electricity tariffs have risen sharply in recent years, due to the rising costs of coal mining and O&M costs to run the power plants. More information can be found in Appendix 7.

Table 16 - SSI Product, South Africa

Electricity demand (2019)	204 TWh (Enerdata, 2019b)
- Exported	14,9 TWh (The Global Economy, 2019)
Demand growth (10 years)[20]	-0,0467 (Burton et al., 2018; Enerdata, 2019b)
Price of electricity	(Global Petrol Prices, 2020)
- Households	0,126 US$/kWh
- Business	0,06 US$/kWh
Price increase (2003 to 2019)[21]	(Eskom, 2020b, 2020a)
- Households	+344%
- Business	+569%

5.2.3. Agents

5.2.3.1. Authorities

Different authorities have a say in the electricity sector of South Africa (Figure14)[22].

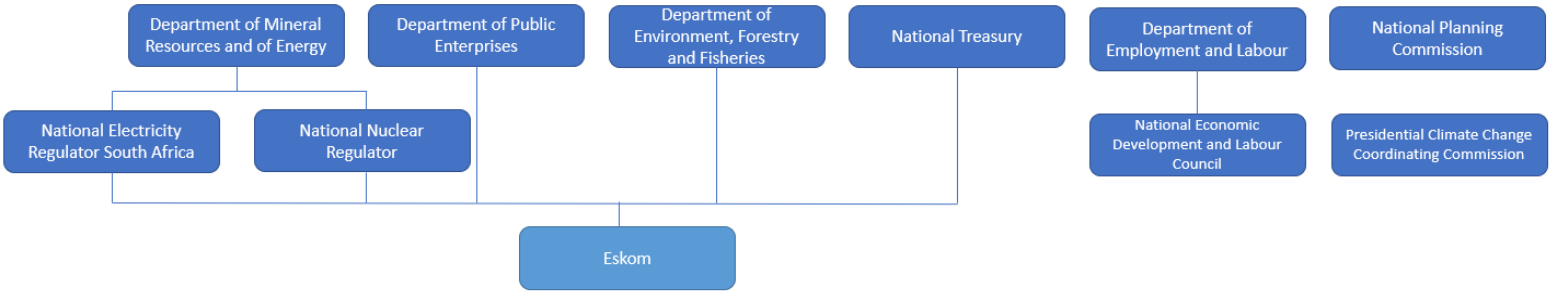

Figure 14 - Power sector in South Africa – Authorities

The **Department of Mineral Resources and Energy**[23] aims to lead the transformation of South Africa's economic growth agenda through the sustainable development of the mining and energy sectors (DMRE, n.d.). The Minister of Minerals and Energy determines if and what type of new generation capacity is needed to ensure the continued uninterrupted supply of electricity (DMRE, n.d.). The **National Electricity Regulator South Africa** (NERSA) sets and/or approves tariffs and prices, licences and registrations. It intervenes in disputes mediating, arbitrating, and handling complaints (NERSA, 2019). The **National Nuclear Regulator** (NNR) is a public entity that is established to provide for the protection of persons, property, and the environment against nuclear damage through the establishment of safety standards and regulatory practices (National Nuclear Regulator, n.d.).

[20] In 2007, South Africa has been hit by an electricity crisis, which is still going on: the supply falls behind the demand, causing severe power outages. To date, Eskom has not been able to solve the issue definitively: load shedding is applied whenever the grid is at risk, while what would be needed is the construction of new power stations.

[21] The electricity price is expected to keep rising since it has not reached cost-reflectivity yet, due to the historical tendency of the National Regulator to adopt "pro-poor measures" rather than "cost-reflective tariffs" (Kessides, 2020; Maphosa & Mabuza, n.d.). Thus, the electricity price has for a long time been kept artificially low: Eskom, the only utility company in the country, had to seek government support, which led to government interference in its day-to-day activities and a further loss of efficiency (Kessides, 2020; Maphosa & Mabuza, n.d.).

[22] The diagram was validated by an expert of the South African energy sector. This interview is not among those included in the chapter *Interviews*.

[23] The Department of Mineral Resources and the Department of Energy were merged into one department in 2019.

The **Department of Environment, Forestry and Fisheries**[24] provides licenses/authorisations to ensure enforcement and compliance with environmental law; improves air and atmospheric quality; leads and supports efficient and effective international, national, and local responses to climate change (DEFF, n.d.). In 2016, the **Minister of Environmental Affairs** has signed the Paris Agreement on climate change at the United Nations in New York, committing to integrate the agreement within the national legal systems (Modise, 2016). The DEEF ensures that the Air Quality Acts are respected: in 2013, Eskom failed to comply with Minimum Emissions Standards in 16 of its power stations (Department of Environmental Affairs, 2014). The utility company requested a long-term postponement from complying with the air quality legislation, which gave origin to protests and petitions from environmental organisations such as Green Peace (Greenpeace Africa, 2014). Besides the objections from civil society, in 2015 Eskom was granted a 5-year exemption from complying with the Minimum Emissions Standards (Centre for Environmental Rights, 2018). Failing to fulfil the requirements by the deadline would force the company to close some power plants: however, Eskom is still seeking to postpone the end of the exemption (Centre for Environmental Rights, 2020; DoE, 2019b).

The **Department of Public Enterprises** (DPE) seeks to ensure that the State-owned companies are financially sustainable, adequately funded, and operationally robust; that their operating models keep pace with global development and innovation; that they provide reliable and cost-effective services; and that they align with national developmental objectives (DPE, n.d.). Therefore, the DPE is in charge of regulating and checking the main utility company operating in South Africa, Eskom (DPE, n.d.). The **National Treasury** is responsible for managing South Africa's national government finances (National Treasury SA, n.d.). It takes care of the public companies' debts when these are not able to generate a profit: indeed, most State-owned companies hold developmental rather than profit-driven mandates. The financial conditions of the public companies in South Africa keep deteriorating. Since 2008, the government has allocated R162 billion (€8,78 billion) to State-owned companies: Eskom has received 82% of these funds (R132,7 billion, equal to €7,2 billion) (National Treasury, 2020a, 2020b).

The **National Planning Commission** (NPC) is a government agency established in 2010, its task is to plan for the sustainable development of the country. The commissioners are appointed by the President based on their specialist skills and expertise. Its priority is to coordinate and monitor the implementation of the National Development Plan (TIPS, 2020a, 2020b), a long-term plan that aims to reduce poverty and inequality as well as to guarantee the sustainable development of the South African economy. According to the commission, the three main challenges faced by the country – poverty, inequality, and unemployment – are coupled with a high vulnerability to climate change (National Planning Commission, 2019). A just transition approach could allow holistically tackling all of these challenges, making the South African economy more resilient and more equal (TIPS, 2020a, 2020b): the NPC has been working for the planning of a just transition in South Africa for the past couple of years, involving energy sector, water management, and land use. In December 2020, following the suggestion of the NPC, the President of South Africa Cyril Ramaphosa appointed members of the inaugural **Presidential Climate Change Coordinating Commission** (P4C) (The Presidency, 2020; TIPS, 2020a). It has indeed been stressed by the NPC the need for an entity dedicated to just transition in South Africa (The Presidency, 2020; TIPS, 2020a).

The **National Economic Development and Labour Council** (NEDLAC) falls under the Department of Employment and Labour. Its purpose is to ensure effective public participation in the labour market and socio-economic policy and legislation, and to facilitate consensus and cooperation between government, labour, business, and the community in dealing with South Africa's socio-economic challenges. NEDLAC's agenda includes the discussion and planning of Just Transition paths. In principle, any law and policy that

[24] In 2019, the former Department of Environmental Affairs (DEA) and Department of Agriculture, Forestry and Fisheries (DAFF) have been merged into the Department of Environment, Forestry and Fisheries (DEFF).

might have an impact on social security should be discussed by NEDLAC members before reaching the Parliament. (NEDLAC, n.d.)

5.2.3.2. *Utility companies*

The electricity sector of South Africa is dominated by one vertical integrated utility company: Eskom Holdings takes care of the electricity generation, transmission, and distribution. It generates 90% of the electricity in South Africa and it is 100% State-owned since 2002: the Government of the Republic of South Africa is its sole shareholder and is represented by the Minister of Public Enterprises (Eskom, 2018). See Appendix 7 for more details.

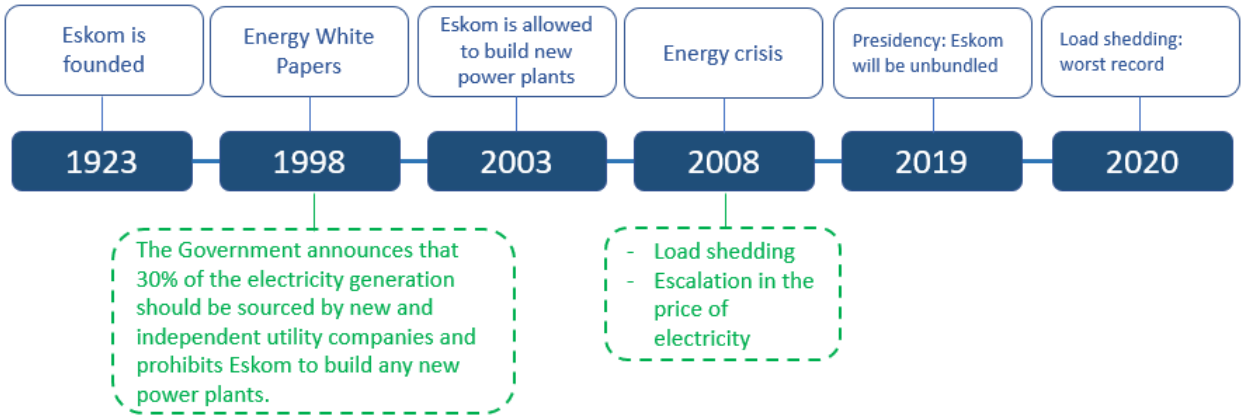

Figure 15 - Eskom's history

The Eskom generating capacity is strongly dominated by coal (Kessides, 2020). Eskom also manages the only South African nuclear power plant, Koeberg, in Cape Town (Kessides, 2020). As of March 2019, the company counted (Eskom, 2019a, 2019b):

Table 17 - Eskom, South Africa (Eskom, 2019a)

Power installed	44,17 GW (Eskom, 2019b)
• *RES installed capacity*	*3,44 GW (7,8%)*
• *Gas installed capacity*	*2,41 GW (5,5%)*
• *Nuclear installed capacity*	*1,86 GW (4,2%)*
• *Coal installed capacity*	*36,48 GW (82,6%)*
Electricity produced	219 TWh (Eskom, 2019b)
• *Electricity produced from RES*	*6 TWh (2,7%)*
• *Electricity produced from gas*	*1,2 TWh (0,6%)*
• *Electricity produced from nuclear*	*11,6 TWh (5,3%)*
• *Electricity produced from coal*	*200,2 TWh (91,4%)*
Electricity distributed in South Africa	209 TWh
Coal extracted	-
Number of customers	6,5 million
Number of employees	46'665

5.2.3.3. *Transmission System Operator & Distribution System Operator*

Eskom owns about 58% of the distribution network, while the remaining 42% is managed by around 87 licensed municipal distributors (Kessides, 2020). These municipal authorities buy the majority of their power in bulk from Eskom, although a few also generate small amounts of electricity in their respective areas of jurisdiction (Kessides, 2020): the municipalities have been authorised to procure their power since last year (DMRE, 2020c; Government Gazette Republic of South Africa, 2020). The electricity transmission is fully managed by Eskom (Kessides, 2020).

5.2.3.4. Coal mining companies

Five firms dominate the coal mining industry in South Africa: Anglo Coal, BHP Billiton/South32/SAEC, Sasol, Exxaro, Xstrata (Makgetla et al., 2019). All of them are multinational companies operating in several continents. The remaining 18% of the coal mining market is controlled by a cluster of much smaller companies (Makgetla et al., 2019).

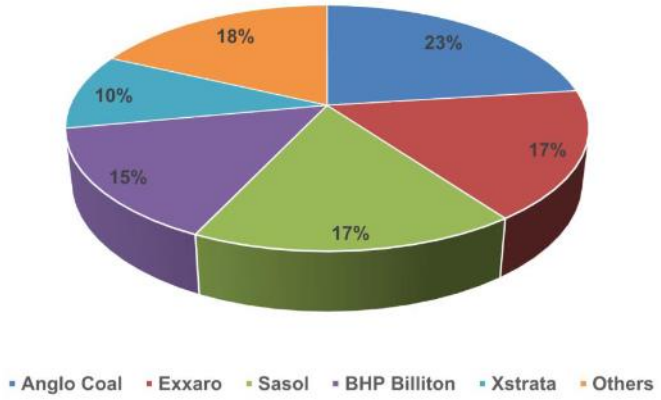

Figure 16 - Coal mining companies, South Africa (Makgetla et al., 2019, p. 12)

The electricity sub-value chain is dominated by Eskom: 70%-80% of Eskom's coal consumption (106 – 120 million tonnes per year) is supplied by Anglo American, Exxaro Resources, Glencore, and South32 (Makgetla et al., 2019). Coal mining and electricity generation are concentrated in Mpumalanga, where 80% of the production of coal occurs (Kessides, 2020). The eMalahleni and Highveld coalfields account for 75% of coal production in South Africa (Makgetla et al., 2019).

Figure 17 - Map of main coal producers, South Africa (Makgetla et al., 2019, p. 6)

5.2.3.5. Trade Unions

Trade Unions have been existing in South Africa since the late 19th century, although for a long time they have only been reserved for white people. Black trade unions have been recognised only since 1979. About 30% of the country's labour force is unionised as of 2013 (Bhorat et al., 2014). They are represented through three main trade union confederations, which account for about 89% of the unionised population (Ludwig, 2008).

Table 18 - Trade unions, South Africa

COSATU (Congress of South African Trade Unions)	Founded in 1985
	Close links with the African National Congress (ANC) and the South African Communist Party (SACP), representing the anti-apartheid movement (Ludwig, 2008)
	57% of all union members (2005) (Ludwig, 2008)
	2011: it adopted a Policy Framework on Climate Change, which prioritises the interests of the working class in the changes necessary to reduce carbon emissions (Barret et al., 2012)
FEDUSA (Federation of Union of South Africa)	Founded in 1997
	17,6% of unionized workers (2005) (Ludwig, 2008)
	FEDUSA is not associated with any political party, but is part of the National Economic Development and Labour Council (NEDLAC)
NACTU (National Council of Trade Unions)	The third-largest trade union in South Africa in terms of membership
	NACTU is not affiliated with any political parties (Ludwig, 2008)
	2011: Together with COSATU, NACTU launched the One Million Climate Jobs (OMCJ) campaign, which aims to pressure the Government to implement just transition strategies and to create new job opportunities in the coming years, while facing the climate emergency (Ashley et al., 2016; Galgòczi, 2018)

5.2.4. Technology & Knowledge

5.2.4.1. Electricity mix

South Africa has a power capacity of 53 GW (U.S. Energy Information Administration, 2017), with 83% covered by coal (Figure 18) (year 2018) (Energy Department – Republic of South Africa, 2019). In 2016, the electricity generated in South Africa was 237 TWh, split by source in Figure 19 (Statistics South Africa, 2016).

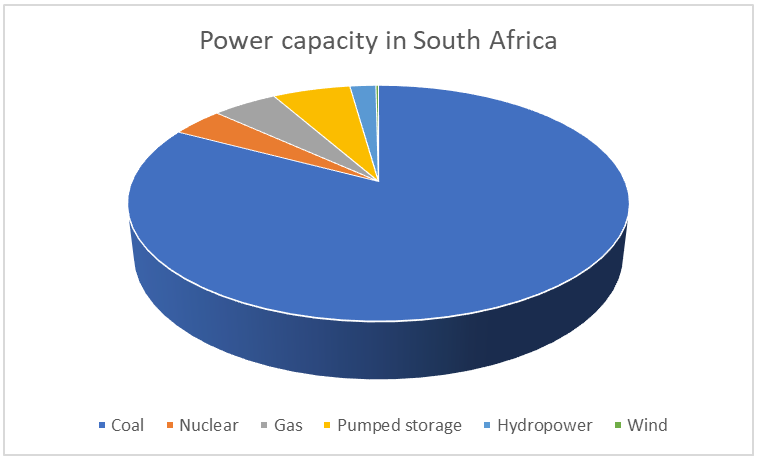

Figure 18 - Power capacity, South Africa, 2018 (DoE, 2019a)

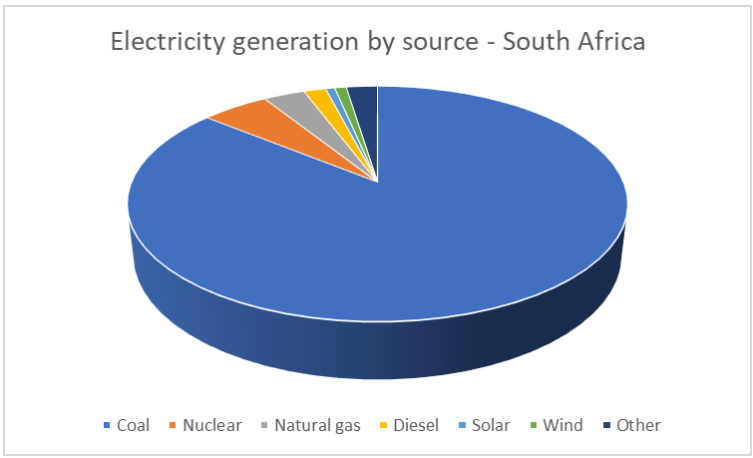

Figure 19 - Electricity generation, South Africa, 2016 (Statistics South Africa, 2018)

a. Coal

The coal mining activities in South Africa started during the 19th century and were managed by European companies (Eberhard, 2011). Coal and coal-fired power stations provided the energy for diamond and gold mining and associated industry and infrastructure, including the railways. Until the first half of the 20th century, nearly all coal mines were owned by gold-mining houses (Eberhard, 2011). From 1950 to 1970, the State imposed strong restrictions on coal exports, which dropped from 15-30% to 2% of the annual production (Eberhard, 2011). The reasons behind this choice were the doubts about the extent of reserves and the growing local demand. During this period, the State also imposed price controls on the domestic market intending to promote industrialisation through cheap energy inputs (Eberhard, 2011). The regulated price was set using a rate-of-return methodology that did not recognise depreciation costs, resulting in amongst the lowest coal prices in the world. The consequences of this pricing policy were low profitability, limited investment, and inefficient mining techniques (Eberhard, 2011). In the 1970s, higher unionisation, higher labour costs, and changes in government policy expanded the investments in the coal industry, promoting mechanisation. The State stopped limiting the coal exports, which raised consistently, and the coal prices were deregulated in 1986 (Eberhard, 2011). One of the reasons for the cheap price of coal in South Africa was the Apartheid regime, which guaranteed cheap black labour (Eberhard, 2011).

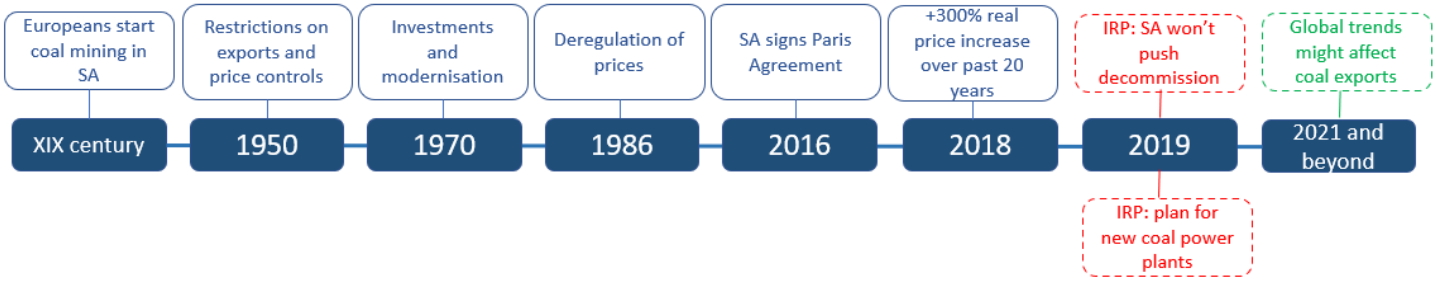

Figure 20 - Coal sector in South Africa: Timeline

Between 70-75% of production is used domestically and around 25–30% is exported (Burton et al., 2018). National consumption is concentrated in the state-owned monopoly power utility, Eskom (65% of local sales in 2014), and the coal-to-liquids energy company, Sasol (22%) (Burton et al., 2018).

In the past 10-15 years, domestic coal prices have risen rapidly due to more difficult geological conditions and Eskom's coal procurement practices (based on open tender processes) (Burton et al., 2018; Kessides, 2020). These practices have become increasingly complex and include poor contract management, poor planning, increased trucking of coal, and corruption (Burton et al., 2018). Mining investment has been constrained due to a variety of factors, primarily political and policy uncertainty: the activity of environmental groups, the decline of electricity consumption (as a result of the increase in electricity prices), Eskom's financial position. Large new investments in Eskom-tied mines have not materialised, and substantial shortfalls in coal supply from key mines supplying large power plants are expected in the coming years (Burton et al., 2018). This failure to invest timeously in new mining areas has resulted in significant quantities of coal having to be trucked into stations by road, adding considerable transport costs to Eskom coal costs (Burton et al., 2018). Eskom's cost of coal has increased from R42,79/ton in 1999 to R393/ton in 2017 (Burton et al., 2018). This translates into a real price increase of around 300% over the past two decades (Burton et al., 2018).

b. Renewable energy sources

South Africa possesses some of the best solar and wind resources of the world, with vast areas of the country suitable for generating electricity at a low cost from renewable energy: these resources have yet to be adequately exploited (Ireland et al., 2017). Taking into account only those zones that have already completed an Environmental Impact Assessment, the South African potential for solar PV already exceeds 220 GW

(Ireland et al., 2017). Furthermore, 72 GW of PV could be installed on rooftops. About 60% of South Africa's land area has technically recoverable wind capacity over 35% load factor (totalling 3500-4500 GW) (Ireland et al., 2017). Besides presenting an opportunity to diversify the electricity mix, renewable technologies show potential for the creation of new industries, job creation, and localisation across the value chain (DoE, 2019b).

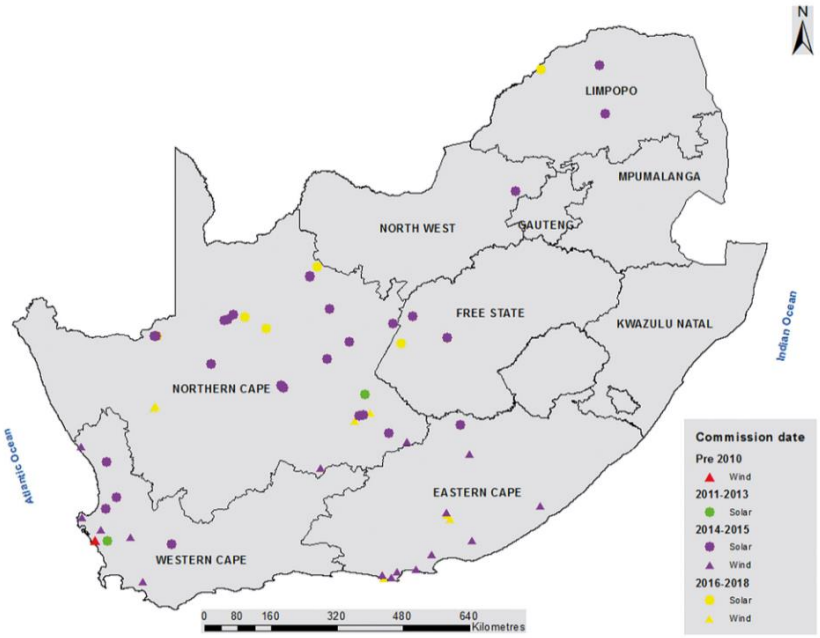

Figure 21 - Location of renewable energy projects in South Africa according to commissioning dates (Lombard & Ferreira, 2015, p. 76)

Most of the existing or planned renewable power plants are located in the southern part of the country, with the majority in the Northern Cape, Western Cape, and Eastern Cape (Lombard & Ferreira, 2015; Mokveld & von Eije, 2018). Thus, most of the new job opportunities in the RES industry are geographically distant from the region of Mpumalanga, where most of the coal industry activities are located (Figure 21). However, recent investigations suggest that Mpumalanga might have sufficient wind resources to justify the construction of wind farms in the region: RES technologies are constantly evolving, and higher turbine hub heights could compensate for lower wind speeds (Creamer, 2020c; ESI Africa, 2019; Govender, 2020). Furthermore, it's worth pointing out that although the solar radiance in Mpumalanga is lower than in other regions of South Africa, the potential is still significantly higher compared to many other areas in the world (Figure 22).

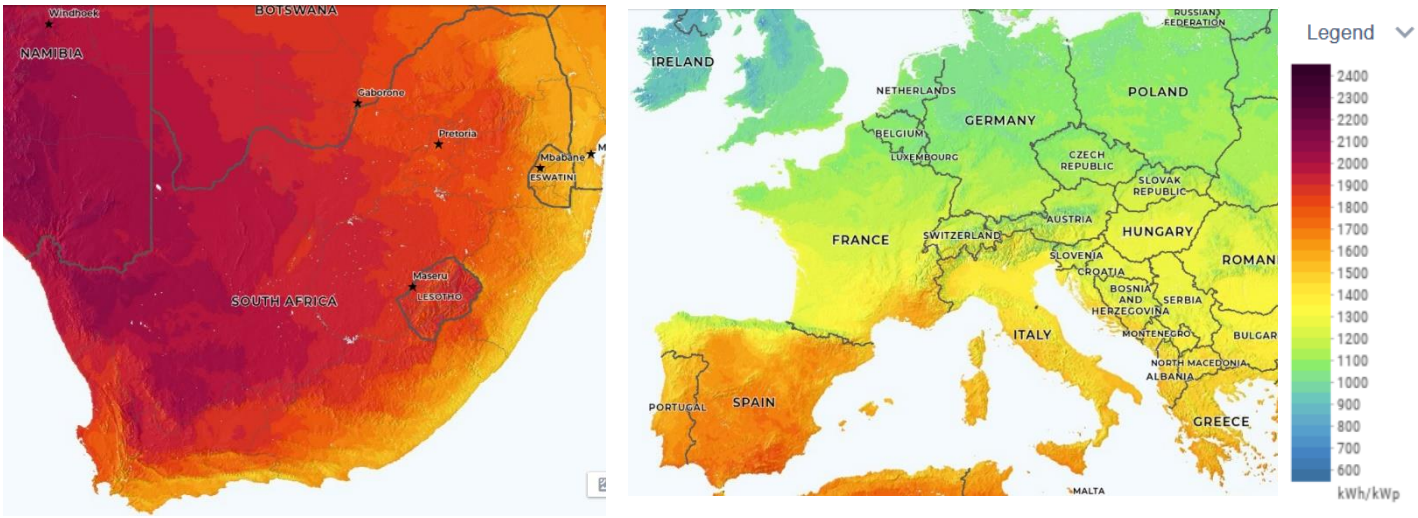

Figure 22 - Solar radiation [kWh/kWp] in South Africa and in Europe (Solargis s.r.o., n.d.)

c. Natural gas

Gas to power technologies in the form of CCGT, CCGE, or ICE[25] provides the flexibility required to complement renewable energy. To date, South Africa has not found significant gas resources and imports natural gas from neighbouring countries, such as Mozambique and Namibia. The gas infrastructures are still low-scale developed: South Africa imports around 240 million GJ/year from Mozambique, half of which are consumed by the chemical plants of Sasol (DoE, 2019a). Exploration to assess the magnitude of local recoverable shale and coastal gas is being pursued. A Gas Utilisation Master Plan is being finalised: it is a roadmap for the development of a gas economy, to identify the short- and long-term infrastructure requirements to enable the uptake of a natural gas market (DMRE, 2020b; DoE, 2019b).

The gas industry is expected to grow and gas-to-power technologies might significantly contribute to the Risk Mitigation IPP Procurement Programme (RMIPPPP) launched by the Government in 2020 (SRK Consulting, 2020): the Minister of Mineral Resources and Energy and the National Energy Regulator of South Africa have determined that 2000 MW of new generation capacity should quickly be procured to face the electricity supply gap. The RMIPPPP is meant to support near-ready projects, which can become operative before June 2022 (DMRE, 2020b). The new supply capacity can be procured by a range of different technologies, it is not required to be a renewable energy source (DMRE, 2020b).

d. Nuclear

South Africa owns one nuclear power plant, Koeberg Power Station (1860 MW), which will reach the end of design life in 2024 (DoE, 2019b). To avoid the demise of nuclear power in the energy mix, South Africa has decided on its design life extension and the expansion of the nuclear power programme into the future (DoE, 2019b). The Government would like to invest in small nuclear units since it would be a much more manageable investment when compared to a fleet approach (DoE, 2019b). The Department of Mineral Resources and Energy foresees to implement small modular reactors (SMRs) and pressurized water reactors (PWRs) technologies up to 2500 MW, at a pace and scale that the country can afford (DMRE, 2020a).

South Africa started researching on nuclear power in the 1950s (Masiza, 1993; Stumpf, 1995). During the international anti-Apartheid boycott, South Africa secretly developed six nuclear weapons, which were later destroyed, as publicly declared at the end of the regime (Masiza, 1993; Stumpf, 1995). The country possesses sizeable uranium reserves, up to 5% of the global reserves (Deaprtment of Energy, n.d.; OECD NEA & IAEA, 2020).

5.2.4.2. Research & Development

R&D investments in South Africa were affected by the 2008 crisis (Chisoro & Inglesi-Lotz, 2015). They started growing again in 2011 and peaked in 2014 (CeSTII, 2021). In 2017/2018, the R&D expenditure was about 0,83% of GDP (Department of Science and Technology, 2019), but it decreased to 0,75% in 2018/2019 (CeSTII, 2021). Energy R&D is about 3% of the total R&D expenditure in South Africa (OECD, 2019; Inglesi-Lotz, 2018).

Concerning sources of funding for R&D, the government is the largest source of funding (46,7%), the business sector is in second place (41,5%), while foreign sources provided 10,2% of the expenditure (Department of Science and Technology, 2019). Compared to the other BRICS countries, South African investments in innovation are lower: there are some exceptions though, for instance, the mining and fuels sectors, which have R&D expenditure comparable to more developed countries such as the USA, Canada, Australia (Steenkamp et al., 2018).

[25] CCGT: Closed Cycle Gat Turbine; CCGE: Closed Cycle Gas Engine; ICE: Internal Combustion Engine (DoE, 2019b)

5.2.4.3. Workforce

The unemployment rate in South Africa stands at 32,5% (Stats SA, 2021) and has been increasing since 2008. The coal industry employs between 90 and 100 thousands people – 19% of total employment in the mining sector, which employs 2,7% of the 16,3 million employed people in South Africa (Development Policy Research Unit, 2019; Minerals Council South Africa, n.d.). The coal industry alone thus employs about 0,5% of the total South African workforce (Development Policy Research Unit, 2019; Minerals Council South Africa, n.d.). More than 80% of coal mining by volume takes place in Mpumalanga, where mining is the largest contributor to gross domestic product[26], although mining accounts for only 6,7% of Mpumalanga's employment[27] (Burton et al., 2018). The region performs poorly on several economic indicators when compared to the rest of the country, reporting higher household poverty levels and a lower human development index than the national average. This is consistent with other coal-mining regions globally, highlighting that economic diversification for regions with intensive coal dependency is important for socio-economic development (Burton et al., 2018).

The sector has experienced an increase in the share of high-skilled workers. Today, unskilled workers in the coal industry are 56% (compared to 70% in 1995), mid-level workers make up 35% of the workforce, while high-skilled workers are about 10% (Hallowes & Munnik, 2019). There is limited data on median wages for coal mining, however, the median monthly wages in the whole mining sector in 2015 were 7'500 R (413 €), which is quite high compared to the median monthly wages in the economy of 3'100 R (170 €) (Hallowes & Munnik, 2019). Different sources report different median wages (respectively, 10'000 R and 5'000 R), but still confirm that miners' earnings are above the national average (Makgetla et al., 2019). As for 2017, about 35% were over 45 years of age and only 1,7% were 65 years old: over the next 20 years, 35% of workers will retire (Hallowes & Munnik, 2019). Compared to other economic sectors, mining is much more unionised, with over 70% of the employees being union members against a whole economy average of 35% (Makgetla et al., 2019). The Electricity, Gas & Water industry employs only 0,9% of the working population but showed a significant increase in employment in 2017 (+31%). Among the industries, the most labour-intensive is the manufacturing one (11,2%), while over 70% of the workers are employed in the tertiary sector (Development Policy Research Unit, 2019).

5.2.5. Infrastructures

5.2.5.1. Power plants

It has already been mentioned in the text that South Africa is facing several issues in its power infrastructures. Starting from 2008, the energy sector has been experiencing a crisis and the electricity demand has often been unattended due to insufficient capacity (see *Agents* and Appendix 7). During the last decade, the Government has been launching several programmes to support the implementation of new power capacity, such as the Renewable Energy Independent Power Producer Procurement Programme (REI4P) in 2011 and the more recent Risk Mitigation IPP Procurement Programme (RMI4P) in 2020 (see the *Electricity mix: Gas* chapter). The need for implementing new electricity capacity is also stressed by the fact that many coal power plants are about to reach their designed end of life: about 5400 MW of power plants will be decommissioned by 2022, increasing to 10 500 MW by 2030 and 35 000 MW by 2050 (DoE, 2019b). Overall, more than 40'000 MW should be built by 2030 (National Planning Commission, 2018).

5.2.5.2. Transmission lines

Eskom manages the electricity transmission lines and a large part of the distribution lines in South Africa. All overhead lines are vulnerable to natural phenomena such as lightning, flooding, strong winds, not to mention

[26] Mining equals 22% of the real-economy sector of Mpumalanga (TIPS, 2016). The real economy (including mining, agriculture, manufacturing and construction) makes up to 40% of Mpumalanga's output (TIPS, 2016). Thus, mining constitutes almost 9% of the provincial GDP.

[27] Mpumalanga records the highest unemployment rate in the country (Stats SA, 2019).

man-made disturbances such as cable theft (Eskom, n.d.-b). All of these cause technical problems that must be fixed so that power can be restored (Eskom, n.d.-b). After the beginning of the electricity crisis, relatively high transmission losses were recorded (around 8,9% between 2010 and 2014), due to lack of maintenance, however, the losses have been reduced in the last years (Ireland et al., 2017). The electricity grid is accessible to only 85% of the population (Carbon Trust, 2017), although it is planned to raise this percentage to at least 90% by 2030 (National Planning Commission, 2018). About 5% of the population still has access to electricity through off-grid solutions, while the remaining 10% don't have access to electricity at all (The World Bank, 2019a).

5.2.6. Institutions

In the SSI framework, "Institutions" include laws, policies, investment mechanisms, as well as informal norms and established practices (Malerba, 2002, 2005).

5.2.6.1. Energy Policy

This section presents the latest key policies affecting the power sector of South Africa, also reported in a timeline (Figure 23).

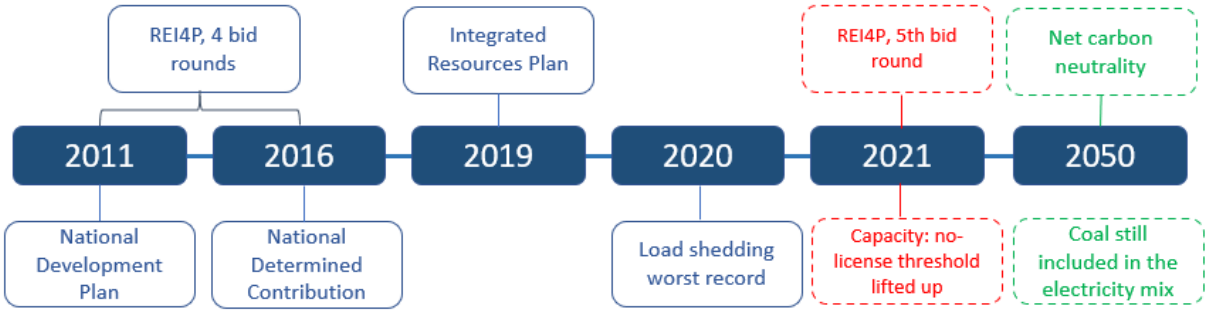

Figure 23 - Energy policies in South Africa: Timeline

a. National Determined Contribution

After signing the Paris Agreement, in 2016, South Africa has submitted the National Determined Contribution (NDC), outlining its commitment to implement climate change mitigation and adaptation measures. As a developing country, the NDC recognises that South Africa must consider climate change commitments within the context of acute challenges such as poverty, unemployment, and food and energy insecurity (ILO, 2018; South African Government, 2016). In this document, South Africa recognises the urgent need of reducing GHG emissions through a heavy transformation of the energy sector (ILO, 2018; South African Government, 2016). However, the country did not finalise a date for achieving carbon-neutrality: the requirement is to reach the emissions pick by 2025-2030 and start the emissions' decline right after (Climate Action Tracker, 2020; Essop et al., 2016; Kuramochi et al., 2019).

The document estimates the investments that will be needed for adapting the current economy into a more sustainable one: for instance, US$3bn per year for 10 years were allocated for the extension of the REI4P programme (ILO, 2018). For mitigating GHG emissions, in the NDC the Government announces that new policies will be introduced in the 2016-2020 time frame (ILO, 2018): in 2019, a Carbon Tax has been introduced (Carbon Tax Act 15 of 2019, 2019). While this is a step forward in the path towards carbon neutrality, the measure has been criticised for being too mild: stricter regulations are demanded for the coming years (Mammat & van der Watt, 2021). The NDC is part of the series of policies and plans included in the Low-Emission Development Strategy (LEDS) and submitted to the UNFCCC in 2020. The LEDS is a dynamic and flexible document that includes sectorial and holistic strategies developed before and after the Paris Agreement. In this document, South Africa reaffirms its commitment to net carbon neutrality (South African Government, 2020).

b. Renewable Energy Independent Power Producer Procurement Programme

The REI4P is a competitive bidding programme created to secure grid-connected electrical energy from the private sector. Independent power producers (IPPs) have been invited to submit bids for onshore wind, solar photovoltaic (PV), concentrated solar power (CSP), small hydro, biomass, biogas, or landfill gas projects (Eberhard & Naude, 2017). Submitted bids first had to qualify for evaluation by meeting minimum compliance requirements, after which they have been evaluated based on price (bid tariff) and economic development criteria (Eberhard & Naude, 2017). To date, there have been four bid windows, between 2011 and 2016, for a total of around R 200 billion of investment (25% of this being foreign investments) (GreenCape, n.d.; Overy, 2018) and 6'327 MW of contracted capacity against the 3600 MW forecasted (Overy, 2018; van der Merwe, 2017) from 102 renewable energy projects (ILO, 2018). A striking outcome of the REI4P has been the decline in average energy prices over time for all technologies except small hydro (Eberhard & Naude, 2017; Filipova et al., 2019; Scholtz et al., 2017). This has resulted in a declining weighted average energy tariff and is an important step for renewable energy IPPs in achieving grid parity, whereby the prices of new renewable energy sources are now cheaper than energy from conventional fuel sources (Eberhard & Naude, 2017; Filipova et al., 2019). Between bid windows 1 and 4, the average price for wind projects declined by 50%, from 1,75 R/kWh to 0,88 R/kWh, while the average price for solar PV projects declined by 75%, from 4,22 R/kWh to 1,06 R/kWh (in 2019 prices) (Filipova et al., 2019).

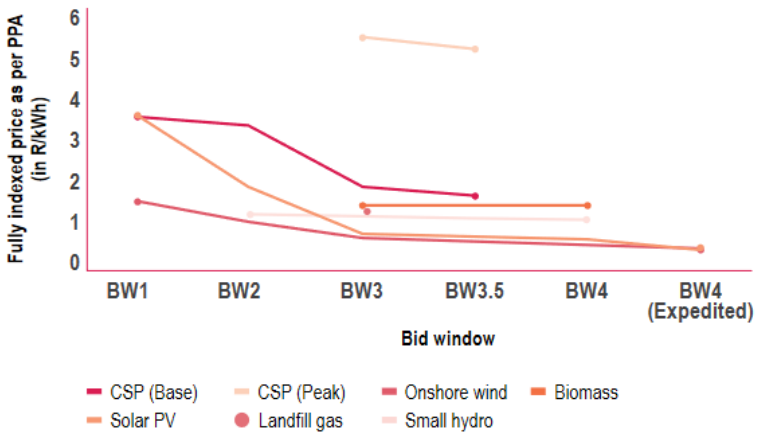

Figure 24 - Movement of prices per technology for the REI4P [R/ kWh] (Scholtz et al., 2017, p. 29)

The forecasted job creation was an important factor to compare different bidders. At the end of the 4 bid rounds, it is projected that 109,444 jobs will be created for local citizens, where a ''job'' is defined as a job-year (Eberhard & Naude, 2017; Filipova et al., 2019). Of this, a substantial 84,564 job years will be awarded to black citizens and 57,690 job years to people from the local communities (Eberhard & Naude, 2017; Filipova et al., 2019). The majority of employment opportunities will be attributable to onshore wind and solar PV projects, given that they represent 79 of the 92 large renewable energy awarded projects to date (Eberhard & Naude, 2017). REI4P has created jobs and has the potential to continue to do so and to provide green skills development opportunities. In 2015 the South African Renewable Energy Technology Centre (SARETEC) was launched, with the main purpose of harnessing job creation opportunities and developing the necessary local green skills in response to the demand created by REI4P (ILO, 2018).

Despite its success, the programme has long been hindered by Eskom dominance and South Africa's complicated bureaucratic landscape. Unfortunately, REI4P's progress has severely been endangered by Eskom's stalling in signing IPP contracts and came to a standstill (Filipova et al., 2019; ILO, 2018). The future of this programme depends entirely on the government creating a stable environment for its development

(Filipova et al., 2019; ILO, 2018). In February 2021, a fifth bid round has been launched (closing date: April 2021) to commit 2,6 GW of solar and/or wind power. A new bid window is expected for August 2021 (GCIS, 2021; South African Presidency, 2021).

c. Electricity Regulation Act

The currently adopted Electricity Regulation Act (ERA) intends to establish a national regulatory framework for the electricity supply industry; to make the National Energy Regulator (NERSA) the custodian and enforcer of this regulatory framework; to provide for licences and registration as how generation, transmission, distribution, trading and the import and export of electricity are regulated (NERSA, 2008). To date, the ERA states that the grid-connected installed capacity of no more than 1 MW does not require a license from NERSA (NERSA, 2008). Any installed capacity exceeding this cap must instead gain a license from NERSA before becoming operative. Stakeholders like Business Unit South Africa (BUSA) argue that this cap is too narrow and deters the investment: the licencing procedures are onerous and lengthy (Kingston, n.d.; Steyn & Renaud, 2020). BUSA would like the cap to be shifted to 50 MW, and Eskom's experts confirmed the technical feasibility of this choice (Kingston, n.d.; Steyn & Renaud, 2020). In February 2021, South African President Cyril Ramaphosa announced the intention to lift the threshold, although he did not commit to a specific capacity cap yet (GCIS, 2021)[28].

d. National Energy Efficiency Strategy

In 2016, the National Energy Efficiency Strategy published in 2005 has been updated (DoE, 2016). The paper claims that the first strategy of South Africa to face the growing energy demand should be improving the energy efficiency in the main sectors: industry, residential, commercial & public sector, transport, and power sector (DoE, 2016). Overall, the policy is expected to reduce the final energy consumption in the South African economy by 29% in 2030 (IEA, 2019). More precisely, a 16% reduction in energy consumption is aimed from 2015 to 2030 in the industry and mining sector, as well as a cumulative total annual energy saving of 40 PJ (DoE, 2016). For what concerns electricity, the NEES aims to reduce the distribution losses below 8% and the non-technical losses below 0,5% by 2030 (DoE, 2016). Cogeneration will support the enhancement of energy efficiency in South Africa: 10 PJ of grid-connected cogeneration plants are expected by 2030 (DoE, 2016).

e. National Development Plan

The National Development Plan (NDP) is a long-term plan developed by the National Planning Commission in 2011. It aims to improve South African living conditions, reducing poverty and inequality, and it claims that this goal should be reached by shifting towards a greener economy and increasing the country's resilience towards climate change (National Planning Commission, 2018). The plan envisages that by 2030 the energy sector will promote economic growth through adequate investments in infrastructure, social equity through expanded access to energy, environmental sustainability. Cleaner coal technology is mentioned as a key driver; the substitution of gas for coal is suggested as another future strategy for cutting South Africa's carbon intensity and reducing greenhouse gas emissions. The NDP also mentions some specific initiatives that will drive the green economy forward, including carbon-pricing mechanisms, consumer awareness initiatives, better infrastructure for recycling to make South Africa a zero-waste society, and the development of green products and services. The NDP identifies renewable energy technologies as being a key area for job creation and skills development (ILO, 2018; National Planning Commission, 2018).

The need for sustainable development, for a greener economy, and the creation of new job places and skills has been repeatedly expressed in many policies and plans during the past years, such as the National Strategy for Sustainable Development and Action Plan (2011) (Department of Environmental Affairs, 2011), the

[28] On June the 10th the President announced that the cap will be shifted to 100 MW within the next two months (The Presidency, 2021).

Medium Term Strategic Framework (2014) (Presidency, 2014), the Industrial Policy Action Plan (2016) (Department of Trade and Industry, 2016). In 2011, trade unions, business organizations, government ministers, and several civil societies have signed the New Growth Path and Green Economy Accord (Department of Economic Development, 2011).

f. Integrated Resources Plan

The Integrated Resources Plan is an electricity infrastructure development plan based on the least-cost electricity supply and demand balance, taking into account the security of supply and the environment (minimize negative emissions and water usage). The plan has been prepared taking into account the direction pointed by the National Development Plan and by the Paris Agreement. The last updated version has been published in 2019, predicting the energy trends in South Africa until 2030. The IRP depicts expected energy demand, investment trends, research, etc. in the electricity supply sector of South Africa: some aspects have already been mentioned earlier in the text (see: *South Africa: Technology & Knowledge*). (DoE, 2019b)

Coal is expected to continue playing an important role in the electricity mix, although many power plants are about to be decommissioned: 5400 MW by year 2022, 10500 MW by 2030, and 35000 MW by 2050 (DoE, 2019b). To mitigate the adverse impacts of the plant retirement programme, South Africa will refer to the just transition guidelines published by the International Labour Organization (ILO, 2015). About 1500 MW of renewables have already been committed for the coming years. The Government aims to achieve 8288 MW of PV, 17'742 MW of wind, 600 MW of CSP, and 4600 MW of hydropower by 2030 (DoE, 2019b). New investments will need to be made also in more efficient coal technologies to comply with climate and environmental requirements: given the significant investments required for CCS[29] and CCUS[30] technologies, South Africa could benefit from establishing strategic partnerships with international organisations and countries that have made advancements in the development of CCS, CCUS and other HELE[31] technologies (DoE, 2019b). The Government is planning to invest in nuclear power as well, in particular in small nuclear units (DoE, 2019b).

5.2.6.2. Public perception of the power sector

People in South Africa are increasingly aware of the threats posed by climate change. According to a worldwide survey conducted in 2017, 59% of South Africans consider climate change the first international threat to national security (Barber & Israel, 2017): like many other developing countries, South Africa is particularly vulnerable to the impacts of climate change on food and water security (Department of Environmental Affairs, 2017). NGOs, NPOs, and civil society actively ask the decision-makers for a shift towards a more sustainable economy (Averchenkova et al., 2019).

On the other hand, though, the country has a high unemployment rate and one of the most unequal societies (Gini coefficient of 0,63 in 2015 (The World Bank, 2020a)). Energy security and energy affordability are main issues in the country: 10% of the population still does not have access to electricity (The World Bank, 2019a); the electricity prices have been steadily increasing in the past decade (Eskom, 2020b, 2020a), and they are expected to keep rising (Kessides, 2020). For these reasons, the public opinion towards the topic of the energy transition is not unanimous.

People living in Mpumalanga, the most coal-dependent region, tend to favour the coal-based system over the spread of renewables, mainly because they fear for their job security (see *Chapter 6*). Furthermore, they appear to be less aware of the causes and the impacts of climate change (Oduniyi, 2013): while climate

[29] CCS: carbon capture and storage
[30] CCUS: carbon capture, utilisation and storage
[31] HELE: high-efficiency low-emission

change might be a concern for the middle and the upper classes, the lower-income population has different priorities, many interviewees reported.

For what concerns nuclear power, while some experts promote it as a practical way to reduce emissions in the country, many NGOs and civil society's exponents express against it (Ferrial et al., 2011). Besides being worried about the environmental issues (Ferrial et al., 2011; Nkosi & Dikgang, 2018), part of the public argues that increasing the nuclear power capacity would result in a further increase of the electricity price (Nkosi & Dikgang, 2018), which would badly affect energy affordability.

5.2.7. Evolutionary and dynamic aspects

The electricity sector in South Africa has long been under a near-monopolistic regime, dominated by the vertically integrated[32] utility company Eskom, which is State-owned since the early 2000s. However, the power sector is undergoing major changes in its structure, due to the pressure by national and international stakeholders.

Eskom has not been able to provide a secure electricity supply in the past decade. The company has cumulated a huge debt (R441 billion or €24,6 billion as of March 2019) (Department of Public Enterprises, 2019) and is currently sustained by the State subsidies. It has been announced that Eskom will be unbundled into three separate subsidiaries, covering generation, distribution, and transmission, each with its management team, and with a holding company (i.e. System Operator) to oversee everything (Department of Public Enterprises, 2019; Kessides, 2020; Power Futures South Africa, 2019). This restructuring proposal has been a long time debated – it was already included in the 1998 Energy Policy White Paper (Department of Public Enterprises, 2019; Power Futures South Africa, 2019).

To date, Eskom's business model is characterised by a lack of transparency, lack of agility, lack of operational excellence, and widespread inefficiencies due to lack of accountability and consequence management (Department of Public Enterprises, 2019). Restructuring or "unbundling" into separate subsidiaries under Eskom Holdings might allow management focus, improve efficiency, create greater transparency around performance, provide greater protection against corruption and rent-seeking, and will give capital providers more visibility of the parts of the sector, resulting in more investment comfort (Department of Public Enterprises, 2019). The reason for unbundling Eskom is also to enhance the competitiveness, and therefore the efficiency of the electricity sector itself.

Figure 25 shows how the reformed electricity supply industry is expected to look like (Department of Public Enterprises, 2019; Geddes et al., 2020; Power Futures South Africa, 2019): besides splitting the utility company into three units, there is no yet concrete plan to privatise them (Department of Public Enterprises, 2019; Geddes et al., 2020; Kessides, 2020; Leprich, 2019).

[32] The business model includes electricity generation, transmission, and distribution, but does not include coal mining (Kessides, 2020).

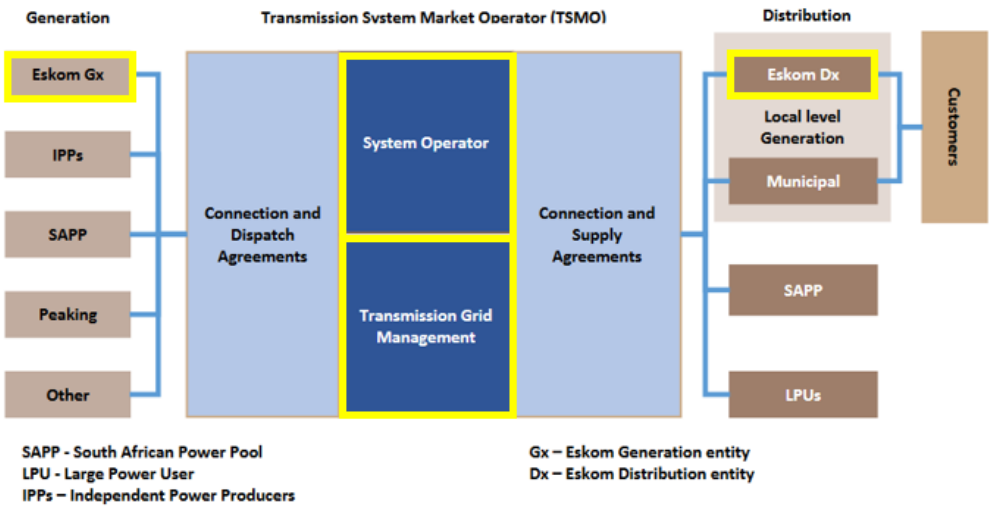

Figure 25 - Reformed electricity supply industry, South Africa (Department of Public Enterprises, 2019, p. 17)

The Government aims to enhance the competition mainly in the electricity generation industry, as it is proven by the numerous initiatives to support new power producers, such as REIPPPP and RMIPPPP. Since 2020, the Municipalities are not obliged to purchase electricity from Eskom, but can generate their own power (DMRE, 2020c; Government Gazette Republic of South Africa, 2020). The transmission grid will likely be still 100% managed by Eskom Holdings: even worldwide, transmission tends to be a natural monopoly, and it is less likely that several transmission entities will be created to compete in South Africa (Geddes et al., 2020). The structure of the new distribution sector will require further consideration: to date, Eskom owns about half of the South African distribution networks. The remaining part is owned by the municipalities, and many municipalities depend on the revenues coming from the electricity tariffs for their budgets (Department of Public Enterprises, 2019). Furthermore, this is a rapidly evolving area and roof-top solar panels or similar local embedded generation solutions keep spreading (Department of Public Enterprises, 2019). Eskom is still defining a precise unbundling plan (Department of Public Enterprises, 2019), and it is not decided yet by when the restructuration should be completed: while the Presidency initially suggested by 2021 or 2022 at the latest (Ndenze, 2020), the Eskom CEO André de Ruyter believes it won't be possible before 2023 (Creamer, 2020a).

There is raising awareness with regards to the concept of just transition: national institutions, trade unions, research centres, and Eskom itself have been mentioning it in their most recent papers and roadmaps. The stakeholders agree that the imminent energy transition should be planned to be sustainable for workers, local communities, businesses, as well as for the environment. It is now time for developing and implementing more concrete projects to ensure the achievement of a more equal economy in South Africa (National Planning Commission, 2019).

To summarise, there are several forces – either internal or external to the sector itself – pushing for a more economically, technically and environmentally sustainable energy sector.

6. System Dynamics Models

The System Dynamic Models for Poland and South Africa have been designed in Vensim PLE following the procedure described in *Chapter Methodology* and can be seen in Appendix 5, while the list of variables is reported in Appendix 6. The present chapter describes the dynamics of both power sectors. Every subchapter analyses one or a few loops, reporting on the commonalities between the respondents. An overview of all loops identified is found in Table 19 and each one was given a unique alphanumerical code, where "R" stands for "Reinforcing" and "B" stands for "Balancing", according to the loop's behaviour (see *System Dynamic Modelling*).

Table 19 - List of Reinforcing and Balancing Loops

Poland	South Africa
Dependence on coal (R1, B1)	Human resources in the power sector (R4)
Cost of Carbon (B2)	Performance of Eskom: impacts on the national economy and the financial situation of the utility company (R13)
Energy affordability (R2)	Access to affordable electricity (R2)
A just transition for coal workers (R3)	NERSA and the electricity price (R3)
A just transition for coal workers - Resistance to change (R4)	Unbundling Eskom (B3)
Nuclear power (R5)	Eskom's debts (R5)
The influence of trade unions (R6)	New job opportunities (B5, B6, B7)
Planning a just transition (R7)	Job opportunities in the coal industry (R6)
	Public opinion on nuclear power (R7)
	Nuclear lobby & political interferences (R9)
	Social acceptance of IPPs (B8)
	Social acceptance of RES (R8)
	Obstructing regulation (R12)
	Long-term politics (R10)
	Taking action (R11)

For some topics, a literature review was conducted to validate the data, to complete or test claims, and to shed further light on the most controversial topics. The text separates the information from the interviews from what comes from literature. The loops identify barriers, carbon lock-in factors, and motivators affecting the just energy transition paths in the two power sectors, where:

- A carbon lock-in factor is a path-dependent processes whereby initial conditions, increasing economic retours to scale and social and individual dynamics act to inhibit innovation and competitiveness of low-carbon alternatives (Unruh, 2000, 2002).
- A barrier is also an obstacle to the clean energy transition, but does not have a self-reinforcing character (Unruh, 2000, 2002).
- A motivator is an agent or a factor that initiates, facilitates, and supports the execution of steps undertaken throughout the transition process (Unruh, 2000).

6.1. Poland

6.1.1. Reinforcing 1, Balancing 1: Dependence on coal and Balancing 2: Cost of Carbon

When asked to describe the power sector of Poland, every interviewee started by saying it is "old and coal dominated". Poland started to exploit coal due to the abundance of this resource in the country: thanks to coal, Poland had cheap electricity for a long time, but this has been changing in the last few years. First, the accessible coal reserves have been exhausted, thus coal mining is becoming increasingly expensive and every year more coal is imported from foreign countries. Second, the EU regulation (e.g. the Emission Trading System) makes the electricity from fossil fuels, especially carbon-intensive coal, less and less economically attractive (Figure 26).

The market trends decreased the profitability of the coal sector in Poland, however, the interviews respondent did not agree on the future of fossil fuels in the country. Three interviewees believe that Poland will phase out coal by 2050, or even before due to economic reasons (two interviewees). Interviewee 1-PL stated that the economy of the country is strictly linked to coal and lignite: "When you say <<Poland should quit coal>>, it's like if you say <<Italy should not eat pizza>> or <<Germans should not be that attached to cars and automotive industry>>. I exaggerate this, but to me, the comparison explains how much coal is linked to the economy, even if people think they are not attached to coal." Although s/he does not believe that Poland will manage to phase out coal, s/he thinks some regions could – the wealthiest ones. The transition might take place at different paces in coal regions and lignite regions: phasing out lignite (s/he

claims) might be easier from a technical point of view. However, the lignite sector is more profitable than the coal one, thus these companies are not used to seek for external support: these dynamics are changing since the carbon price is highly impacting the lignite-based activities too. Interviewee 4-PL commented that the coal phase-out is not a demand-driven issue, but a supply-driven one: ”We have like 50 or 60 million tons of coal each year and we need to do something with that.”

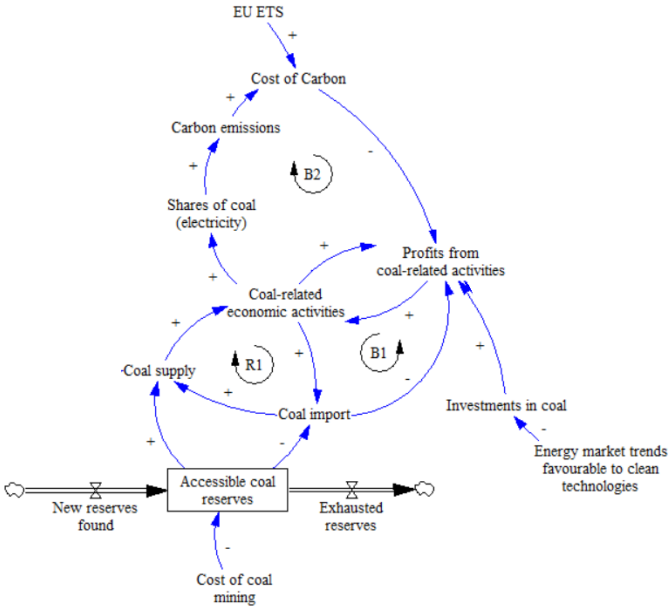

Figure 26 - Feedback loops R1, B1, B2 - Poland

While the market trends suggest that the energy transition in Poland is unavoidable (as expressively stated by 6 interviewees), the economy of the country is still locked into coal exploitation for many reasons that will be explored in the next chapters.

6.1.2. Reinforcing 2: Energy affordability

1. Description

The coal and the power sectors are strictly linked, and the decline of the former one might affect the energy security in the country. At least three interviewees are worried that Poland might face energy security issues since the coal fleet is old and inefficient, the sector is unprofitable, and the State won’t be allowed to subsidise it anymore due to the EU regulation. Poland is embedded in the European electricity market: Poland can buy electricity from other countries and prevent a supply gap (Figure 27). However, as stated by interviewee 7-PL, this can’t be a solution in the long term, since every State should be independent and should not rely on cross-border capacity as its first source of electricity.

The price of electricity has been rising in the past few years due to the cost of coal mining and carbon prices. Three interviewees mentioned that 10% of the households in Poland are energy poor and could not bear a steep price increase, which (they stated) will certainly take place if the power sector stays the same. In 2025 the capacity market will be removed: this will impact the survival of some utility companies, the electricity price, and the security of the electricity supply (4-PL, 7-PL). The respondents do not all agree on the effect that higher shares of renewables would have on the electricity price: two of them believe the price will decrease, while one of them affirmed that the electricity will become more expensive since there will be a need for a “double capacity” – the RES-based power sector as well as the traditional one to guarantee a baseload.

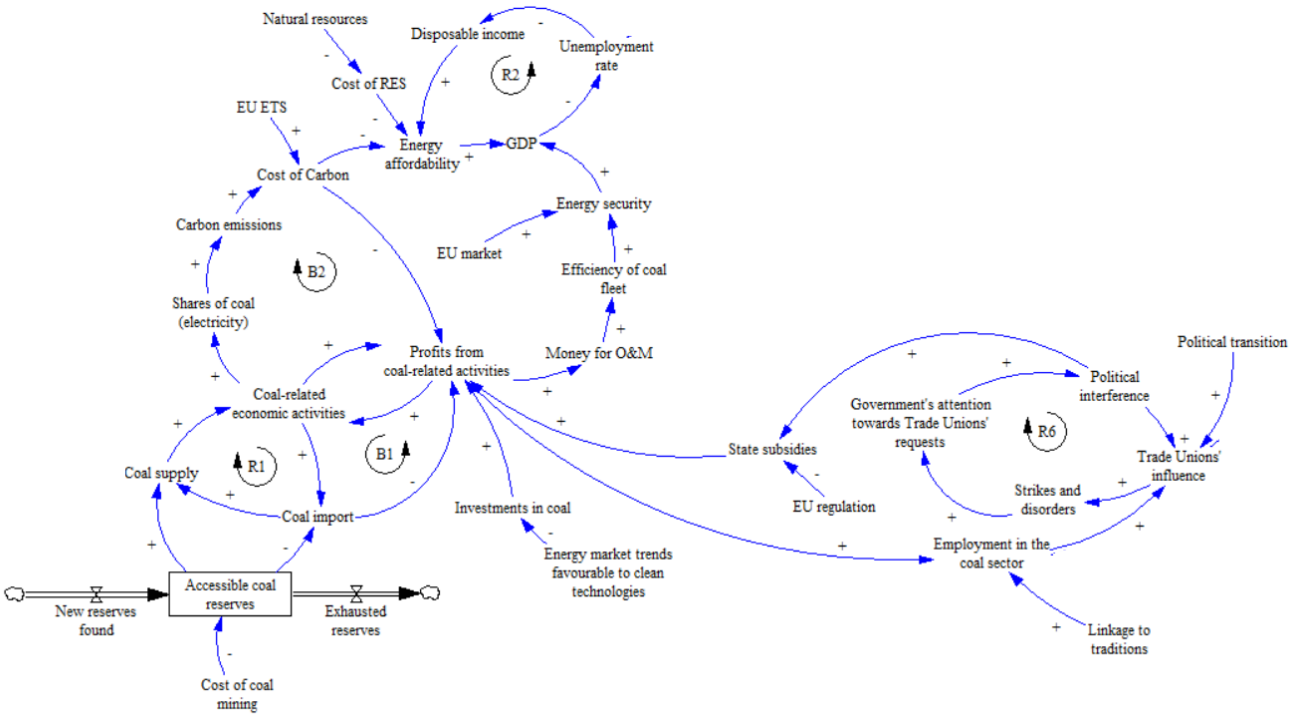

Figure 27 - Feedback loops R2, R6 - Poland

The Polish Government has recently proposed a restructuration plan that foresees a much higher involvement of the State in the coal and the power sectors: the old and inefficient coal power plants will be bought from the private sector by a State-owned agency, and this should help the utility companies to invest in new energy sources. The interviewees were asked to comment on this plan: not all of them were familiar with it – since it is still quite new – and those who were expressed several concerns. First, the presence of a huge State-owned actor in the power sector might affect the dynamics of the market. Second, the European Commission won't allow Poland to keep subsidising the coal sector, thus the respondents believe that this restructuring plan will be rejected.

The R2 feedback loop provides further reasons to plan the transition and shows the potential risks of failing to do so.

2. Literature review

The Capacity Market Act entered into force in 2018. Three auctions have been launched so far and the winners have been entitled to a fixed payment for 1, 5, or 15 years according to the nature of the capacity supplier and whether or not it is sustaining any capital expenses at the moment of the auction (Gawlikowska-Fyk et al., 2019). The payments come from a capacity fee which is paid by the electricity buyers in addition to the cost of the electricity consumed – it has been added to the electricity bills for the first time in 2021 (Gawlikowska-Fyk et al., 2019). The energy market has become a dual-product market, where, apart from the purchase and sale of physically consumed electricity, the readiness to supply is also purchased (Tucki et al., 2019). The Capacity Market Act has been implemented to prevent energy security issues in Poland: a good share of the coal power fleet is unable to self-sustain, and in the long run, this might increase the risk of brownouts and blackouts (Komorowska et al., 2020). The fund mobilised by the capacity market has benefitted for 40% already existing supply unity (including old and inefficient coal power plants that would not be able to stay in the market without support), for 30% it sustained modernisation projects on already existing units, and for 30% it supported new units (such as the coal-fired power plant in Kozienice and the Fortum CHP plant in Zabrze) (Gawlikowska-Fyk et al., 2019). So far, the mechanism has not delivered diversification of generation capacity (Gawlikowska-Fyk et al., 2019; Tucki et al., 2019). Starting from July

2025, the EU ban on public support of high-emitting power plants will enter into force: the MSs will not be allowed to subsidise any plant emitting more than 550 gCO_2/kWh (Gawlikowska-Fyk et al., 2019; Komorowska et al., 2020). This means that most of the Polish power plants existing today won't have access to the capacity market auctions anymore: therefore, the power sector of Poland urgently needs to diversify its energy mix to avoid threatening the security of the electricity supply (Gawlikowska-Fyk et al., 2019).

In August 2020 the Polish Government proposed a restructuring plan for the energy sector (Czyżak et al., 2020; Czyzak & Wrona, 2021). The plan foresees that Enea and Tauron would be incorporated into the PGE Group by 2021, while Tauron Cieplo would be acquired by PGNiG to avoid excessive market concentration (Czyżak et al., 2020). Then, the combined coal assets of Enea, Tauron, and PGE would be transferred to a newly created National Energy Security Agency (NABE) and would gradually be decommissioned thanks to the financial support provided by the Early Decommissioning Mechanism (EDM) (Czyżak et al., 2020). Although this plan is the first attempt done by the Government to start discussing the coal phase-out, it has been largely criticised:

- The decommissioning pace assumed is not aligned with the EU regulations, which target a CO_2 emission reduction of 55% in 2030 compared to 1990. The plan is a form of State-aid that will unlikely be approved by the European Commission: in this scenario, the power plants would become impossible to maintain and will have to be closed. If the RES growth rate will not be sufficiently rapid, there country's energy security will be threatened (Czyżak et al., 2020; Czyzak & Wrona, 2021).
- Failing to take into account the recent steep price increased of Carbon, the Government underestimated the cost of the project: according to the think-tank Instrat, NABE will generate over PLN 30 billion of losses (around € 7 billion) by 2040, instead of the planned PLN 3,6 billion (€ 0,8 billion) of positive cash flows. The overall NABE and EDM costs should be as much as PLN 63,3 billion (€ 13,78 billion). Neither the Just Transition Fund nor the sale of CO_2 emission allowances under the EU ETS might finance the EDM (Czyżak et al., 2020; Czyzak & Wrona, 2021).
- The new structure of the electricity market would consist of a near-monopoly in the distribution and a duopoly in the sales area: the Office of Competition and Consumer Protection (UOKiK) might not approve the restructuration plan since a high market concentration in the electricity sector typically leads to an increase in tariff prices for the consumers, who are also not able to switch suppliers (Czyżak et al., 2020).

6.1.3. Reinforcing 6: The influence of trade unions

All the interviewees identified the trade unions as one of the main obstacles hampering the transition (Figure 27). The trade unions are highly influential players in the country since the times of the political transition in the 80s, and the coal sector is highly unionised compared to other economic sectors. Four interviewees sustained that the Government is scared by the trade unions since they can quickly organise huge strikes and paralyse the country. At least four of the surveyed stakeholders believe that the Government is not talking clearly with the trade unions: the Government aims to delay the transition and blames the EU for pushing it. However, four other interviewees said that only a few trade unionists are very radical, while it is possible to discuss with most of them. While some interviewees (four) perceive the relationship between the authorities and the trade unionists as conflictual, at least two think that the situation has changed in the past few years since now the transition appears unavoidable to most: they also recognise though that starting the transition a few years ago would have been much easier. Poland might have benefitted from several European funding mechanisms before the Just Transition Fund, and the country wouldn't need to rush it. One interviewee, instead, expressed a very different opinion: "There's no amount of money that will compensate them [Ed. the trade unionists] for the political power they gained over the last few years. It's not something you buy with money, even if it's unconditional money for you every day, even if you get them one million every day, they won't accept it."

The R6 loop describes a lock-in factor that characterises the energy sector of Poland: some of its aspects will be analysed by the R4 loop.

6.1.4. Reinforcing 3, 4: A just transition for coal workers, Reinforcing 5: Nuclear power

1. Description

The strong influence gained by the trade unions in the years ensured the coal workers be among the most privileged in Poland. Citing 5-PL interviewee: “Even if you are, I don't know, a secretary [Ed. working for a company in the coal sector], and you've never been downstairs in the mine, still, you get subsidies and these are a huge amount of money. For example, they are not only given the regular 12 salaries, like most workers. They also get a 13th and 14th salary each year. Besides, they get… the deputy? I don't know how to translate it to English, but they can take some coal from their mine for themselves. It's like a ton of coal or something, but they do not have to take the coal, they take money instead. And there are a lot of other things like these, like three days for the <<Miner day>> and some other financial subsidies, even if you're a widow and your husband was a miner, you're still getting paid his additional benefits. A lot of things were given to miners, and there is no wonder that they're not willing to give them up.”

Due to the privileges gained in the years, some of the interviewees believe that the coal workers are showing little flexibility to change (Figure 28). One interviewee mentioned that some voluntary leaving programs have been implemented in the past: the workers have been offered a gold hand-shake to leave the coal company they were working in; however, the program showed to be ineffective or not accurately designed since it was found that many of them accepted the financial compensation but applied for the same job position in a different company. A few interviewees think that the coal workers should be retrained and reskilled to access new employments. For instance, interviewee 6-PL said that Poland lacks workers in the construction sector, while according to 8-PL the pandemic highlighted the need for more employees in the health sector. However, getting a new job offer by the same employer might be preferred by many, since the change would be less drastic, thus many might prefer to work in renewables. According to 8-PL, though, the transformed energy sector won’t be able to absorb all the coal workers – therefore the need for diverse options. On the other hand, three other interview respondents reported – based on their professional experience – that most of the coal workers would rather accept a gold hand-shake than a retraining program: this is also due to their average age, most of them are 50 years old. One of them, who works for a big coal manufacturer in Poland, explained that the Ministry of State Assets, the main trade union groups, and the companies of the sector are involved in a discussion to agree on the future of coal workers. S/he reports that the trade unions request that, if the employer won’t be able to guarantee a job place for a worker, then the latter should receive 80% of the salary until the age of retirement: they don’t want to reskill, change their qualification, or displace.

Most of the coal workers live in Silesia, where people have been employed in coal mining for generations. In the traditional Silesian family, the husband is the only one perceiving a salary, while the wife is usually a stay-home mother. Most of the coal workers have low levels of educations and are aged 50 or older. All these demographic aspects were mentioned by a few interviewees to argue why coal workers are little prone to change. However, according to at least one of the respondents, most of the employees will reach the age of retirement in a few years - the sector has been struggling to attract a younger workforce for years -, so there won’t be a need to implement huge reskilling or replacement programs.

Several surveyed stakeholders said that the awareness of climate change has been raising during the past few years, therefore people are favourable to renewables, and – according to the polls – around half of them would be willing to pay more for green energy bills. Also thanks to the favourable regulations, the number of solar PV rooftops steeply increased in the last two years. However, one-third of the interviewees believe that the Polish population is less educated on climate change than the rest of the Europeans. Some trust that the Polish power sector could transit towards solar and most of all off-shore wind power, while a few think that the country does not have sufficient natural resources for a complete conversion of the power sector. All the interviewees are sceptical towards the idea of nuclear power playing a role in the transition: any nuclear plans have been stuck since the 60s; the public opinion is strongly against it; no investors are willing to

support the development of nuclear plans in Poland; even if the project for a nuclear plant was approved, it would take years before starting the construction and before operating it, thus it cannot serve the purpose of generating new job places. If gas was chosen to play the role of the transitional fuel for Poland, the country would need to import huge amounts – and this might become a geopolitical issue.

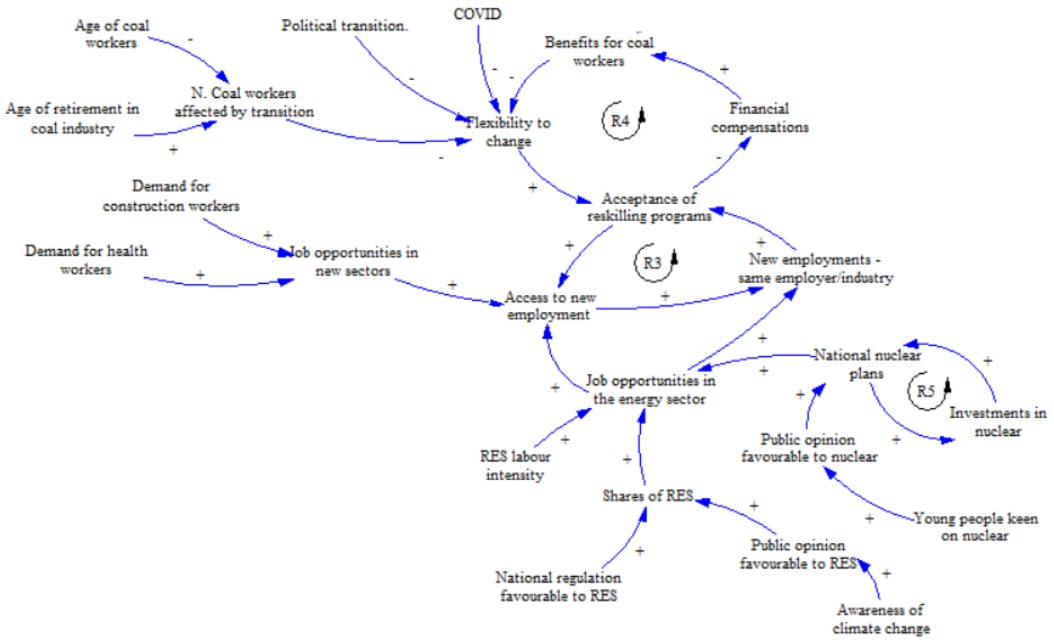

Figure 28 - Feedback loops R3, R4, R5 - Poland

The R4 loop describes the dynamics of an important barrier to the transition in Poland, while loop R3 describes how new concrete job opportunities might drive the transition. The development of nuclear power plants in Poland (R5) is completely stuck and does not seem a promising transitional path, to date.

2. Literature review

Between 1998 and 2001, over 100'000 employees voluntarily left the mining industry and accepted severance pay. The mining severance pays costed nearly PLN 2 billion, which came from a loan from the World Bank. To get access to this financial support, the employees were asked to sign a pledge not to return working in a mine. However, the ban formally expired at the end of 2002 and was not renewed, since the sector was experiencing a shortage of workers. Many workers who had previously accepted the gold handshake were newly employed in the coal sector, nullifying the achievements of the previous manoeuvre. (MEP Gadowski & MEP Saługa, 2008; Minister Pawlak, 2008; Wyborcza, 2006)

6.1.5. Reinforcing 7: Planning a just transition – State of play

1. Description

The interviewed stakeholders had different opinions on the state of play of the discussion on the just transition in Poland. Not all of them were familiar with the expression "just transition", and in many cases, they only associated it with the European funding mechanism, not with the ideological movement. Several interviewees claimed that the discussion on just transition themes has started very recently in Poland, together with the launch of the European Green Deal. The knowledge of this topic might still be restricted to a few experts: it seems to be well-known among policy makers and researchers, while other stakeholders might be less involved in the discussion. A couple of interviewees mentioned that the modus operandi of the Polish Government is quite authoritative, and the Government tends to centralise the decision-making without involving many stakeholders (Figure 29). However, some other interviewees reported that local

authorities such as the Municipalities are organising seminars, roundtables, and conferences to engage the local actors in the discussion. In those regions where the local actors are proactively pushing forward the discussion on just transition paths, the State should intervene more delicately. The State should instead lead the way in those regions where the discussion has not started yet.

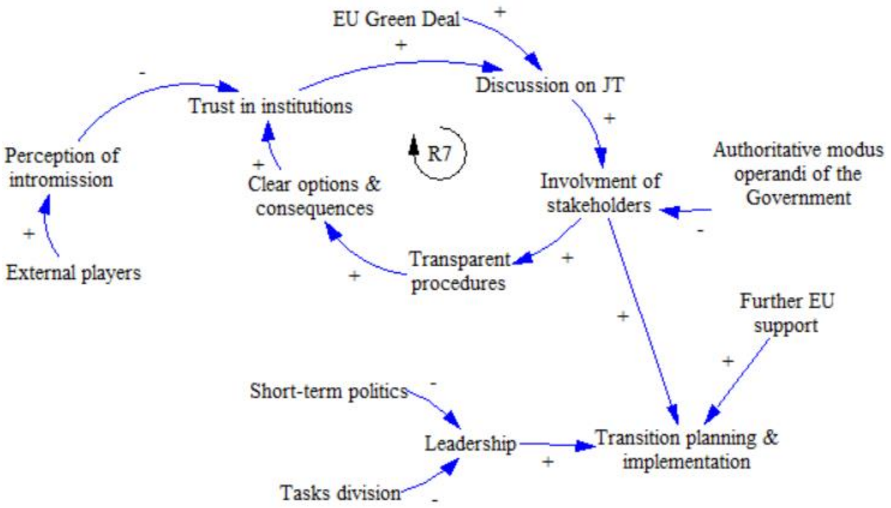

Figure 29 - Feedback loop R7 - Poland

To receive the funds from the EU, every MS has to prepare and submit a national plan explaining how these funds will be spent. While conducting the interviews it emerged that the stakeholders did not hold the same information on who should be in charge of the plan. One interviewee said that the Municipalities are in charge of developing local plans with the support of some advisory companies since the Just Transition Fund aims to be perceived as close as possible to the end beneficiaries. However, the Ministry of Climate is parallelly writing a plan as well: according to him/her, the Ministry would have no right to do so, and it is doing it only for political reasons and for annoying the regional authorities. A second interviewee, who is involved in the development of the just transition plan by the Ministry of Climate, explained that the Ministry will gather all the regional plans and ensure they are coherent one with the other before sending a comprehensive report to the European Commission: s/he said that the intervention of the Ministry is meant to be additional support to ensure that the regional plans fulfil the requirements set by the EC. A few stakeholders reported that the funds coming from the Just Transition Fund will not be sufficient to sustain the transformation: Poland will need to apply for different funding mechanisms, attract foreign investors, or the State will need to contribute.

Three ministries are involved in the management of the Polish energy sector: the Ministry of Climate, the Ministry of State Assets, and the Ministry of Regional Funds. They have different agendas, but they often need to meet and discuss the same project or topic. Two interviewees pointed out that this task division sometimes happens to slow down the decision-making procedures. One of them reported that the Ministries do not have a cooperative relationship, but they sometimes obstruct each other, for instance, one might not inform the other about a meeting. This is a consequence of the fact that Poland has a heterogeneous Government, where different Ministries might represent different factions.

Unclear procedures tend to slow down the discussion and the decision-making, failing to expose clear options to those who will be affected by the transition. According to a few interviewees, if the workers and the trade unionists were presented with a few concrete options among which to choose, clearly depicting the consequences of each, the discussion would be much easier: what is scaring them the most is the uncertainty. As one of the interviewees recalled, Polish society has continuously been in transition in the past decades: people are tired of changes and uncertainty.

One interviewee said that s/he does not see how Polish stakeholders will manage to push forward the (just) energy transition, since they keep fighting and pursuing their interests: s/he hopes that an external player (e.g. the EU) will intervene. On the other hand, s/he as well as other respondents remarked that "Colonialism does not work in Poland": Polish people are very proud of their independence and do not like to perceive intrusions.

The R7 feedback loop highlights how the framework of just transition could overcome the social barriers hampering the transformation of the power sector.

2. Literature review

Looking at the instructions made publicly available by the EC on how to draft the Just Transition Territorial Plans, it appears that the EC expects each MS to provide a national plan (DG for Communication, 2021b; European Commission, 2020f, 2021; Widuto & Jourde, 2021). Although the projects proposed should be specific for a region or a community, the national authorities need to ensure that the local plans are consistent with the national goals and aligned with the EU regulations (see also *Institutions*) (Widuto & Jourde, 2021). One of the interviewees had a very different understanding of the procedures since s/he perceived the intervention of the Ministry of Climate as intrusive and unjustified. This is not confirmed by the publicly available regulations for accessing the JTF, however, the literature review confirmed that the Polish regional authorities are demanding a decentralised structure where they can coordinate the use of funds for their local plans (Mustata, 2020). As mentioned before, the Government is often thought to have a sometimes excessively authoritative approach: the feeling of a pervasive modus operandi perpetuated by the central authorities combined with some misinformation can arise annoyance and disenchantments towards initiatives such as the Just Transition Fund. The situation is further complicated by the fact that the national government has not officially committed to a coal phase-out date, but is sending mixed messages instead (Mustata, 2020).

The resources allocated by the EU to the JTF will not be sufficient for the scale of the challenge, as some interviewees affirmed (Cameron et al., 2020; ZPP, 2020). To make a comparison, Germany – one of the main coal consumers in Europe - instituted a Commission on Growth, Structural Change and Employment ("Coal Commission") in 2018 (BMWi, 2019; Litz et al., 2019). The purpose of the Commission is to plan and lead a just transition from coal to renewables: the federal Government will spend around €40 billion to assist the coal regions in transition and around €10 billion will be spent to compensate the coal power plants' operators (Litz et al., 2019). For the transition to be just, Poland would need to draw on national reserves and apply to different European financial support schemes besides the JTF.

6.2. South Africa

6.2.1. Reinforcing 4: Human resources in the power sector

1. Description

When the Apartheid regime came to an end, the new Government decided to introduce several affirmative action measures that bound the employers to recruit a minimum share of the black workforce, with the intent of correcting years of inequalities. According to one of the interviewees (5-SA), the decline of Eskom would be an unplanned side effect of these policies. During the post-Apartheid years, a large number of white employees left Eskom: the interviewee believes that this happened because of an over-application of the affirmative action policies. To correct the low shares of non-white employees, the company would have dismissed many white workers or modified their employment conditions, so that they would have spontaneously left. The claim is that the dismissals and the recruitments did not reflect the real needs of Eskom in terms of human resources. After years of discrimination, the skills were not yet equally distributed among white and black South Africans: laying off many highly-skilled white employees would have led to a sudden lack of skills within the utility company. This is identified as one, if not the main, of the causes that

led to improper maintenance of the power plants: lower levels of efficiency mean higher management costs (Figure 30). As it will be explained by looking at the loops R2 and R3, Eskom has not been able to cover the system operation costs for a long time: as the company's financial security is reduced, Eskom is increasingly less able to attract and retain a skilled workforce.

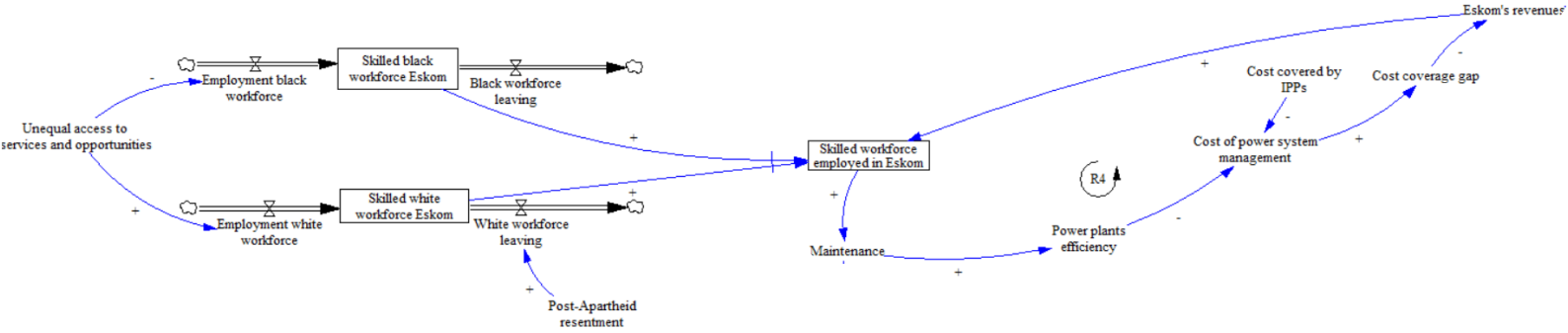

Figure 30 - Feedback loop R4 - South Africa

Taking as a reference the definition of a carbon lock-in factor reported earlier in the text, it is therefore recognised that the R4 loop describes the dynamics of carbon lock-in. The vicious cycle described prevents Eskom both to guarantee a secure electricity supply and mobilise investments in new generation technologies.

2. Literature review

For over 40 years and until the early 90s, South Africa has been subjected to a racial segregation regime known as Apartheid (Archibong & Adejumo, 2013; Clark, 2014). During this time frame, the white minority of the population was favoured over the black majority, which was systematically prevented to access the same services and the same opportunities offered to the white minority (Archibong & Adejumo, 2013; Clark, 2014; Kloot & Rouvrais, 2017). For the black population, it was more difficult to access tertiary education, and certain jobs were designated as "White only" (Archibong & Adejumo, 2013; Clark, 2014; Kloot & Rouvrais, 2017). This situation was reflected in Eskom as well, where most of the higher-level job positions were covered by white employees (SAPA, 1997).

The literature review seems to support the interpretation of facts reported by interviewee 5-SA (Archibong & Adejumo, 2013; Leopeng, 1999), which has also been confirmed during different informal conversations with other power sector exponents. It has been estimated that from 1994 to 2002, at least 10'200 white staff members, constituting more than half of the utility's white employees, left their employ (Solidariteit, 2015). According to a research conducted by the trade union group Solidarity and involving 1200 testers, the root cause of this phenomenon is that white people felt alienated by Eskom's affirmative action policy (Solidariteit, 2015). 81% of the subjects of the research believed that policies on racial representation impeded their career prospects. 75% thought that promotions did not fairly take place and 71%, felt uncertain about their positions (Solidariteit, 2015). Eskom tried to drive the Black Economic Empowerment (BEE) also by renewing its coal supply contracts: in the early 2000s, many of its 40-years supply agreements came to an end, and the company took it as a chance to sign new contracts with small and younger black-owned companies (Kessides, 2020). Kessides sustains that while this choice boosted the black economy, it might have not benefitted Eskom, since the cost of buying coal increased and the new mines were often far from the power stations – thus, the transportation cost increased too (Kessides, 2020).

Solidarity and NUMSA repeatedly complained about Eskom's Employment Equity Plan, claiming that the plan aimed to achieve a greater diversity with a mere mathematical calculation of the shares of employees, without considering the needs of the organisation or the availability of skills (Joubert & Calldo, 2008;

Solidariteit, 2015). The South African labour market lacks skilled workforce, and particularly engineers (Joubert & Calldo, 2008; Rasool & Botha, 2011). Around 300 qualified engineers leave South Africa every year; the country has only one engineer for every 3'200 people, compared to one engineer for every 130 people in China, one engineer for between 250 and 300 people in Europe, one engineer for 450 people in Australia, one engineer for every 227 people in Brazil (Joubert & Calldo, 2008).

6.2.2. Reinforcing 13: Performance of Eskom: impacts on the national economy and the financial situation of the utility company

1. Description

Due to the poor maintenance delivered in the past years, the power plants of Eskom are now old and inefficient. The power capacity is often unable to cover the electricity demand and South Africa has been experiencing load-shedding since 2008, reaching the worst record of load-shedding hours in 2020. The lack of a secure power supply is a threaten to the national economy since it affects commercial and industrial activities as well. Eskom has been losing customers during the past few years: both householders and companies have been looking for alternative supply solutions, although the current regulation does not favour self-consumption (as it will be explained when discussing the Reinforcing 12 loop). The revenues obtained by the company are proportional to the number of customers, thus reducing the number of customers decreases the resources that Eskom can use for all of its activities – including covering the operation and maintenance cost and employing skilled workforce (Figure 31).

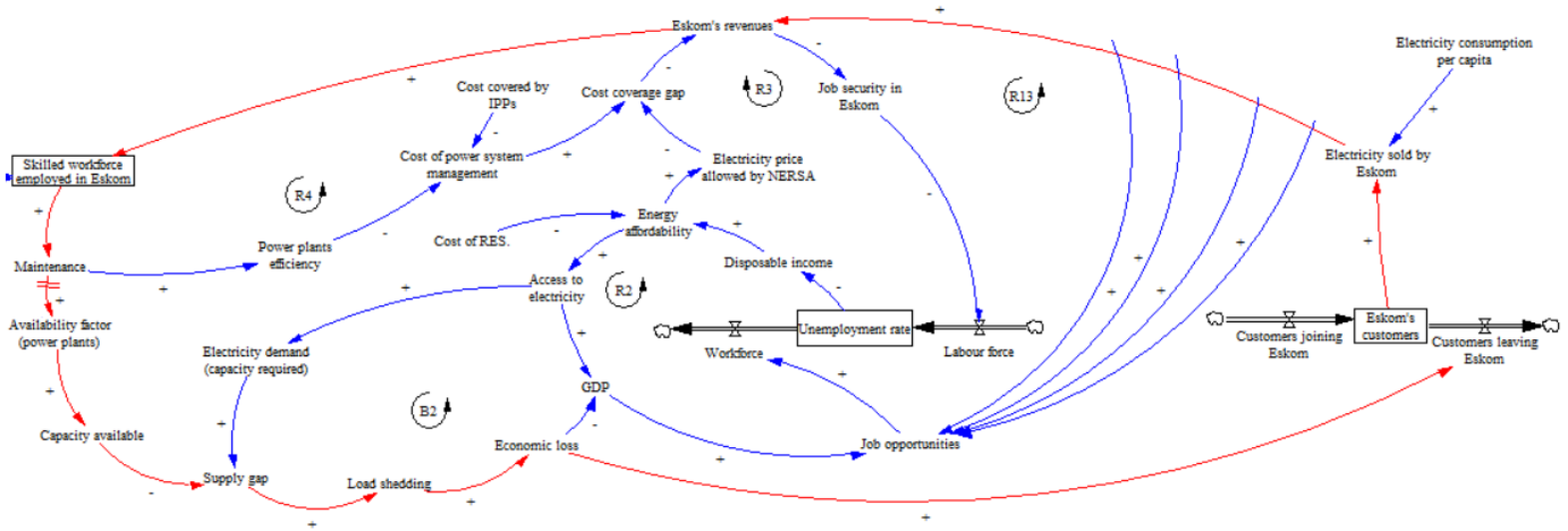

Figure 31 - Feedback loop R13 - South Africa

All the interviewees discussed the unreliability of the power supply in South Africa, explaining its causes and its consequences on the national economy. Several of them mentioned that many householders and companies would prefer to become independent rather than keep purchasing electricity from Eskom, but the national regulation makes this decision difficult to pursue in practice (Reinforcing 12). One of them (SA-1) mentioned that the utility company has recently changed its pricing system, increasing the fixed costs for grid connection. Many households have been installing private PVs on their rooftops, and thus they have been consuming electricity from the grid only at night: if the electricity consumed from the grid is reduced, the price paid is not sufficient for Eskom to cover the grid management costs, unless the grid connection fee is increased.

The R13 loop describes a lock-in situation: the worst Eskom performs, the fewer resources it can mobilise for improving its condition. Eskom is not able to invest in the energy transition on its own. In a way, though, the dynamics described might also be considered to be a driver: since the state of play of the power sector is highly unsatisfying, there is a need to look for alternative electricity supply solutions.

The literature review confirmed that the new trends observed in the electricity sector lead Eskom to change its pricing system (Eskom, 2019c, 2020d; Kritzinger et al., 2020; Leprich, 2019). However, as will be discussed later in the text (Reinforcing 3), Eskom is still unable to reach cost parity.

6.2.3. Reinforcing 2: Access to affordable electricity and Reinforcing 3: NERSA and the electricity price

1. Description

As mentioned earlier in the text, the continuous load-shedding challenge the national economy, since the unstable power supply impacts existing commercial and industrial activities and discourages new foreign investments in South Africa: a stagnating economy generates fewer job opportunities. Several respondents mentioned that unemployment, and consequently energy affordability and energy access are serious issues in the country. It has been mentioned already that the electricity price in South Africa has been rising during the last years, and it is expected to keep increasing. To avoid the electricity price to skyrocket, the National Energy Regulator (NERSA) is in charge to approve any price increase proposal before it is applied: a couple of interviewees reported that NERSA has more than once prevented Eskom to raise the electricity price as high as the company asked. One of the interviewees said that "NERSA should apply an algorithm or a formula to come up with a price increase on an annual basis […] It's a well-known secret in this country that any price increase above 8% will not be approved. No matter how objective it is, if a price increase indication is above 8, 9, or 10%, they won't even talk about it, they will say: <<It looks like you can cut costs>>.". According to the interviewee, the reason behind this choice is political: an excessive price increase would not be easily accepted by the population, the national regulator wants to protect the poorest social classes. Since Eskom has been prevented to increase the electricity price, the tariffs have not yet reached cost reflectivity and the utility company has been operating at loss for the past years: the company has increasingly fewer resources for both improving its performance (as described earlier in the text) and guarantee job security to its employees (Figure 32).

The dynamics described by the R2 and R3 feedback loops are, in a way, both carbon lock-ins and drivers. Eskom is locked in a vicious cycle that keeps worsening its financial situation, and thus the health of the national economy. The current electricity system is not sustainable since the electricity price will keep raising, hampering the economic growth: a transformation of the system seems to be unavoidable.

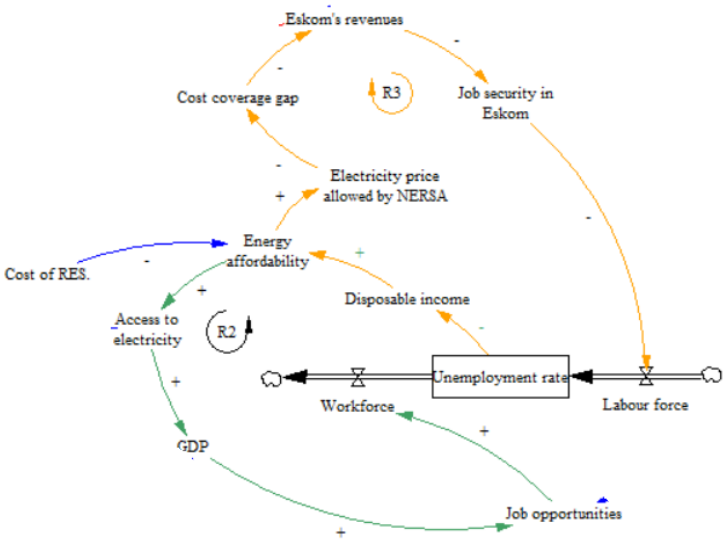

Figure 32 - Feedback loops R2, R3 - South Africa

2. Literature review

The methodology adopted by NERSA for evaluating electricity price adjustments is known as Multi-Year Price Determination (MYPD) and was first introduced in 2006 (Maphosa & Mabuza, n.d.; NERSA, n.d.). The MYPD methodology aims to ensure Eskom's sustainability as a business while ensuring the change in tariffs is consistent with the socio-economic objectives of the Government (NERSA, n.d.). However, the development of the methodology does not preclude NERSA from applying reasonable judgment on Eskom's revenue after due consideration of what may be in the best interest of the overall South African economy and the public (NERSA, n.d.). The literature review confirms that NERSA has systematically put a cap on the electricity price increase, despite Eskom's requests to increase the tariffs to reach cost-reflectivity (Kessides, 2020; Maphosa & Mabuza, n.d.). Except for the first few years after the electricity crisis in 2008, the yearly price increase has been around 8%, as can be observed from the data available on Eskom's website (Eskom, 2020b, 2020a). While NERSA has historically adopted "pro-poor measures" rather than "cost-reflective tariffs" (Kessides, 2020; Maphosa & Mabuza, n.d.), it seems that the trend is going to change: in 2021, the electricity tariff will increase by 15,06% for households and 17,80% for municipalities (Eskom, 2020c).

6.2.4. Balancing 3: Unbundling Eskom and Reinforcing 5: Eskom's debts

1. Description

In 2019, the Government announced the intention of restructuring or unbundling Eskom. The vertically integrated utility company will be separated into Generation, Transmission, and Distribution. The interviewees have been asked to comment on the restructuring plan and explain whether they believe it will support the (just) transition or not. This has been maybe the topic on which the interviewees disagreed the most: the feedback loop integrated into the model gathers the points of which the majority of them agreed, however, some clarifications will be made along with the description. Out of eight interviewees, three claimed that unbundling Eskom is desirable and/or necessary, one expressed strongly against it, while the remaining four were either neutral or uncertain.

The causes of Eskom's financial situation have already been analysed: the company has been dependent on its creditors (mainly the Government) for several years now and has cumulated a debt of R441 billion (€24,6 billion) as of March 2019 (Department of Public Enterprises, 2019). The larger the debt becomes, the more it is evident that a major intervention is needed, since the electricity system as it is today is not sustainable (Figure 33). The first concern about unbundling Eskom (expressed by one of the interviewees) is that it might get unclear which one of the new companies will need to pay back the debt cumulated by Eskom: this is an aspect of the scission plan that should be defined in advance.

One of the arguments most often adopted to support the plan is that the privatisation of the electricity sector will allow more companies to access the market: the competition will enhance the overall efficiency of the sector, so the phenomenon of load-shedding will come to an end. Most of the interviewees are neither strongly supportive nor against the privatisation of the power sector: they believe that whoever can prove to be more efficient, should be in charge of the generation, the transmission, or the distribution. One of the interviewees, though, expressed strongly against the privatisation of (even part of) the power sector: s/he affirmed that this would threaten the job security in the power sector since many of the job places might be found redundant and private companies would pursue profit-making only, while the State would not prioritise profits over job places. Another issue raised by this particular interviewee is that the public sector is, at the moment, in a weak position. If it opened the negotiations for the (partial) privatisation of the electricity system, most likely the private actor(s) involved would be in an advantageous position. Thus, the interviewee fears that "[…] the private business will pick and choose. Especially they may prefer the distribution part, not the generation, because the generation calls for infrastructure and maintenance. They don't like to be bogged down by those costs, but they just like to benefit from the distribution of their power, that has already been generated (to make a profit from it). […] the cost of maintenance is still to be borne

out by the State entity more, while the profitable parts of the unbundled entities belong to the private sector. So that's just a risk that unbundling brings."

An aspect of the unbundling plan that has been largely criticised during the interviews is that the three new companies will be coordinated by a System Operator: this function will be taken over by the Transmission subsidy, which is expected to remain State-owned. Thus, what some of the stakeholders feel is that Eskom will act "both as a player and as a referee": there will always be a perception that the System Operator will favour Eskom Generation over the other generation competitors.

Finally, one of the interviewees thinks that unbundling Eskom won't solve the root cause of its problems, which is by him/her identified as a human resources issue (see R4 feedback loop).

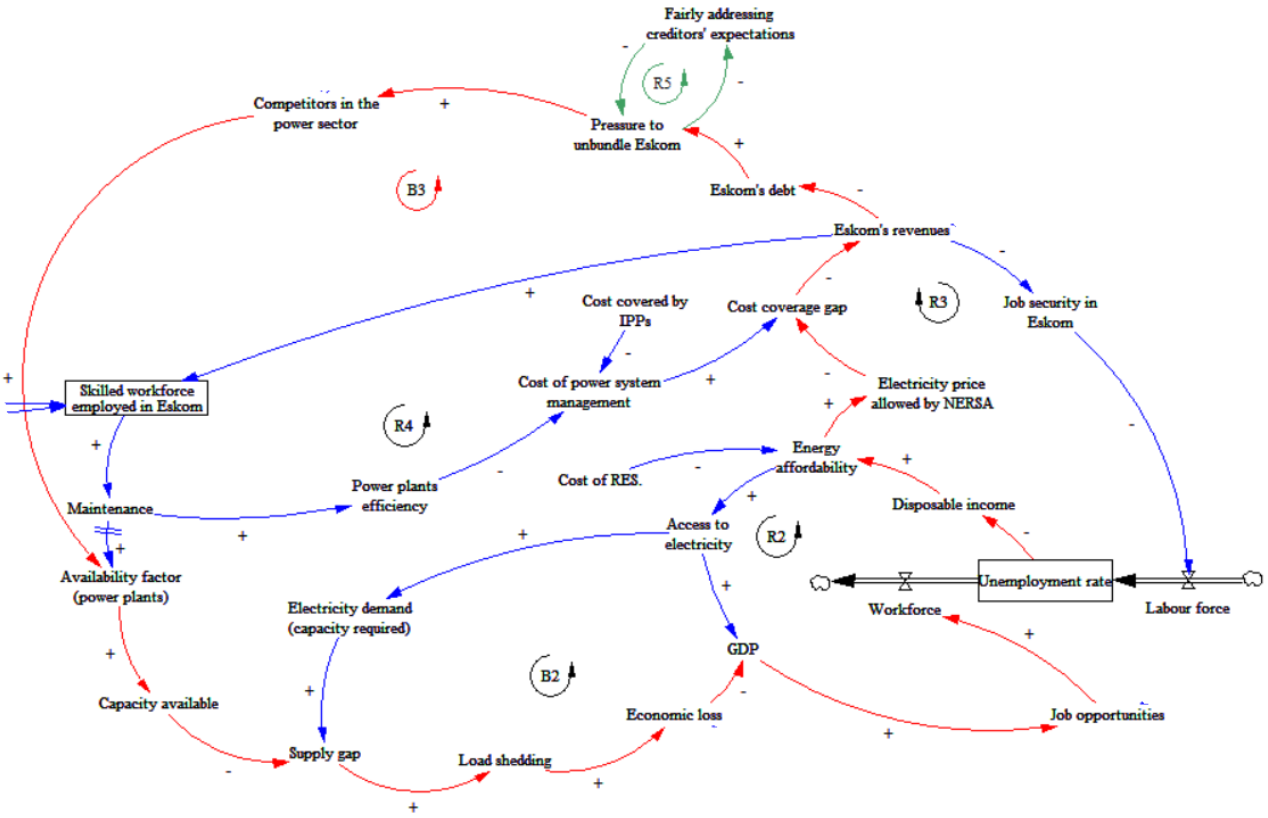

Figure 33 - Feedback loops B3, R5 - South Africa

2. Literature review

The idea of unbundling Eskom is not new, however, the decline of the company in the recent past has put much more pressure on the Government for moving forward with this plan (Department of Public Enterprises, 2019; Kessides, 2020; Mamorobela, 2021; Phalatse, 2020; Power Futures Lab & University of Cape Town's Graduate School of Business, 2019).

The variety of opinions collected during the interviews reflects the fact that this topic is highly debated in South Africa, as it was also found conducting the literature review. While it is settled that Eskom will be unbundled, a precise restructuration plan has not been finalised yet (Creamer, 2020a; Department of Public Enterprises, 2019; Ndenze, 2020). The scission process will take some time, and Eskom CEO André de Ruyter believes it won't be completed before 2023 (Creamer, 2020a). It is yet to be defined how will the new subsidiaries repay the debt, nor if the whole debt will ever fully be paid back (Baigrie et al., 2020; Bloomberg, 2019; Creamer, 2020a).

It has been mentioned that one of the arguments most often adopted to justify the plan is that the privatisation of the electricity sector will allow more companies to access the market, and this should enhance the overall efficiency of the sector (Department of Public Enterprises, 2019; Leprich, 2019; Power Futures Lab & University of Cape Town's Graduate School of Business, 2019; Power Futures South Africa, 2019). To date, there is no concrete plan for privatising Eskom: the three subsidiaries, including the System Operator, will still be state-owned (Department of Public Enterprises, 2019; Geddes et al., 2020; Kessides, 2020; Leprich, 2019). Private actors (Independent Power Producers) will be allowed to participate in the generation of electricity, as they are already: so, the worry of a conflict of interest (real or perceived) between Eskom Generation and Eskom System Operator/Transmission Entity seems to be legitimate. Whether the private sector should have greater access to the power sector is a highly debated matter in the country: part of the Government, and most of all the trade unions strongly opposed to this idea and fear job losses (Baigrie et al., 2020; Mamorobela, 2021; Omarjee, 2021).

One of the interviewees fears that if Eskom will be privatised, the private sector will be interested in the transmission and the distribution only, and not in the generation subsidiary. This risk may or may not materialise according to the reforms and policies that will come together with the possible privatisation of the power sector. The private sector seeks profit-making and might prefer immediate profits over collective and long-term interests – which usually is or should be a prerogative of the public sector. To date, the generation component is the one that is dragging down the utility company, while the transmission and the distribution components are more efficient and profitable: if no signals or constraints are put in place by the Government, likely, a private company would rather take over the last two. However, for the nature of the activity, the transmission is quite often a (State-owned) monopoly (Geddes et al., 2020), so if it were sold, it would probably have to be bought by a big player. It is more common to observe greater competition in the generation and distribution markets (Geddes et al., 2020).

Since the 1980s, there have been many examples of electricity market structural reforms, mostly supported by the same arguments raised by those in favour of unbundling Eskom: not all of them have fulfilled the expectations (Geddes et al., 2020; Phalatse, 2020). The main lesson learnt from these cases is that the process of unbundling and privatising a State-owned utility company should be accompanied by several support policies: the risk, otherwise, is that the unbundling plan will have limited or counterproductive impacts (Baigrie et al., 2020; Geddes et al., 2020; Kessides, 2020; Phalatse, 2020).

To date, the energy regulation in South Africa is acting as a barrier to the spread of renewables technology that could potentially take place (see Reinforcing 12): the natural resources of South Africa, the declining cost of renewable technologies like PVs, the global trends suggest that the generation market might be the most attractive for the private sector and that the new capacity installed will likely be based on renewables

(Filipova et al., 2019; Kritzinger et al., 2020; Scholtz et al., 2017; Solargis s.r.o., n.d.). A greater opening of the electricity market – in a more favourable regulatory scenario – would likely drive the sustainable energy transition.

6.2.5. Balancing 5, 6, 7, Reinforcing 6: Job opportunities

1. Description

Albeit with varying degrees of conviction, most respondents would like to see South Africa's electricity mix become more diversified. Since the trust in Eskom to be able to achieve a diverse electricity mix is low, it is generally thought that this goal could be achieved if more actors were involved in the power sector. Of course, higher shares or renewables would create new job opportunities in the solar and wind industries (B7) (Figure 34). The new job places directly linked to renewables might not be sufficient to absorb the low-skilled labour force in the country – e.g. the coal workers (R6) – although some programs might be developed to overcome this issue (see the discussion on B8 and R8). What could make the difference to both increment the shares of renewables in the power mix and guarantee a higher number of new job positions in the country is a more consistent implementation of the already existing policies. One of the interviewees commented that the REI4P program is well designed and has shown to be successful, however, there should have been more frequent bids. To develop new job places in the sector, the renewables value chains should be Nationalised as much as possible, sustained three interviewees. This would also enhance the favour of the public opinion towards the IPPs: one of the respondents said that people do not like the fact that most renewable energy companies are foreign-owned. According to him/her, there would be two reasons for this: first, due to the experiences of the past, the population is afraid to be trapped in new forms of Colonialism. Second, if the main RES companies operating in South African are foreign-owned, these companies would give a job to fewer local workers than if they were national companies. When asked to comment on these statements, a different interviewee clarified that claiming the RES industry to be foreign-owned is not fully accurate: only 60% of the investments in the last 4 bid rounds come from foreign investors, and every foreign company is asked to partner with a local one. However, s/he also confirmed that a good part of the manufacturing is not completed in South Africa. Several interviewees believe that the regulations and policies should be designed to attract more foreign investments in South Africa. One of them, instead, would support the full nationalisation of the RES value chain: although the first PVs and wind turbine manufacturers would likely be less competitive compared to the foreign ones, there is no way to develop the know-how in the country other than starting and trying. A different interviewee suggested that the policies and regulations should facilitate exportations: investors are looking for an extensive potential market, and South Africa alone might not be sufficient.

One of the respondents suggested that the easiest way to guarantee the coal workers new employment is to undertake a transition within the mining sector (B6) (Figure 34). The global demand for renewable technologies is driving the demand for minerals, such as Platinum, Lithium, Cobalt, Tellurium, etc. Since South Africa is rich in minerals, this interviewee would recommend that while decarbonising the power sector, the mining industry should focus its investments on these increasingly popular minerals.

The interviewees did not agree on the role that natural gas might play in the energy transition. Some of them think that gas might play a role as transitional fuel: although to date most of the gas consumed in the country is imported from Mozambique and Namibia, a few new reserves have recently been found. The advantage of gas would be that the technology is more familiar and thus it would be easier to transfer workers from the coal to the gas industry (Figure 34). On the other hand, other interviewees said that the newfound reserves are not sufficient to support the transition and that the political instability of Mozambique makes it hard to increment the imports. So, it might not be easy for the gas industry to grow.

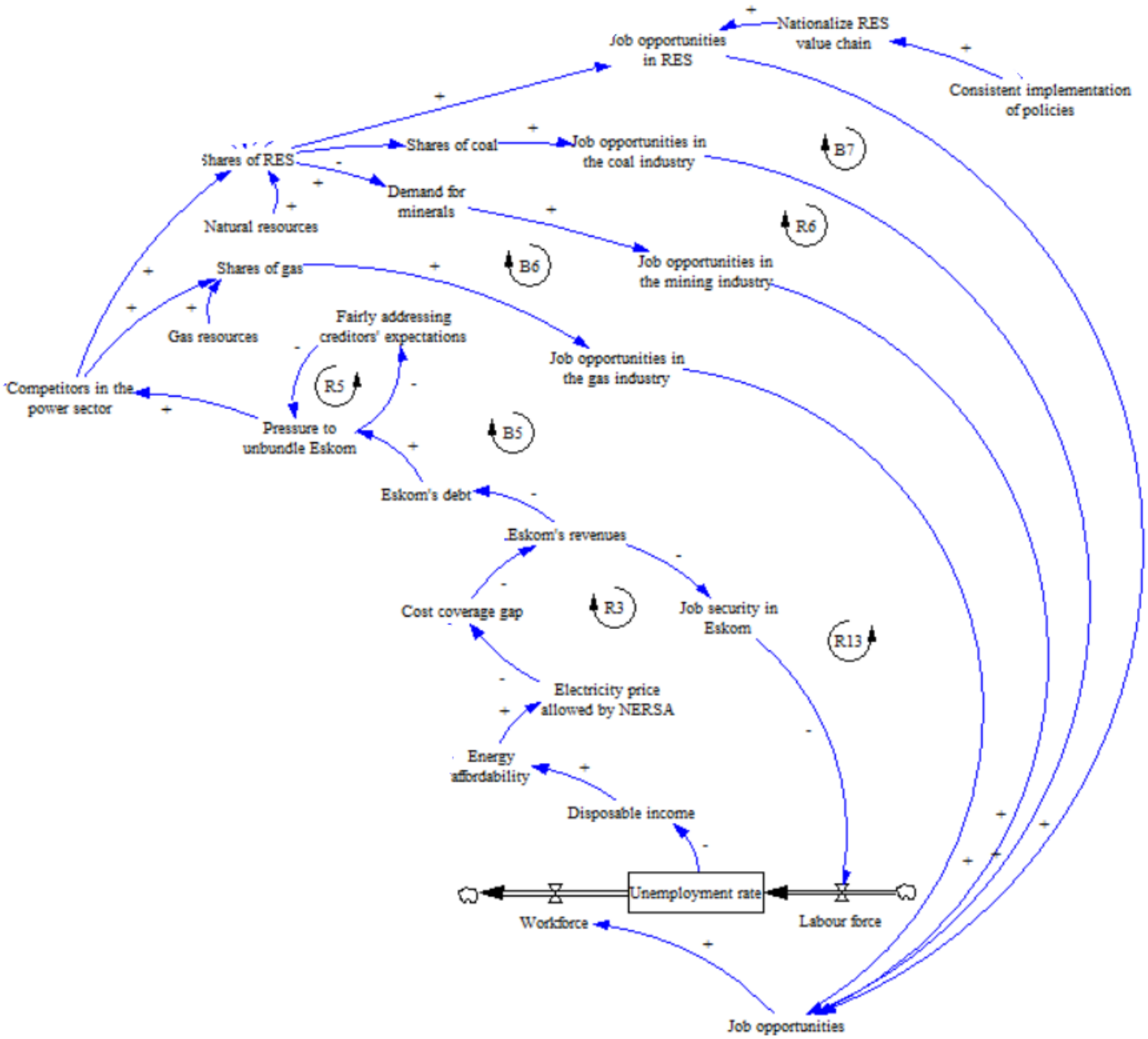

Figure 34 - Feedback loops B5, B6, B7, R6 - South Africa

2. Literature review

In the first 4 bid rounds, 60% of the equity providers were foreign shareholders (Eberhard & Naude, 2017; Filipova et al., 2019): in fact, the REI4P instructions set a minimum threshold for the South African equity participation and provided guidelines on the requirements to be met for fulfilling the definition (Filipova et al., 2019). Many of the foreign shareholders were involved in local-foreign equity partnerships (Eberhard & Naude, 2017). Part of the projects was instead financed through debt, and in this case, most of the debt providers were local entities (Eberhard & Naude, 2017; Filipova et al., 2019). Generally speaking, the REI4P set a list of rules to guarantee that the new capacity projects would have benefitted the most the local economy (see *Conclusions & Suggestions: Elements of Just Transition* and Appendix 8).

6.2.6. Reinforcing 7: Public opinion on nuclear power and Reinforcing 9: Nuclear lobby & political interferences

1. Description

South Africa has great solar and wind power potential compared to most of the other locations in the World. The availability of great natural resources combined with the decreasing cost of renewable technologies makes the country attractive for investments in RES: the industry will keep growing, reducing the steepness of the learning curve and increasing the technological know-how in the country. At the same time, nuclear power might become a less attractive option, due to the high investment required and the long time that a plant needs to become operative. According to 7 interviewees out of 9, nuclear power is not a feasible option for South Africa (Figure 35). Most of them reported that the public opinion in the country is against nuclear power, and they identify the cost of the technology as the main reason for this: they don't think the population is worried about the risk and environmental impacts of the technology as much as they are for the cost.

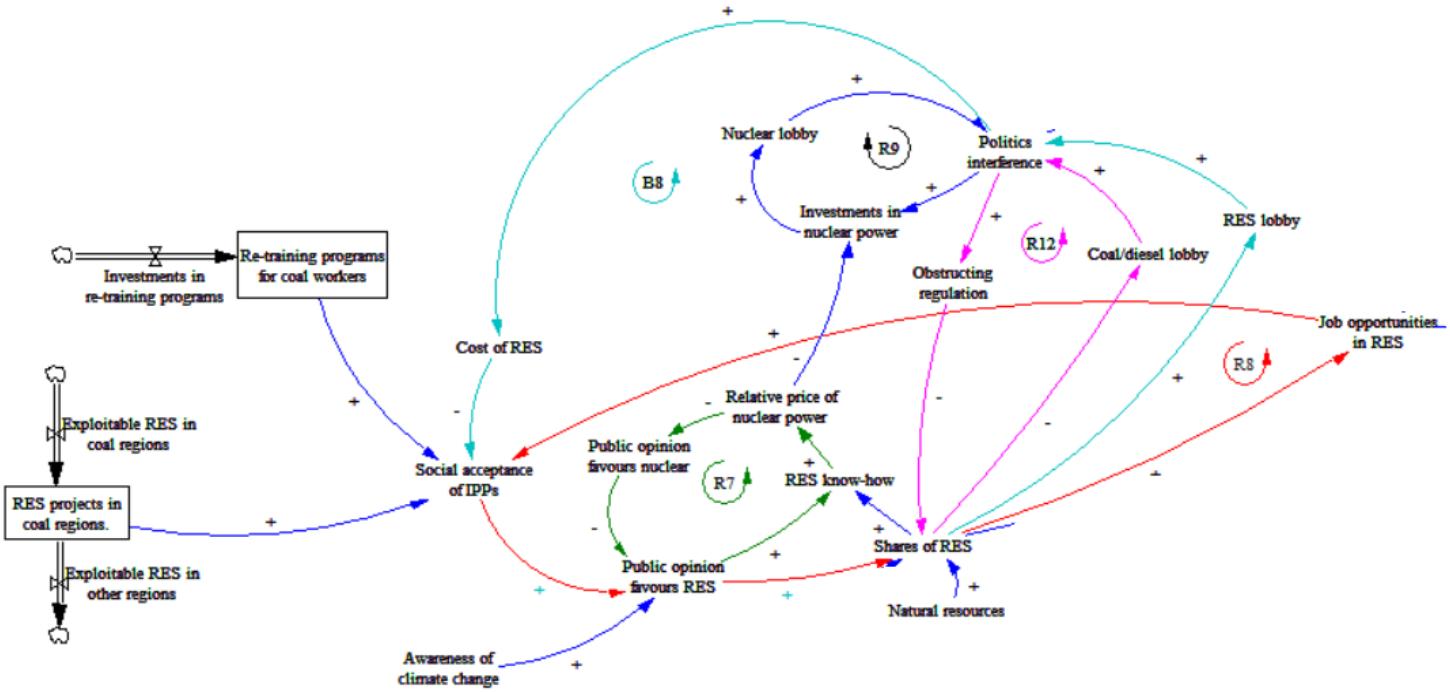

Figure 35 - Feedback loop R7, R9, B8, R8, R12 – South Africa

At least 3 interviewees think that there is no technical reason to support why nuclear power plants have been listed in the Integrated Resource Plan 2019, and they suspect that the real reason is that some politicians might be close to the exponents of the nuclear lobby and might have personal interests in mobilising investments to support nuclear power (Figure 35).

To date, nuclear power is largely perceived as a not feasible option: this is a carbon lock-in factor since it represents a one-less alternative option to coal. The fear of high electricity costs and environmental risks caused by nuclear mean that a possible transition towards nuclear power would be perceived as highly unjust. The energy crisis demonstrates that South Africa needs reliable, quickly available, cheap, and clean energy supply sources: if the Government truly wants to increase the national nuclear capacity, it should demonstrate that this technology can fulfil all these requirements, as well as effectively communicate it to the population.

South Africa has been operating the only nuclear power plant on the continent since 1984, which will reach the end of life in 2024 (DoE, 2019b): so, compared to other countries, there is nuclear know-how in South Africa. However, at least until 2011, the availability factor of the two reactors at the Koeberg nuclear power plant (71%) has been lower than the world average (77%) (Ferrial et al., 2011). Part of the problem is their location in the Western Cape, which has limited electrical connections to the rest of South Africa. This has meant that when both reactors are operating, not all the power available can be used and if one of the reactors does break down, the power supply to Cape Town can fail (Ferrial et al., 2011).

Assessing whether investing in more nuclear capacity would be cost-effective for the country is not a straightforward answer (Lombaard & Kleynhans, 2016). Nuclear power plants require a high initial investment (Ferrial et al., 2011; Lombaard & Kleynhans, 2016): in the IRP 2019, it is not specified who would cover the initial cost. Due to its poor financial conditions, Eskom would likely require some external support. However, as discussed for the case of Poland, the newer nuclear technologies are more flexible and more dispatchable than the traditional large-scale nuclear power plants (Vaya Soler et al., 2021): a Small Nuclear Reactor (SNR) might require only 3 to 5 years for being constructed instead of 20 (ANSTO, 2020; Martini, 2021). The shorter time of construction reduces the risk of the investment and might generate new job opportunities for the former coal workers in a reasonable timeframe.

The use of nuclear power is highly debated: its supporters highlight how the technology might play an important role in climate action and might complement the deployment of variable renewable energy (Vaya Soler et al., 2021). Greenpeace – one of the actors that more strongly opposes nuclear power – reports that the Government claimed its intention to increment the nuclear capacity of the country in the past decade already, but this did not happen due to the lack of investors (Ferrial et al., 2011). While some shares of the population and some NGOs strongly oppose the spread of nuclear power (Ferrial et al., 2011; Nkosi & Dikgang, 2018), an investigation conducted in 2018 shows that most of the population is not well informed about the pros and cons of nuclear power (Nkosi & Dikgang, 2018). If the South African power sector will transit towards higher shares of nuclear power, the authorities should make sure to involve the civil society and address their concerns: otherwise, this transition will not be perceived as “just”.

6.2.7. Balancing 8 and Reinforcing 8: Social acceptance of IPPs and RES

Part of the resistance to a smooth transition towards renewables comes from a general lack of trust in the Independent Power Producers. During the first bid rounds conducted in the country, the price of the electricity that the IPPs sold to Eskom was very high. Two of the interviewees believe that the IPPs overcharged Eskom to maximise their profits, and they think that the RES industry is not exempt from corruption. Generically speaking, the interviewees involved in the study seem to trust the actors of the power sector very little. The theme of corruption has been raised more than once, and each interviewee suspected elements of corruption in different sub-sectors of the energy industry (see R9 and R12 in Figure 35).

The high cost of the electricity generated by the first bid-winners affected their popularity and thus the social acceptance of renewables: this is a barrier to the transition. However, the interviewees identified a few elements of “just transition” that, if the IPPs were able to guarantee, would significantly enhance their acceptance.

First, if the IPPs can guarantee a large number of job places, then they will be much more welcome. One of the interviewees (1-SA) suggested that the IPPs should integrate re-skilling programs into their business model: they might re-train former coal workers and employ them in the construction and maintenance of RES-based power plants. The renewables power plants are less labour intensive than the coal industry, and most of the labour force is required during the construction phase. Interviewee 1-SA suggested that the IPPs should develop a long-term program of RES projects: in this way, the same people employed in the

construction of a solar or wind farm might be employed again in the construction of another RES plant. This solution would compensate for the lower labour intensity of the renewables industry.

When discussing just transition, one of the issues which are most frequently mentioned is how to guarantee new employment to the coal workers. A couple of stakeholders mentioned that most of the RES projects developed so far have been constructed in different regions than those where the coal industry is dominant. They would perceive as more fair to the coal workers that at least some RES project were built in Mpumalanga. Interestingly, interviewee 7-SA, who is involved in the RES industry, gave a different opinion: s/he stated that guaranteeing the new RES job places to the former coal workers would not be "just". S/he explained that most of the RES projects developed or planned so far are located in less-developed areas of the countries: people living in these regions also deserve a shot, so the coal workers should not have priority access to these job opportunities. Furthermore, the interviewee insisted on the fact that the RES power plants should be constructed where it makes more economic sense to do so, and the decision should not be guided by politics. However, s/he also mentioned that wind speed measurements are being taken in Mpumalanga, and the results, combined with the technological evolution of the wind turbines, seem promising for the development of wind farms in the region.

Different stakeholders shared the opinion that the IPPs might have been a bit too insular in their thinking: the perception is that the new power producers have been thinking about their business activity without worrying about the downstream of the value chain, nor about the state of play of the South African economy – from which comes the suggestion of a new business model to integrate training programs. The management of the power system, including the keeping of the frequency and the voltage – which are of course affected by the input of RES electricity into the grid – have been carried by Eskom alone. According to interviewee 6-SA, the IPPs should take over part of the power system management costs (see R4).

6.2.8. Reinforcing 12: Obstructing regulation

In different ways, almost all the interviewees said that the national energy regulation is acting as a barrier to a wider spread of renewable technologies (Figure 35). The lack of a political will and the influence and corruption of the fossil fuels industry would be (according to some of them) the main obstacle to remove these regulations. Particularly, several interviewees mentioned the 1-MW cap as the main example of obstructing regulation that is not justified by any technical reason: to date, the ERA states that the grid-connected installed capacity of no more than 1 MW does not require a license from NERSA[33]. Any installed capacity exceeding this cap must instead gain a license from NERSA before becoming operative. Two interviewees argued that this cap is too narrow and deters the investment: the licencing procedures are onerous and lengthy. One of the interviewees reported the example of Goldfieldsed, a mining company that wanted to install 40 MW of solar since 2016: NERSA granted them the right to do so in 2021, so it took them 5 years to get the approval. The interviewee says the bottleneck to be the capacity of NERSA: "As far as I know, there are only 8-10 regulators, and most of them are even at the top level of the regulator. And most of them are part-time regulators, they're not even full-time.".

The length of the bureaucratic process discourages other companies to follow the same path. The Presidency recently announced the intention to lift the threshold, although he did not commit to a specific capacity cap yet. Two interviewees said that the request from the industry is to shift the cap to 50 MW since there would be no technical reason not to do so, and this claim seems to be confirmed by Eskom's experts. If the cap will be shifted to 50 MW, it is likely to expect that many more commercial and industrial actors will choose to invest in electricity self-production, however, it would be desirable to increase the frequency of IPP bid rounds (interviewees 1-SA, 2-SA, 3-SA, 6-SA, 7-SA).

[33] On June the 10th the President announced that the cap will be shifted to 100 MW within the next two months (The Presidency, 2021).

6.2.9. Reinforcing 10: Long-term politics and Reinforcing 11: Taking action

Most of the stakeholders involved in the study feel that the discussion on the topic of Just Transition has been carried on for several years in the country, but in a scattered way: the dialogue has started to become more centralised and cross-sectorial only in recent times. Before, separate discussions were conducted in the academic world, among the industry, or by NGOs and NPOs. Some interviewees explicitly said that, and some indirectly confirmed this claim. Generally speaking, each stakeholder was aware of just transition research initiatives in the academy, in the industry, in the civil society, or among institutional players, according to their background and professional experience. Some of the interviewees involved in the industry were unaware of the work conducted by the academic world on the topic of just transition, while some academy exponents claimed the academy to be much more involved in the national discussion than the industry.

One actor feels that the trade unions, although being highly interested in the topic, are not proactive enough: "There may be a bit passive in the sense that, although there is a bit of research being done, they project to the government often or to business to say how are you going to achieve a just transition. They look to other constituencies to bring solutions to them. In a lot of cases and a lot of the discussions or dialogues that I've been in, where it would be, I think, more productive if they were a bit more solutions orientated. I think in short they are very supportive of a just transition, wholeheartedly agree that there must be a just transition, but not very proactive in how we can achieve a just transition." The trade unionists involved in the interviews affirmed that the Government does not seem quite committed yet. One of the interviewees believes that what is hampering the transition is that the people who understand the technical aspects of the issue are not able to effectively communicate with the population and the decision-makers, while the decision-makers do not understand the technical challenges of the transition. S/he claims that South Africa lacks great leaders to guide the country towards the transition.

The lack of clear information on what is the state of play of the discussion, what other stakeholders are doing to push the just transition forward, and what concrete options South Africa has, affect the level of trust that the different actors have in the institutions in charge for the energy sector (Figure 36). Many of them were not aware or not fully aware of the activities conducted by the institutions involved in developing national just transition plans, like the National Planning Commission, the Presidential Climate Change Coordinating Commission, and National Economic Development and Labour Council (this was said in different ways by at least 4 interviewees). It is perceived by many that these institutions focus on the discussion of theoretical concepts and ideas but fails in taking action and implementing the plans since they don't have the mandate for it. One of the interviewees affirmed that the Government does not always allow NEDLAC to fulfil its mandate. The interviewee reports that NEDLAC's councillors should, in principle, discuss any policy proposal that might affect the social security of the country: however, it is only in the case of Labour Laws that the mandate is strictly complied with. The Government, one of the major constituents of NEDLAC, would sometimes avoid raising the most controversial topics (like the one of just transition planning) in the council to avoid that they could be rejected.

A different interviewee strongly sustains that none of these entities will ever succeed in their tasks unless they will manage to convince a few powerful people in the Government. Quoting from what s/he said: "At the end of the day, there are, I would say, probably ten individuals in this country that really make the really important decisions. Those decisions are made, probably in discussions with each other and then trickled down and implemented through organizations like the DoE etc. I don't think it's a bottom-up process in this country yet. We'll get there. But the belief that you could put together a committee to influence the DoE, put together a plan to get the plan approved and signed off in cabinet… None of that's going to happen unless ten people like this. I had a friend at Eskom who was part of the IRP process many years ago. He kind of resigned from the process. I asked, why. He said, because no matter how many objective facts and figures we gave the facilitators of the process, they were fixed on a particular path. They wanted a particular outcome."

As the interviewee from the National Planning Commission stated, the reason for implementing the NPC was precisely to institutionalize long-term planning beyond the administration of a particular period. The NPC has advised the Presidency to appoint the P4C to specifically deal with the transition and climate-related issues. The commission has been officially formed in December 2020: therefore, it is likely to expect that many stakeholders do not know yet what to expect from this new statutory body. The R10 and R11 feedback loops describe carbon lock-in situations, but these dynamics have very recently started to be influenced by external events – such as the just mentioned formation of the P4C. The COVID pandemic has, for sure, put a lot of pressure on the already weak South African economy: however, it has also motivated the different stakeholders to gather and centralise the discussion on the topic of just transition.

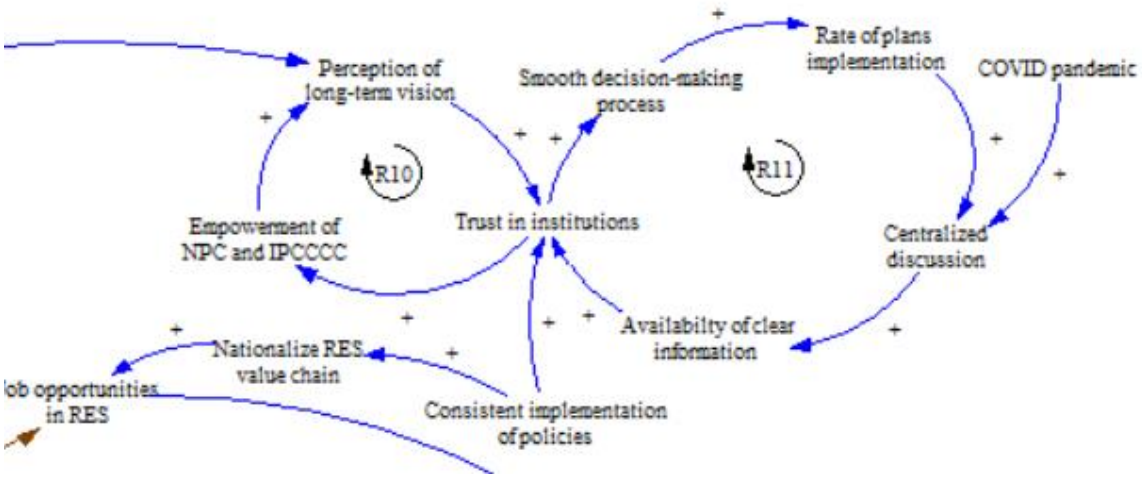

Figure 36 - Feedback loops R10, R11 - South Africa

7. Discussion & Suggestions

By looking at the feedback loops described in the previous chapter, it was possible to identify the dynamics that hinder the transition in the power sectors of Poland and South Africa. This chapter introduces some suggestions that might help to defuse the feedback mechanisms and overcome the barriers faced in both countries. The suggestions have been inspired by the results of the interviews and the System Dynamics Models, and have been complemented with a literature review.

7.1. Poland

7.1.1. Design and prepare a more ambitious restructuring plan

It was mentioned earlier in the report that the newly proposed restructuring plan for the coal and the energy sectors in Poland has received several criticisms. Similarly, the Polish Energy Policy until 2040 (PEP2040) assumes unrealistically high shares of coal for the next decades. The PEP2040 assumes only a 32% share of RES in electricity generation in 2030, while the EU average is expected to be 68% (Czyzak & Wrona, 2021). The European Commission estimates that the average reduction of CO_2 emissions in the power sector should amount to approximately 70% in 2015-2030, whereas in the PEP2040 it is 25% (Czyzak & Wrona, 2021). It is unlikely that the European Commission will approve the policies and plans proposed by the Polish Government since these would prevent the entire Community from reaching the 2030 climate targets (Czyżak et al., 2020; Czyzak & Wrona, 2021). As explained earlier in the text, the capacity market will soon come to an end, thus many power plants won't be able to operate anymore: if by then Poland will not have installed sufficient new capacity, the country risks facing security supply issues (Czyżak et al., 2020; Czyzak & Wrona, 2021). In 2020, due to the pandemic, the electricity demand in Poland decreased: however, the electricity generation decreased even more, thus the electricity import has increased by 25% compared to the previous year, accounting for 7,8% of the consumption (Jedra, 2021).

The Polish think-tank Instrat has analysed the restructuring plan and the PEP2040, and designed an alternative solution: according to the study, Poland can fulfil the EU requirements by phasing out all the coal-fired power plants by 2035 and spending less than what forecasted by the Government (Czyzak & Wrona, 2021). To find a path for shutting down the individual coal power units, the study takes into account the expiry dates of power contracts, the marginal cost of energy generation, the emissivity, and the commissioning dates. At the same time, the RES potential of Poland is analysed to assess the possibilities of replacing the power capacity. The wind and solar energy potentials obtained are more conservative than those estimated by the EC; the investments in new gas-fired power plants were minimised; conservative assumptions have been made concerning energy imports: nonetheless, the model estimates that the RES capacity will exceed the conventional one by 2030. The optimisation shows that when the demand peaks, importing is generally cheaper than generating electricity from the traditional capacity units. The analysis also includes a scenario that limits the import to the minimum: this makes the share of coal in the energy mix increase to 25% (instead of 13%), however, the share of RES would be 63% - twice as planned in PEP2040 (Czyzak & Wrona, 2021). None of these two scenarios can allow Poland to meet the EU climate objectives (i.e. -55% GHG emissions and 2% of coal in the electricity mix by 2030), but they are much more close to the goal than the scenarios proposed by PEP2040 (Czyzak & Wrona, 2021).

The plan proposed by Instrat is much more ambitious than those prepared by the Government: is it feasible, though?

The reason why the capacity market in Poland will expire by 2025 is that a new EU regulation states that "units emitting more than 550 gCO_2 from fossil fuels per kWh of electricity and more than 350 $kgCO_2$ from fossil fuels on an annual average per kWe of installed capacity" will be prevented from receiving State-aids (Czyzak & Wrona, 2021; Gawlikowska-Fyk et al., 2019; Komorowska et al., 2020). The joint structure of the conditions is crucial: if a generating unit reduces emissions of CO_2 to 350 kg/kWe, it is not subject to exclusion from payments under the capacity market. According to the model, in the 2030s, the volume of energy from renewable sources in the Polish power system is so large that coal-fired power plants are used only to secure the power balance at times of low windiness, and this opens the door to conclude additional capacity market contracts which would not contribute to an excessive CO_2 emission (Czyzak & Wrona, 2021).

As discussed in the previous chapter, the restructuring plan by the Government is criticised for not taking into account important factors and therefore underestimating the costs of project implementation. Instrat estimates that the restructuring plan (i.e. NABE/EDM) would cost the State Treasury (i.e. the tax-payers) €13,78 billion, while the above described alternative proposal would cost €3,11 billion (Czyżak et al., 2020; Czyzak & Wrona, 2021). However, the proposed mechanism partially relies on the funds generated by the capacity market: it might be necessary to diversify the sources of financing to avoid burdening energy-poor households and the competitiveness of the Polish industry (Czyzak & Wrona, 2021). Higher shares of RES require extensive transmission network projects: the report by Instrat does not discuss this point but mentions that the issue will be discussed in one of the next publications (Czyzak & Wrona, 2021).

A further option that Poland might evaluate is to emulate the decarbonisation plan adopted in Germany to phase out coal-fired power generation by 2038. The plan has been proposed by the specifically established Commission on Growth, Structural Change and Employment ("Coal Commission") and it foresees to gradually decommission the coal fleet, to avoid jeopardising the system stability (BMWi, 2019; Litz et al., 2019). A bidding process has been designed to determine the order of decommissioning and the compensation to be received for early shut-down of hard-coal capacities (Litz et al., 2019). Even this plan has not been exempt from criticisms: the first auction has taken place in 2020 for the decommission of 5 GW of hard coal power plants (Czyzak & Wrona, 2021; Wehrmann, 2020). Half of the power units that won it were 7 years old or younger: this means that while the newest power plants shut down, the oldest and most inefficient ones keep running (Czyzak & Wrona, 2021; Wehrmann, 2020). The competition observed at this first bid round was stiff, and the reverse auction mechanism failed to take into account factors such as the efficiency of the

power units (Czyzak & Wrona, 2021; Wehrmann, 2020). For what concerns lignite plants, a bidding scheme could not be applied since there are only two operators in the country: the compensation will be paid according to mutual agreements (Litz et al., 2019; Wehrmann, 2020). The German Government plans to pay the two operators a total amount of €4,35 billion for foregone profits and additional mine rehabilitation costs resulting from the anticipated closure (Wehrmann, 2020). However, the EC has not yet given its consent to conclude the operation: the Commission has opened an in-depth investigation to verify that the compensation will be kept to the minimum necessary (Podesta & Astuti, 2021).

If Poland adopted a coal phasing-out plan similar to the one of Germany, the cost that the State Treasury is expected to pay for the auctions amounts to PLN 16,1 billion (€ 3,5 billion) (Czyzak & Wrona, 2021).

The proposal described in this chapter might still need some further investigations; however, they show that Poland can draw more ambitious coal phase-out plans than those recently published by the Government and that it will have to for meeting the EU constraints. Several literature resources remark that the Polish Government has not committed yet to a date for phasing out coal, which would be needed to establish a timeline and send a clear message to the involved stakeholders (Czyzak & Wrona, 2021; European Commission, 2020e; Mustata, 2020): the Government and the trade unions have recently proposed to phase out coal by 2049, but this deadline is criticised by many for being too far (Gera, 2021). Poland also needs to speed up the installation of alternative capacity to avoid an electricity supply gap: the regulative framework should be transformed for being more favourable to the spread of new power technologies. Since 2016, the spread of onshore wind power plants has been hampered by the so-called 10H Distance Act, which prevents a wind turbine to be closer than 10 times its height from a residential area (Gajowiecki & Lasocki, 2020; Ministry of National Assets, 2019a). As the technology evolves and the turbines become higher, it is increasingly difficult to find land available for the construction of new wind farms. The regulation prevents around 98% of the country's land to be used for wind farms, and it is blocking the construction of houses and buildings as well (Gajowiecki & Lasocki, 2020; Ministry of National Assets, 2019a; SEOgarniacz, 2021). The Ministry of Development, Labour and Technology announced its intention to amend this act (Gajowiecki & Lasocki, 2020; SEOgarniacz, 2021).

7.1.2. Nuclear power: will it play a role?

Poland claimed that nuclear power will play a central role in the decarbonisation of the power sector: 6 to 9 GW of nuclear capacity should be installed by 2043 (around 10% of the electricity generation), and the first unit should be operative by 2035 (Ministry of National Assets - Poland, 2019). Several interviewees stated to be sceptical about this claim: no concrete action has been taken by the Government to pursue this plan; there seems to be a lack of investors willing to support the project; the public opinion is strongly against nuclear power and the Chernobyl accident is still impressed in the public memory (Brauers & Oei, 2020; Şahin, 2018).

The trend in Europe might not be the most favourable to nuclear power: many countries such as Germany, France, and Belgium started phasing out nuclear after the Fukushima accident in 2011 (Appunn, 2021; Golombek et al., 2016; Martini, 2021). However, the use of nuclear power is still highly debated and its supporters highlight how it could play an important role in climate action. The newer nuclear technologies are more flexible and more dispatchable than the traditional large-scale nuclear power plants: a Small Nuclear Reactor (SNR) might require only 3 to 5 years for being constructed instead of 20 (ANSTO, 2020; Martini, 2021). The shorter time of construction reduces the risk of the investment and might generate new job opportunities for the former coal workers in a reasonable timeframe. New applications of nuclear energy companied with electrolysis are being studied, and the produced hydrogen could serve the role of energy storage and stabilize the fluctuating load of the electric power grid (Jianu et al., 2016; Martini, 2021).

The Polish nuclear plans to date are still at an early stage of development, but there is an urgent need for new and low-emitting power capacity units. If Poland intends to invest in nuclear capacity, it is necessary to

accelerate the project design phase. However, it would also be necessary to educate the population on the advantages of nuclear power: a transition towards nuclear power might be accepted and perceived as "just" only if the central Government will put a lot of effort into a communication campaign to address people's concerns on the safety and the environmental impacts of the technology. Looking at the global trends, investing in renewables and walking people through a transition towards renewables might work out better for pursuing a just energy transition in Poland.

7.1.3. Elements of Just Transition

Pursuing a Just Transition means trying to address every stakeholder's needs and draw a plan on which everyone can agree. This does not come easy, especially when major changes are expected. In the case of Poland, two key aspects for guaranteeing a just energy transition emerged from the interviews.

- Collect data on the coal workers and open a dialogue with them

For a long time, the workers employed in the coal industry have benefitted from advantageous contracts (Baran et al., 2018; Lewandowski et al., 2014): they are reluctant to change because they fear a worsening in their working and living conditions. Whilst it is rightful and necessary to take into account their perspective, it should not be forgotten that the coal sector has been performing very poorly for years (Baran et al., 2018; Lewandowski et al., 2014; Nyga-Lukaszewska et al., 2020; Schwartzkopff & Schulz, 2017). The above-average favourable contracts of the coal workforce are sustained by the State, thus by the taxpayers: this situation is not "just" for the rest of the population. The global trends in the energy sector and the EU climate targets make it hard to justify why the State keeps subsidising a declining industry. As largely discussed, the transition in the power sector is much needed: for it to be fair towards the coal workers too, it is necessary first of all to educate them on the reasons for the transition. According to many of the interviewees, the Polish population – and particularly the coal workforce – is less educated on climate change compared to the other Europeans.

One of the interviewees stated that the discussion on phasing out coal is sometimes quite emotional and too little fact-based. A lot of emphases is put on the impacts that the power sector transformation will have on the labour market and the employment levels. The employment in the coal industry has been declining for years, and the average age is around 50 years old: many coal workers are close to retirement (Baran et al., 2018; Lewandowski et al., 2014). The demography of the coal workforce might not the same in all regions though: in Wielkopolska, 45% of the employees won't acquire pension rights by 2030, thus they'll need support in re-entering the market job (Azau et al., 2021). A more recent and comprehensive demographical analysis of the coal workforce of Poland is the first step needed to start discussing concrete plans.

For the transition to be perceived as inclusive, the employees who will be impacted by it should be provided with a few options among which to choose: this emerged from the interviews, and a similar criticism was made against the German coal phase-out plan, namely the fact that the affected stakeholders were not given more than one alternative (Litz et al., 2019). From the data currently available and the testimony of the interviewees, it seems that most of the coal workers would rather accept a gold handshake instead of a retraining program. However, the early retirement mechanism should be designed in a way to prevent them from both receive financial compensation and get a job in a different coal mine or power plant, as happened in the past (MEP Gadowski & MEP Saługa, 2008; Minister Pawlak, 2008; Wyborcza, 2006): this would vanish the effectiveness of the program. Younger employees should be offered different options than those closer to retirement. The economy of Poland can absorb most of its labour force and the unemployment rate has been quite stable despite the pandemic (5% in 2019, around 6% in 2020) (Sas, 2021; Statistics Poland, 2021). The coal workers might prefer to get a new job from the same employers, thus in the energy sector (R3): as explained already, Poland needs to mobilise great investments in new capacity units, so the RES industry will create many jobs (Azau et al., 2021; Slimko, 2019). Other sectors such as logistics, IT, tourism, construction, and healthcare might offer further opportunities (Azau et al., 2021; Slimko, 2019).

- Share experiences and adopt a more inclusive approach

When discussing loop R7, it was reported that some stakeholders perceive that the Government operates in an authoritative and not inclusive way. The regional authorities would sometimes prefer to be given more autonomy in their activities since they are not always aligned with the directives shared by the central Government. At the same time, while the discussion on just transition paths for the power sector might be advanced among some experts, the topis is still quite new to some stakeholders. Furthermore, the discussion is sometimes lead by emotive topics rather than facts.

In some regions, the discussion over just transition is at a more advanced stage compared to the rest of the nation. A few interviewees mentioned the case of Wielkopolska: ZE PAK (the great lignite producer of the region) committed to ending coal operations by 2030 (Azau et al., 2021; Hetmanski, 2021; Slimko, 2019). In Wielkopolska, the civil society has been asking for the closure of the opencast mines for a few years, due to the negative impacts these have on the agricultural activities, and it has been the first to become involved in the EU Platform for Coal Regions in Transition (Slimko, 2019). In April 2019, over 40 entities from the region (private companies, NGOs, local government) signed the Agreement on Eastern Wielkopolska's just energy transition, declaring their willingness to enhance their cooperation in implementing new initiatives and investments in the region (Slimko, 2019). The agreement was the result of several conferences, debates, and public hearings organised in the region during the past few years, to discuss the major issues of the area: the reduction in yields and the loss of ground water caused by the polluting mining activities; the outflow of young people from the region; the monolithic nature of the local economy; the low profitability of the lignite industry (Hetmanski, 2021; Slimko, 2019). The discussion has not always been easy, due to the variety of visions: it takes time to agree on what "just transition" means, and compromises are required from all interested parties; the communities living outside big cities complained about being less involved in the decision-making process compared to the urban communities; the debates so far have focused on the economic and social issues and have partially omitted the environmental ones, which are also relevant and should be taken into account (Slimko, 2019). One of the obstacles faced is the absence of guarantees and clear directives from the central Government, but support will be provided by the EU Just Transition Fund (Hetmanski, 2021; Mustata, 2020; Slimko, 2019). Given the proactivity demonstrated by the regional actors, the Government is only required to support the already launched activities and projects.

The case of Wielkopolska is a positive example that should be shared and replicated in other regions of Poland. The central Government might support other regions in adopting the same approach. This seems to be the intention of the Ministry of Climate, in charge of compiling the National Just Transition Plan (Reinforcing 7). It is recommended that the central authorities will make the communication on the pursued activities as clear and transparent as possible, to reduce the perception of intrusion and the mistrust felt by some stakeholders.

7.2. South Africa

7.2.1. Addressing the lack of skills and know-how in the power sector

Eskom has already tried to compensate for the lack of engineering skills in the country by implementing some training programs (MacColl et al., 2012). An example is given by the Eskom Power Plant Engineering Institute (EPPEI) launched in 2012 (EPPEI, n.d.; Jestin, 2018; Wyrwa et al., 2016). The Institute offers Master and Doctoral programs that involve eight Universities in South Africa and provide the students with the skills required to face the energy crisis. The courses and the research projects proposed to the students are designed by the Academic institutes in partnership with Eskom Holdings (MacColl et al., 2012). To enrich the offer of EPPEI and enhance the renewable energy know-how in South Africa, the Institute has tried to develop cooperation agreements with similar post-graduate programs in Europe, such as the Masters provided by EIT InnoEnergy (Wyrwa et al., 2016). These kinds of collaborative activities can be a great support to mobilise knowledge and skills towards the South African power sector and support Eskom and the IPPs in advancing the energy transition, thus more similar initiatives should be developed. Similar projects would benefit the

foreign partners too, since their post-graduate programs would be enriched with more hands-on experiences of what does the energy transition looks like in less developed economies, giving the students a more global perspective on the challenges of the sector. As discussed earlier in the text (B7, B8), the lack of engineering skills in South Africa is an issue for the IPPs too and several companies in the emerging renewable energy sector are either (at least partially) foreign-owned or in partnership with foreign companies. If the renewable energy know-how grew in the country, it would benefit several stakeholders: some IPPs and some foreign investors might be interested to support different forms of international cooperation. South Africa has a good solar and wind power potential, and the emerging RES companies need more people able to design a project that is both technically and economically feasible, as well as to write a proposal for the approvement of the project by the authorities and the possible investors.

7.2.2. Transform the power sector: new business models

The South African power sector is not sustainable neither from an environmental nor from an economic point of view, as it was extensively explained. The current situation suggests that a major change in the structure of the power sector might be needed, and this is the same reason why the Government has announced the intention to unbundle Eskom. There is little evidence to support that unbundling Eskom could be sufficient to solve the energy crisis that the country is facing, and the Presidency likely aims to, eventually, introduce elements of privatisation in the sector. As also emerged from the interviews, there are a few key points that should be taken into account while designing the power sector reform.

First, the three new subsidiaries and the System Operator in charge to oversee their activities should be independent of each other. It is desirable to remove the buying function from the tasks assigned to the Transmission Entity, and to create a separate System Market Operator to purchase the electricity from the power producers: this will be necessary to guarantee non-discriminated access to the grid.

If the three entities were to be sold to the private sector, it might be difficult to find investors interested in buying coal-based generation facilities. A few options might be considered and evaluated:

- Eskom Generation – thus, the coal power fleet - should remain State-owned, but at the same time, the normative context should become more attractive for the spread of new independent power producers. The 1-MW cap should be lifted[34], and there should be more frequent REI4P bid rounds. The increasing availability of electricity providers will reduce the electricity supply gap and thus the State/Eskom will be able to gradually decommission the coal power plants, starting from the more inefficient ones. This scenario might only be effective if the policies and regulations will favour new investments in RES, possibly gas and/or nuclear.
- The State should design and implement some policies to incentivise the private sector to purchase and then repurpose the coal fleet. For instance, the State might introduce a new type of bid: the aspiring IPPs could be required to not only design a power supply solution, but also a repurposing project for the decommissioning power plant they are going to replace. In case an aspiring IPP cannot design both projects, it might partner with an external company, even from a non-energy-related sector. This kind of bid might drive the economy and generate new job opportunities in different fields: the Government might decide to set specific constraints concerning who might access these new vacancies, and this might be a solution to guarantee employment to the coal workers of the decommissioning plant. However, as pointed out by one of the interviewees, in a country where one-third of the workforce cannot find a job, everyone deserves a shot: thus, instead of securing the new job positions to the former miners only, the Government should elaborate a mechanism to generally facilitate the less advantaged social classes, as it did already in the REI4P program (see *Elements of Just Transition: Job security*). The case reported by

[34] On June the 10th the President announced that the cap will be shifted to 100 MW within the next two months (The Presidency, 2021).

loop R4 demonstrates that designing similar constraints might be challenging since the risk is to distort the dynamics of the labour market.

- The State may opt for decentralising the management of the power sector. Since the Municipalities have recently gained more autonomy in the choices concerning electricity procurement (DMRE, 2020c), new and diverse solutions might be designed and tailored-made according to the needs of different regions (Montmasson-Clair et al., 2017). It might be easier to test a new business model or electricity market reform on a small scale first.

Eskom is losing customers due to the spread of rooftop PVs, and it is unlikely that the utility will manage to stop the trend. In other countries, the utility companies that have been facing the same challenge have decided to embrace the change and adapt their business models (Barbose & Satchwell, 2020; Dunlop & Roesch, 2016; Mishra et al., 2018). Similarly, Eskom might become the one that assists the householders to implement a rooftop PV, and this business model might have several advantages (Barbose & Satchwell, 2020; Dunlop & Roesch, 2016; Mishra et al., 2018):

- Eskom would not lose the customers that opt for a PV panel, but will charge them for the installation and maintenance services;
- Given the increasing price of the electricity that Eskom generates from fossil fuels, paying for the adoption of a rooftop PV might be advantageous for the user, depending on the tariff scheme that Eskom will propose;
- The centralised management of the PVs spread will have the advantage of the economy of scale and will ease the task of grid management;
- If the solar PVs spread was centrally managed, it might be easier to find new job opportunities for the coal workers, since they will still be employed by the same employer;
- If Eskom cannot provide these new services, it might find an agreement with a partner like South African Photovoltaic Industry Association (SAPVIA). SAPVIA might help both for the installation and maintenance of the PVs as well as for training the former coal workers.

Albeit there are many hypotheses in this business model proposal that would need to be validated, this solution might support the power sector to undertake the energy transition in an organised way: several of the interviewees stated that to be "just", the transition should be planned to take place gradually.

7.2.3. Elements of Just Transition

Different stakeholders have different interests, thus it is not an easy task to define a solution that will satisfy every actor involved. Nonetheless, a Just Transition approach endeavours to guarantee the fairest solution to everyone. While conducting this research, a few key elements for a just transition in South Africa have been identified:

- Job security

The stakeholders who ask for a slower transition are mainly concerned by the impacts that the transition will have on the labour market. The loops B5, B6, B7 identify the sectors where the respondents foresee that new job opportunities will be created, although some of them doubt the number of job places provided by some studies. What would benefit the pace of the energy transition and would make it fairer towards the different interested groups is to prepare tangible plans. The REI4P bid program is a successful example from which to learn (Deloitte, 2019; Eberhard & Naude, 2017; Overy, 2018):

- It achieved to contain the load-shedding phenomena, which would have been much worse otherwise. The RES proved to be reliable and increasingly affordable as the technologies evolve and the know-how spread in the country.
- It included some just transition principles: the projects were evaluated according to a multicriteria 70:30 split between price and economic development criteria respectively (Filipova et al., 2019). The economic

development criteria included the number of jobs created, elements of broad-based black economic empowerment, etc., as shown in Appendix 8.

Projects like the REI4P one should be implemented more frequently, to ensure a faster spread of new electricity sources in the country (Deloitte, 2019; Overy, 2018). As mentioned in the *Transform the power sector: new business models,* new bid schemes might be designed to address the concerns relative to the power sector transition: new employment opportunities for the coal miners; economic development of the poorest regions of the country; repurposing of the coal mines and the coal power plants. Ideally, South Africa should try to launch several and frequent bid rounds, that might have different constraints one from the others, to boost a diversified economy and to distribute the benefits among the country.

There are different examples of coal power plants and coal mines repurposing projects around the world, and the repurposing activities might address the need for new job opportunities. Converting former coal plants into solar plants seems to be profitable in India (Shrimali & Jindal, 2020), while a study in Chile investigated the possibility to retrofit a plant into a thermal storage plant (Geyer et al., 2020). Coal mines might be converted to serve agricultural purposes, or to become touristic attractions (Staple & Slavin, 2012; Tyson, 2020; World Bank Group, 2018).

While other regions show greater solar and wind power potential, the RES potential in Mpumalanga is still quite high (Solargis s.r.o., n.d.): some of the future calls for projects might introduce a geographical constraint, to secure that a share of the new projects will be developed in the coal regions. Several options might be taken into account, and it is necessary to investigate what would have the best possible output: however, a diverse set of bid rounds could be less risky than opting for a single solution. Moreover, Mpumalanga is rich in valuable minerals also compared to the rest of the country: the energy transition is driving the demand for minerals, and this trend might favour the economy of the region (DEDET, 2011). Mining, however, is carbon-intensive, so a green transition is also needed in the mining sector to avoid nullifying the benefits of higher shares of renewable energy and addressing climate change (Hund et al., 2020; The World Bank, 2017).

- Transparent communications

During the interviews, it emerged that each stakeholder might have access to different information, and it might be difficult for some of them to have a holistic understanding of the subject. The debates and researches on the possible transition paths for South Africa have been scattered and sectorial in the past years, but this has recently been changing, as demonstrated by the institution of the Presidential Climate Change Coordinating Commission (P4C). This statutory body has been formed to coordinate and oversee the just transition towards a low-carbon, inclusive, climate change resilient economy and society since it has indeed been stressed by the NPC the need for a dedicated entity (Creamer, 2021; The Presidency, 2019; TIPS, 2020a). Reflecting on the outputs of the interviews, it appears that if the citizens had more easy access to information such as the activities conducted by institutions like the NPC or NEDLAC, there would be a higher level of reciprocal trust in South Africa. If the state of play of the discussion on the transition could be understood by the whole population, and not only by the insiders, it would be easier for everyone to recognise the reasons behind the transition and thus accept it. The need for the authorities to be transparent in their activities is not unique to South Africa: the SDG number 16 asks for "accountable institutions" (United Nations, 2016); the EU is striving to guarantee the citizens greater access to its decisions, policies, and documents (Panizza, 2019). Similarly, the guidelines for a just transition provided by the ILO stress the need to establish a social dialogue and ensure that all the stakeholders are involved (ILO, 2015).

The digital transformation might enhance the transparency of the authorities, and South Africa might benefit from European projects to advance the digitalisation: the European Commission has been promoting Africa-EU cooperation since 2000 and has recently reiterated its intention to strengthen this strategic partnership by supporting investments to boost the green transition and digitalisation (European Commission, 2018;

Marin-egoscozabal, 2020). In September 2020, the EC launched a €1 billion call for research and innovation projects that respond to the climate crisis and favours digitalisation (European Commission, 2020g). The call includes opportunities for international cooperation in addressing the needs of less-developed nations, particularly in Africa, in the context of the Paris Agreement as well as the Sustainable Development Goals (SDGs) (European Commission, 2020g). One of the interviewees argued that, according to him/her, the country lacks people with both technical and leadership skills – a linkage between the technical and the political worlds - who might push forward a just energy transition. This issue recalls what was discussed in the *Addressing the lack of skills and know-how in the power sector* chapter. More multidisciplinary training and educative programs should be arranged, and the funds from the Africa-EU cooperation might be mobilised to support similar initiatives (European Commission, 2018, 2020g).

- Electricity access and affordability

The SDG 7 asks for "Affordable and clean energy" for all since access to electricity is a key element to guarantee the development of an economy (IEA et al., 2019; United Nations, 2016). The South African power sector to date is failing to provide the population with access to affordable electricity, and this affects the wellbeing of the national economy. 10% of the population does not have access to electricity (The World Bank, 2019a), and electrification is lower in the rural areas of the country (IEA et al., 2019). In the rural areas, implementing distributed energy resources (DER) such as microgrids can be much more cost-effective than connecting to the grid: furthermore, the national grid would not be able to support an increase in the electricity demand. Since the Municipalities are now entitled to self-generate electricity, new solutions can be designed according to their local power needs (Montmasson-Clair et al., 2017). A more favourable normative context and the spread of RES know-how in the country would allow 10% of the population to finally access electricity, improving their living conditions and opportunities.

The interviewees had conflicting opinions on the effect that higher shares of renewables immitted into the grid would have on the price of electricity (see Balancing 8). On one hand, the favourable natural resources and the declining cost of renewable technologies seem to suggest that a renewable-based supply system might be more affordable than the existing one, which is old and inefficient (Solargis s.r.o., n.d.; Taylor et al., 2020). On the other side, higher shares of renewables pose several challenges to the stability of an electricity grid: this is a side of the matter which is often left out of the discussion (IRENA, 2017; OECD & NEA, 2019). Nonetheless, installing a new renewable power capacity is now cheaper than installing a new coal power capacity (Taylor et al., 2020).

8. Conclusions

This research aimed to identify and study the barriers that obstruct a just transition to take place in the power sectors of Poland and South Africa as well as the factors that are, on the contrary, pushing it forward. The juxtaposition of the two countries highlights the similarities and differences of pursuing a just transition in different political, economic, and social contexts, enriching the literature available on the application of these theoretical concepts to real-life case studies. First, the power sectors of Poland and South Africa were explored by applying the Sectorial System of Innovation framework. The data collected from the literature review were subsequently integrated with the information gained from 17 interviews with stakeholders involved in the power sectors of the two countries. The interviewees were asked questions also on what they would consider as a just transition for all, what they perceive to be the state of play of the discussion on the topic in their country, and what they believe to be the main obstacles to a fair transition.

Both power sectors are strongly reliant on coal power plants. In both cases, the coal industry has been facing a decline in productivity and profits due to the increasing costs of mining activities. This trend is having an impact on the power sectors of the two countries. Poland is and will be facing a steep increase in electricity tariffs due to the emission allowances prices in the EU ETS (Gawlikowska-Fyk et al., 2019; Ministry of Climate, 2020; Paska et al., 2020). The Polish coal power fleet has been subsidised by the State since 2018, but by

2025 EU regulation requires Poland to stop such subsidies (Czyżak et al., 2020; Czyzak & Wrona, 2021). The European Union aims to become the first carbon-neutral continent by 2050 and the MSs are undergoing major transformations to reduce their emissions (European Commission, 2019a): the GHG emissions should be reduced by 55% in 2030 (McPhie & Rietdorf, 2021), and to meet this target the EC estimates that the CO_2 emissions in the power sector should decrease by 70% (Czyzak & Wrona, 2021). The power and heating sectors in Poland are responsible for about 50% of the national emissions (Eurostat, 2020b; IEA, 2018a), thus the country will need to install high shares of low-emitting power sources in the next few years. New capacity units are needed also to prevent electricity supply gaps in the future since the coal power fleet is getting old and inefficient (Gawlikowska-Fyk et al., 2019). South Africa, instead, has been facing electricity security issues since 2008. Due to poor maintenance practices in the past, the coal power fleet to date is extremely unreliable (Kessides, 2020). The State-owned utility company Eskom is facing a critical financial situation, thus it is not in the position to mobilise huge investments in new capacity units. On the other hand, the National Energy Regulator prevents the electricity price to reflect the full generation cost to protect the low-income population (Maphosa & Mabuza, n.d.; NERSA, n.d.).

Both in Poland and South Africa, the coal industry is highly unionised and its workforce benefits from advantageous working contracts compared to other employments requiring a similar level of education. Trade unions are among the stakeholders not keen on a fast energy transition due to the uncertain consequences this will have for the employees of the sector. In South Africa the issue is exacerbated by a high unemployment rate and a high Gini coefficient: around 65% of the coal workers are below 45 years old (Hallowes & Munnik, 2019), and finding a new job might not come easy to them. The economy of Poland is much more capable to absorb the workforce in the country, and the average age of the coal workers is higher (Baran et al., 2018), thus more employees might be able to retire in the coming years. However, in Poland as in South Africa, the coal activities are concentrated in a few regions which have a little diversified economy: if no action is taken, the fading out of the coal industry will leave these areas with few income opportunities.

The Just Transition framework does not provide a precise roadmap, since every application case differs from the others (ILO, 2015). However, a just transition path generally undergoes three steps: Engagement, Planning, and Enactment (Henry et al., 2020) (Table 20).

Table 20 - Just Transition phases in Poland and South Africa

	Poland	South Africa
Engagement		
Planning		
Enactment		

In South Africa, the discussion on just transition has been carried on for a while, although in a scattered way: the COVID pandemic has pushed the stakeholders to coordinate their efforts. The stakeholders can meet and dialogue through platforms like the National Economic Development and Labour Council (NEDLAC) or the webinar series organised by the research institute TIPS. The Presidency has recently appointed the Presidential Climate Change Coordinating Commission (P4C) to oversee the national just transition planning (The Presidency, 2020; TIPS, 2020a), and Eskom has created a Just Energy Transition Office to evaluating green financing options that could help accelerate the deployment of renewables and facilitate the repurposing of its older coal plants (Creamer, 2020b). South Africa needs more qualified people to carry out the transition and a plan to finance the Enactment phase (see *Discussion & Suggestions*). In Poland, instead, the discussion on just transition started more recently, concurrently with the hosting of COP24 in Katowice (2018) and the launch of the EU Green Deal (2019). The Polish authorities have a long time denied the need for a transition, slowing it down. The ruling style of the Government, as a legacy of the Communist era, is to manage decision-making with little consultations of the interested parties. Exception made for the positive

case of Wielkopolska (see *Elements of Just Transition*), the Engagement of the stakeholders in the social dialogue has been limited so far. The main uncertainty in Poland comes from the lack of clear direction from the Government: however, as soon as a national plan – aligned with the EU goals – will be defined, the country will likely have access to more funding opportunities for supporting the Enactment phase.

Table 21 summarises the barriers, carbon lock-ins, and driving factors affecting the two transitions studied during this research.

Table 21 - Barriers, Carbon lock-ins, and Motivators affecting the just transition in the power sectors of Poland and South Africa

	Poland	**South Africa**
Barriers	Nuclear power - Lack of plans (R5)	Obstructing regulation (R12)
		Fewer job opportunities in the coal industry (R6)
		Public opinion is against nuclear power (R7)
		Nuclear lobby & political interferences (R9)
		Part of the public opinion looks at the IPPs with suspect (B8)
Carbon lock-ins	The dependence on coal is a supply-driven issue (R1, B1)	The decline of Eskom is a human resources issue (R4)
	The trade unions are influent stakeholders (R6)	The poor performance of Eskom threatens the national economy and weakens the financial situation of the utility company (R13)
	A just transition for coal workers - Resistance to change (R4)	Eskom's debts (R5)
		NERSA prevents Eskom to raise the electricity price to protect the lowest classes (R3)
Motivators	The cost of Carbon affects the coal industry (B2)	Enhanced access to affordable electricity is positive for the national economy (R2)
	Energy affordability (R2)	Unbundling Eskom (B3)
	A just transition for coal workers (R3)	New job opportunities (B5, B6, B7)
	Planning a just transition (R7)	People favourable to RES and IPPs (R8)
		Long-term politics (R10)
		Taking action (R11)

Table 22 summarises ways to unlock just transitional paths in both countries. Poland might benefit from clearer communications from the central authorities, and a more participative decision-making process. The plan that will be developed has to be consistent with the EU climate action goals, but then there will be opportunities to unlock subsidies and finance the transition. South Africa needs to find a new business model for its power sector, which should be more sustainable from an economic, environmental, and social point of view. There is a need to attract new human and capital resources into the country.

Table 22 - Dimensions of Just Transition in Poland and South Africa

	Poland	Answer to	South Africa	Answer to
Procedural justice	Greater involvement of the stakeholders could benefit the social dialogue	R6, R3, R7	More communication about what discussed in each platform/sector	R10, R11, R7, R9, B8
	More transparency, clarify roles and procedures	R6, R7		
Distributional justice	Support energy poor households	B2, R2	Support energy poor households	R13, R3, R2
	Offer more than one option to the coal workers	R6, R4, R3, R7	Coal workers should be reskilled	R6, B8, R4, B5, B6, B7, R8
	Many coal workers are close to retirement and would prefer a gold handshake rather than a reskilling program	R6, R4, R3, R7	New job opportunities should come from every economic sector and should be offered to both coal workers and other unemployed people	B5, B6, B7, R8, B8, R6
Recognitional & Restorative justice	Address the environmental issues caused by coal (e.g. Impacts on agriculture)	B2	Diversify economy in coal regions	R6, R13, R5, R8, B8, R11
	Diversify economy in coal regions	R1, B1, R3	New business models are needed for a more sustainable power sector and a more dynamic economy	R12, R6, R3, B3, R5, B5, B6, B7

9. Possibilities for future research

This exploratory research undertook a broad perspective to analyse the power sectors of two countries, how the just transition framework could support their transformation, and what are the main challenges they are facing. The electricity sectors of Poland and South Africa are both regulated by complex dynamics, and delving deeper into a more specific topic was not possible due to limitations of research scope, time, and resources. More in-depth research is required to enable the two countries to make fact-based decisions and push forward the transition towards more sustainable power sectors.

The information collected would be more accurate if more stakeholders were interviewed: for instance, it was not possible to reach any exponent of a Polish trade union group to dialogue with them. Similarly, it would have been interesting to involve in the investigation someone from the Eskom Just Energy Transition Office. The time limitation did not allow to interview more exponents of the same Agent-type (i.e. representatives of more than one trade union group, utility company, coal-mining company, and so on), which would have enriched the results of the research.

The System Dynamic Models that illustrate the dynamics governing the Polish and the South African power sectors have been developed qualitatively only. This methodology is often used for designing quantitative models. The two models introduced in this report might be adapted for a quantitative simulation, although this would require some work. In some cases, when typing the equations to link one variable with the others, it might be necessary to add more auxiliary variables: for instance, to link *Skilled workforce employed in Eskom* [N. employees] to *Maintenance* [Hours], one would need to know the hour worked by each employee and the share of working hours that are spent on maintenance activities (Reinforcing loop 4, South Africa). Some of the variables used in the two models (Appendix 6) have not been assigned a unit of measurement, and doing so would require taking some assumptions – e.g. *Post-Apartheid resentment*. Modify the two models and adapt them to a quantitative simulation would allow estimating the long-term impacts that different interventions may have on the systems. Regardless of the methodology adopted, the decision-makers in the two countries need to collect more detailed data (e.g. demographic data on the workforce employed in the coal industry) to analyse different scenarios (e.g. what kind of and how many job places would different business model generate in the electricity system) and make informed decisions.

Future analysis might focus on small-scale examples of just transitional paths undertaken by a region, a community, a decommissioning coal power plant, or a coal mine: e.g. the region of Wielkopolska in Poland and one of the projects conducted by the Eskom Just Energy Transition Office in South Africa. A detailed analysis of the concrete actions taken to achieve a positive change in a small-scale reality would be beneficial to successfully replicate the experience in a different context. While both Poland and South Africa need a national-scale transformation, the just transition framework, as well as the output of this research, points out that there is not a single solution that can be applied to all situations. Different solutions might be implemented in different regions, however, they should be coordinated so that each local plan will contribute to achieving a national goal. As emerged from the interviewees conducted in both countries, there is a need to share successful case studies and demonstrate that a just transition can be achieved.

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Appendix 1: Interview guide

Poland

Status quo / Expectations on the electricity sector	• How would you describe the electricity sector in Poland **today**? Which main challenges is it facing?
	  ○ How do you envision the Polish electricity sector in 10, 20, 30 years?
	  ○ How fast do you estimate Poland will be able to **phase out coal**?
	  ○ I read that the Government is preparing a restructuring plan for the energy sector, involving both power and coal sectors. Can you talk to me about it? What is your opinion? How could it impact the transition?
	• Who would you define as the main **actors** of the electricity sector and what is their role?
	  ○ Who according to you is **acting against** the coal phase-out and who is **favouring** the transition? Who has a greater influence?

Perception/Opinion on just transition mechanisms	• Are you familiar with the term "Just Transition"? What does it mean to you?
	• Do you think that this concept is relevant for different stakeholders involved in the power sector? Is this a topic on their agenda?
	  ○ Do you think the discussion is well developed already? What is the **state of play of the dialogue** on this theme?
	  ○ How would you describe the relationship among the different stakeholders?
	  ○ Who should take the **lead** in the transition?
	  ○ Are there any actors who have not yet been involved in the discussion?
	• What is your opinion about the **Just Transition Mechanism** proposed by the EU?
	  ○ How has it been accepted by the different interested parties?
	  ○ Do you think it will truly enable Poland to phase out coal?
	  ○ Which projects do you think the JTM should support?

Perception of different stakeholders	• How is the **public opinion** on topics such as just transition, green energy transition, EU Directives …?
	  ○ RET and nuclear power
	• What is the role of **trade unions** in the energy transition? Are they aligned?
	  ○ Do they ease or obstruct the process?
	  ○ How is their relationship with utility companies, government, EU?
	  ○ How did they accept the JTM proposed by the EU?
	• What do you think would be a just solution for the **coal-sector employees**?
	• What is the role of the **utility companies**?

Carbon lock-in factors and barriers	• What is obstructing or favouring a green (just) transition in the electricity sector?
	  ○ Is the **domestic legislation** favourable to the transition? What are the main challenges?
	  ○ How is the relationship of the **government** with the EU directives?
	  ○ Do you think enough investments are being mobilized to transform the power sector?
	  ○ Do you think there is sufficient know-how in the country on RET?

Further aspects	• In your opinion, what can be done to facilitate/make sure that the electricity transition happens, and that it's **just**?
	  ○ What **key aspects** should be taken into account when planning a JT in Poland?
	  ○ What is your opinion on nuclear power?

South Africa

Status quo / Expectations on the electricity sector	• How would you describe the electricity sector in SA **today**? Which main challenges is it facing?
	  ○ How do you **envision** the South African electricity sector in 10, 20, 30 years?
	  ○ How fast do you estimate South Africa will be able to **phase out coal**?
	• Who would you define as the main **actors** of the electricity sector and what is their role?
	  ○ Who according to you is **acting against** the coal phase-out and who is **favouring** the transition? Who has a greater influence?

Perception/Opinion on just transition mechanisms	• Are you familiar with the term "Just Transition"? What does it mean to you?
	• Do you think that this concept is relevant for different stakeholders involved in the power sector? Is this a topic on their agenda?
	  ○ Do you think the discussion is well developed already? What is the **state of play of the dialogue** on this topic?
	  ○ How would you describe the relationship among the different stakeholders?
	  ○ Who should take the **lead** in the transition?
	  ○ Are there any actors who have not yet been involved in the discussion?
	  ○ What do you think of the **National Planning Commission**'s activity? How do you think these dialogues can be translated into action?
	  ○ What do you think of the **NEDLAC**'s activity?
	  ○ What are your expectations towards the **Presidential Climate Change Coordinating Commission**?

Perception of different stakeholders	• How is the **public opinion** on topics such as just transition, green energy transition, phasing-out coal, Paris Agreement …?
	  ○ RET and nuclear power
	• What is the role of **trade unions** in the energy transition? Are they aligned?
	  ○ Do they ease or obstruct the process?
	  ○ How is their relationship with the other stakeholders?
	• What do you think would be a just solution for the **coal-sector employees**?
	• What is and what should be the role of the **utility companies**? (Eskom)
	• What is your opinion on the project of **unbundling** Eskom? Do you think it might have an impact on the power sector transition?

Carbon lock-in factors and barriers	• What is obstructing or favouring a **green (just) transition** in the electricity sector?
	  ○ Is the **domestic legislation** favourable to the transition? What are the main challenges?
	  ○ Do you think enough **investments** are being mobilized to transform the power sector?
	  ○ Do you think there is sufficient **know-how** in the country on RET?

Further aspects	• In your opinion, what can be done to facilitate/make sure that the electricity transition happens, and that it's **just**?
	  ○ What **key aspects** should be taken into account in the context of South Africa?
	  ○ What is your opinion on **nuclear power**?

Appendix 2: Coding, Step 1

Poland

	Code	Opinions	How many interviewees	Code	Different opinions/Contrast	How many interviewees
Status quo of the power sector	1	The power sector has long time been coal dominated. Poland did not diversify the investments, the generation fleet is not flexible.	7	75	Every year Poland needs to increase the amount of fossil fuels imported from other countries, since national production is not convenient any more. We move lot of money outside of Poland - we should	1
	2	The coal fleet is old	5			
	3	The coal price has been raising and thus the electricity price	4			
	4	The restructuration plan proposed by the Government (energy+coal sector) might affect the competitiveness of the market. It is a bad idea.	2	76	The restructuration plan cannot work for a country in the EU. We need a more ambitious plan.	1
	5	I can't foresee when Poland will phase out coal, it might never happen	2	77	Poland will phase out coal around 2050 (maybe a few years later)	3
				78	What is most important is the trend, which is clearly in favour of decarbonisation. If we still have a 20% of coal in the mix by 2050, it's not a big deal as long as the decarbonisation trend is clear	1
	6	Completing the transition by 2049 is too late, it's riddicolous. The State is not brave enought to be direct with the trade unions.	1	79	Poland will phase out coal even before than what is claimed due to economic reasons and regulations. Around 2035.	2
				80	The transition is unavoidable	6
	7	Phasing out lignite might be easier than phasing out coal (technical reasons). Upper regions are more ready than southern regions. Heterogeneous reality.	1			
	8	There is a decarbonization plan, but no concrete action has been taken	2			
	9	Three ministries are invovled in the power sector: Ministry of Climate, Ministry of State Assets, Ministry of Regional Funds	2			
	10	The energy and coal sectors are largely State-owned. This is a conflict of interest. The sectors are State-owned also because many international players left - they know that coal is not profitable anymore	1			
	11	We should have started the transition years ago, starting now makes it more challenging. We denied the need for a transition until a few years ago. If we don't act fast we will face issues like blackouts	3	81	Poland does not have energy security issues thanks to the European market	1
	12	Higher RES share will increase the energy bills because we will need a 'double capacity'	1	82	The transition will reduce the energy bill	2
				83	Poland should transition towards RES because these will introduce more democracy in the power sector. Nuclear should be the last option.	1
	13	The discussion on the transition is too emotional sometimes. We need more logical arguments.	1			
Procedural justice	14	The Government is not prepared to phase-out coal. No one is powerful enough to lead it	2	84	Political forces are in for the transition. The attitude has changed. They were investing in coal in 2015-2020 and now they aknoledge it was a mistake	2
	15	We need a strong leader (Margaret Tatcher in Poland)	1	85	Politicians do not want to disappoint the inhabitants of the coal regions	1
	16	The three ministries involved actively obstruct each other	1			
	17	The JTM might succeed in some regions but will fail in some others, due to politics interference.	1	86	If the process will be well managed, the JTM can make the difference. I trust who is managing the process. Getting the money can show that the government has a solid plan.	2
	18	The JTM money is not enough for the Polish transition to take place. The government would need to largely contribute.	3	87	Poland could benefit from different EU mechanisms besides JTM (e.g. Recovery Plan, Modernization Fund...)	2
	19	The T.U. are not interested in the JTM. The money cannot buy their power.	1	88	Althought the JTM money is not enough, the fact that there is some money is driving and speeding up the discussion on the transition.	
	20	The JTM is meant to be managed by the regions.	3	89	The National Plan is the one that will be sent to the EC in June	1
	21	There are lot of debates and seminars organised by the Municipalities. Some Municipalities are very active e.g. Wielkopolska. In these cases, the State should let them lead and do not intervene.				
	22	JASPERS (EC research center) is supporting the regions in developing the plans	1	90	The EC cannot intervene	1
	23	The Ministry of Climate is writing a National Plan just to make the regions nervous. Politics interference.	1			
	24	Colonialism does not work in Poland: EU cannot manage the Polish transition. Polish are scared that the transition will benefit foreign countries e.g. Germany (external actors gaining control on our decisions making processes)	2	91	Although this opinion is very unpopular in Poland, I think we need an external player to supervise our discussions on the transition	1
	25	Utilities, Government, and Trade Unions are quite aligned in their visions	1	92	Trade unions are very powerful, their protests can be very impactful. They can be violent. They are respected because of the role they played during the political transition	4
	26	Only a few trade unionists are very radical, you can discuss with most of them.	4	93	The Government is scared by the Trade Unions, they don't want to piss them off. They will agree to their requests and then blame the EU if they can't respect their promises. Trade unions can be violent.	4
				94	Trade unions have financial interests in the coal industry	1
				95	T.U. and government are fighting. They are just pulling the line. No real discussion. Individual trade unionist might be in favour of the transition, but they cannot claim it in public.	4
	27	The society, specially the coal workers and the trade unions, are not quite convinced yet to phase out coal	1	96	NOGs, SMEs, Academy, and Municipalities are quite involved in the discussion. Big utility companies were not convinced in the past but they are changing their attitude now.	1
	28	NGOs are gaining more influence	1			

	29	Prosumers are gaining more influence	1			
	30	Our government does not involve other stakeholders in decision-making processes (for any kind of decisions). Autorative method/cetralized decisions. Lack of transparency.	2			
	31	The transition should be slow	1			
	32	The transition will be painful	3			
	33	The discussion on the transition started with the EU Green Deal/COP24	3	97	We don't discuss about JT in Poland	1
	34	The discussion is well developed among scientists and policy makers, but not among common people. Even in regional plans, the civil society is not involved	1	98	NGOs are writing unofficial reports (useful)	1
				99	National plan: we will involve civil society	1
	35	There is discussion but no implementation	2	100	We will soon need a JT legislative document in order to benefit from EU money	1
				101	People are scared because they can't see a clear plan, some options	1
	36	We need to educate people and explain why the transition is needed. If not, the JTM money won't be as effective as it could be.				
Distributional justice	37	There is no one single solution that fit all the workers. They want to see options and be informed about the consequences. Broadly speaking they don't want to replace too far and they want to keep the same living conditions.	1			
				102	Most of the coal workers will reach the age of retirement before the transition takes place. We barely have young workers in the sector (and we can re-train them). So I don't see the problem at all.	1
	38	Many workers will prefer to receive money rather than change their job (expecially 50+ yo)	3	103	Voluntary leaving programs have failed. People were receiving money and applying for a new job in a different mine.	1
	39	We should retrain younger people. Even non for a specific job place. Make them feel they are needed by the society.	4	104	Re-skilling programs for non-energy related jobs have not been taken into account as an option	1
	40	Companies, Ministry of State Assets, and Trade Unions are discussing an agreement. If the company can't guarantee a job place, they should guarantee the workers 80% of their salary. No re-skilling.	1	105	Retraining projects are being developed only for marketing purposes, no significant impact (Silesia)	1
	41	Don't ask them to become entrepreneurs, give them solid job opportunities. E.g. Repurpose of mines	2			
	42	Utility companies are retraining their employees for internal job openings	1			
	43	30% of the coal workers will find a job in the energy sector. We need more sectors to absorb the workforce.	1			
Recognitional and restorative justice	44	10% of the population is energy poor. We will need to provide for them. We need a long term plan.	3			
	45	The capacity market will be removed by 2025. The capacity market increases the energy bills today, but if it is removed what will likely happen is that the energy bills will rise even more. This affects commercial activities and industries	1			
Barriers	46	The coal sector has always been supported by the government, while the lignite sector has always been proud to be independent. They are not used to seek for help. Lignite is more carbon intensive thus will be more affected by carbon	1			
	47	Coal affects the whole economy. Direct jobs (200'000) + indirect jobs (200'000)	4			
	48	In the traditional Silesian family, the woman does not work and the man is a miner. Mining is part of their identity. Impacts on whole families.	3			
	49	Coal workers have very advantageous working conditions compared to other sectors. They don't want to give up their benefits.	2	106	Although they make good money, working in the coal industry is terrible. No one wants that for their sons. RES jobs are way more pleasant.	1
	50	RES projects are not as labour intensive as coal projects	1			
	51	The legislation does not support RES	1	107	There are lot of investments in off-shore wind	2
	52	We need more flexible regulations and we need to train the administration. The bureaucracy takes too long.	1	108	The legislation favours prosumerism. Steep increase in the past 2 years.	1
	53	We lack of good RE natural resources	2	109	Good potential in off-shore wind	2
				110	Poland has good soalr and wind potential, but the technology today is not able to capture that energy	1
	54	Offshore wind is an option but it requires lot of infrastructures (costly)	2			
	55	We don't have gas reserves, we import. We would need huge amounts for a transition.	2	111	Gas is also under attack. It could potentially provide job opportunities though.	2
	56	Nuclear: the program is stucked since 60s. The public opinion is strongly against. No know-how. No concrete plan. No investors. New job opportunities would arrive years from now.	6	112	Younger generations are more keen on nuclear	1
	57	Short-term thinking politics. There is fight over power.	2			
	58	Hydrogen is not ready yet to become commerical	1			
	59	Poland relies on coal for heating too. Large scale CHP - it's difficult to fully decarbonise the energy sector	1			
	60	Communism era legacy: our mentality is a barrier, we are not keen to change; we are tired of transitions and uncertanty (we had a transition in the 90s); someone still looks at the private sector with suspect	1			

	61	The labour market is changing and people are scared. There will be increasing request for entrepreneurial skills - people are scared.	1			
Drivers and opportunities	62	Climate change awareness raised in the past decade	6	113	Coal miners don't care about climate change. Misconception (climate and weather). Daily issues. The Polish public opinion is less educated on the subject compared to Western countries.	3
	63	EU policies and regulations are the main drivers e.g. Carbon pricing	4			
	64	The EC won't allow the government ot keep subsidizing the coal sector	3			
	65	50% of the Poles are willing to pay more for electricity if it is green	1			
	66	We miss construction workers in Poland	1			
	67	We miss workers in the health sector. We could retrain the young coal workers. This can be achieved in a 10-years time frame	1			
	68	RES - job opportunities	2			
	69	The Polish economy, even despite the pandemic, is doing good. The unemployment rate is low, the economy can absorb the labour force.	1			
	70	Most of the people appreciate being in the EU	1			
	71	Most of the coal fleet is old. The investment has been recovered already	1			
	72	There is lot of discussion on gas as potential transitional fuel. I see no other option since hydrogen and RES are not ready yet. However, we will need to find more import sources (to date we import 70%)	1			
Other	73	The problem of the transition should not be looked as a demand-driven problem. It's a supply-driven problem. We keep extracting coal and then we need to do something with it.	1			
	74	We should invest in cross-border capacity, but we should also be independent	1			

	Code	Opinions	How many interviewees	Code	Different opinions/Contrast	How many interviewees
Status quo of the power sector	1	Coal dominated, aged, unreliable power sector has bad impacts on SA's economy. We experience frequent load-shedding.	8	78	Without coal, our economic situation would be way worste. It favoured the development.	1
	2	The coal fleet did not receive sufficient maintenance in the past	8			
	3	Load shedding leads more companies to look for alternative electricity supply solutions. This reduces Eskom's revenues and thus threatens job security	1			
	4	Unbundling Eskom will favour the transitionIs necessary.	3	79	Unbundling Eskom would not be just and it's technically impossible. Strongly against.	1
				80	The most liberalized market might not be the best solution to decarbonize a country. The market gives you signals only up to 3 years.	1
				81	Eskom's financial situation makes unbundling difficult	1
				82	Unbundlign Eskom doesn't necessarily support the transition/privatization of the sector. It only means separating the 3 entities, there is no plan for privatization. However we will likely privatize Generation.	1
	5	The Generation could be either public or private (whoever is best at it). The transmission is a natural monopoly and should be State-owned.	2	83	Unbundling: the private sector will pick and choose the Transmission. The Generation (which causes many issues) will be left to the public sector and will be a burden for the State.	1
				84	Unbundling won't solve the issue, it's a lack of skills issue. We lack of skills in the OEMs industry too.	1
	6	Unbundling: we need an independent system market transmission operator so that IPPs and Eskom Generation are treated the same.	2	85	Weak point: the Holdings company will still be State-owned. There will always be a perception of bias.	2
	7	The main issue in the power sector is the job security due to Eskom's poor financial situation. 10'000/40'000 workers might be claimed redundant.	1			
	8	Many people still lack access to electricity	1			
	9	Electricity affordability is an issue in SA . The electricity price is expected to keep growing and it is due to the current power system (coal based, old)	5			
	10	Grid-connected RES will increase the electricity price	2	86	Grid-connected RES will reduce the electricity price (economics of scale)	2
	11	Corruption/Politics interference affects the electricity price - diesel industry; Eskom	4			
	12	Corruption affects the price of the electricity sold by IPPs	2			
	13	The coal phase-out will take place after 2050. It depends on the end-of-life of the coal power plants (no acceleration, IRP). *The Paris Agreement only requires us to reduce our emissions starting from 2035*	3	87	The coal phase-out might never take place. Our economy strongly depends on coal (exports; developing country; balck economy is suffering)	2
				88	Lower Emission Development Strategy (LEDS): carbon neutral by 2050	
				89	Eskom committed to carbon neutrality by 2050	2

Procedural Justice	14	The discussion on just transition has been scattered so far. It's now becoming more centralized. (Engagement phase)	4	90	The dialogue is strong. The relationship is cooperative.	2
	15	There is agreement on the principles but not on the implementation. What is yet to be discussed are the pace of the transition and the practicalities (roadmap)	7	91	It's a social issue, the technical questions have already been answered. It's a communication issue - people need to see what's in for them	2
	16	COVID pandemic accelerated the discussion on JT. JT is a way to recover.	1			
	17	There is lack of clear communication on what NPC is doing for JT. They just talk. No decisional power.	4			
	18	There is lack of clear communication on what P4C is doing for JT	6			
	19	NEDLAC plays an important role	3	92	The Government doesn't always respect NEDLAC's mandate	1
				93	People in NEDLAC just talk, they have no decisional power.	1
				94	It took some time for NEDLAC to approve the IRP. Committment for a JT plan by 2021.	1
				95	All the stakeholders are strongly involved	1
	20	Academy is not involved	1	96	Academy is highly involved, the industry is getting involved now	1
	21	The organized business is not quite convinced yet	1	97	Eskom JT Office. Pilot project – repurpose a power station. Ask the community.	2
	22	The civil society might be more involved	2			
	23	Trade Unions are supporter of the transition but they are passively waiting for companies/government to provide them with solutions. They might be more solution oriented.	2			
	24	The international organizations have been disappointing. They could have put pressure on the government.	1			
	25	The government is not committed	1			
	26	The government (=Eskom) should lead the transition	4	98	No-one should lead the transition, but the Presidency should make sure everyone understands how important it is	1
				99	Pragmatism and technical evidence should lead the transition	1
	27	We lack long-term vision. NPC (-> P4C) aims to support long-term vision.	2			
	28	The transition is too slow, we should speed it up	2	100	The transition should be slow. We agree with IRP's pace.	2
	29	The transition is slow because it is not clear yet what the alternative is. I doubt IRP's assumptions.	1	101	If we follow the IRP's plan, we will be ok. The implementation of the plan (not the plan) is a problem.	1
	30	We need a great leader like Mandela (technical knoweldge + people's trust)	1			
	31	We should choose what's best for the majority, there will always be some losers	1			
Distributional Justice	32	Coal workers should be guaranteed a job place	5			
	33	Coal workers should be reskilled	8			
	34	The new job opportunities should be in the same geographical area	1			
	35	We should nationalize solar and wind value chains as much as possible	3			
	36	We need more policy certainty (to keep the businesses). Policies should facilitate exports too.	4			
	37	IPPs should be given more responsibilities. They focus on generation only. They should bear part of the system costs.				
	38	IPPs might include re-skilling projects in their business case.	3	102	IPPs do not want to pay for re-skilling project nor they want to reserve job places for the coal miners. Everyone deserves a shot.	2
				103	New job places are responsibility of the whole economy, we need a national plan	1
Recognitional and restorative justice	39	Historical inequalities, difficulties of a developing country. Most of the people struggle for survival	5			
	40	Former RES projects were not in the same geographical areas as coal mines.	3	104	IPPs created new job opportunities where there were not any before.	1
				105	IPPs will develop projects in Mpumalanga only if it makes economic sense	1
	41	Western countries benefitted from coal, now it's our turn but the world has changed	1			

Barriers	42	Coal workers have low levels of education	8			
	43	Low-skills labour in RES are required only in the construction phase	3			
	44	Next RES investments will have stricter requirements due to the need for affordable energy	1			
	45	The whole economy is coal-dominated	8			
	46	We lack consistency in policies and investments (RES)	4	106	Media favour RES, it's difficult to understand what is true. Corruption favours RES.	2
	47	People don't like that most of the RES companies are foreign companies. We complain too much, we should just start.	2	107	RES industry being foreign-owned is a misconception. Only 16% is foreign investment. All the companies have local subsidiaries or local partners.	1
	48	No OEMs in the black economy - that the State wants to support	3			
	49	There is no political will	2	108	We lack of alternatives. We don't have a big gas infrastructure, we import from Mozambique (unstable).	1
				109	Lack of alternatives. Nuclear is too expensive.	7
	50	We lack skilled human resources. in '94-'96, Eskom was one of the top 5 utilities in the world. 1994 – end of Apartheid – Eskom was found to be employing mainly whote people. They left/were forced to	1			
	51	Decision-making in SA is a consensus seeking process. You need to hear everyone's opinion. Slow.	1			
	52	Only a few people (maybe 10) have real power in SA. They can obstruct any initiative they don't like.	2			
	53	Public opinion - OEMs will bring away our jobs	3			
	54	Public opinion and RES industry are against nuclear (cost, long time of construction, waste, danger)	7	110	Nuclear lobby is anti-RES	1
	55	Nuclear might not be a feasible option (more expensive than RES, more long to build, ...)	7			
	56	Political interferences. Nuclear is there because someone wanted it there. No technical justification.	3			
	57	People living in the coal regions are way less favourable to a transition	3			
	58	Domestic legislation obstructS RES (1MW cap). Building RES capacity outside of the REI4P program is quite prohibitive.	3			
	59	Ordinary people aren't aware of the climate change issues. Social issues are more noisy than environmental issues. Environmental issues get postponed.	3			
	60	Lack of alternatives. Wind resources are not so good. They are only good offshore, but this is not cost effective.	1			
	61	Lack of trust in the numbers provided in terms of e.g. RES job places	2			
	62	Decision-makers in SA are either trusted leaders with no technical knowledge or technocrats with no communication skills. We lack leadership.	1			
	63	Political interferences. NERSA is supposed to apply a formula to set a price. They don't for political/consensus-seeking reasons, they keep the prices lower than they should be.	2			

Drivers and opportunities	64	Public opinion - if OEMs create new jobs for the coal workers, they will be accepted. Labour - A long-term program in RES can create low-skill job opportunities.	2			
	65	Domestic legislation is changing in favour of RES (remove 1MW cap; Municipalities...)	4			
	66	Further investments in RES are scheduled (new bid windows)	7			
	67	Natural resources - favourable for transition (solar, wind, gas)	7	111	No cost-effective wind resources	1
	68	2nd, 3rd, 4th bid windows - way cheaper electricity prices	3			
	69	We might have a mineral to mineral transition (fuel cells and batteries need different minerals, which we have)	1			
	70	Building RES capacity and operate it is already cheaper than building new coal capacity and operate it/operate the existing one	3			
	71	The public opinion supports the Paris Agreement. Their main concern is air pollution. They blame businesses and government for not acting fast enough.	4			
	72	The unreliability of the power sector is an opportunity for IPPs	8	112	Although most of the coal power plants are very old, some are quite new and efficient. These would be more difficult to phase-out (loss)	1
	73	Anyone who has ever worked in a coal power station knows that it is terrible	1			
	74	We should look at other countries in a similar situation. Skilled people could be sent from Poland to SA. EPPPEI program: we tried to address the lack of skills issue but there is still much to do.	1			
	75	3 manufacturers (wind) are investigating wind potential in Mpumalanga - positive feedback. Early stage.	1			
	76	If the electricity market is liberalized, Paris Agreement, Article 6: emission trading systems can support decarbonization by providing income to the countries	1			
Other	77	South Africa would like to purchare electricity from other countries. Regardless how this electricity is produced, this would be a way to decarbonize the local economy	1			

Appendix 3: Coding, Step 2

Poland

Argument 1: The Polish economy is strongly linked to coal

#1	Argument:	The Polish economy is strongly linked to coal						
Causal Structures		Causal variable	Coal reserves (hard coal + lignite)	Exploitation of coal	Economy (GDP)	Employment in coal sector	Political transition	Trade unions' influence
		Effect variable	Exploitation of coal	Economy (GDP)	Employment in coal sector	Trade unions' influence	Trade unions' influence	Benefits for coal workers
		Relationship type	(+)	(+)	(+)	(+)	(+)	(+)
		Reference code (from Codes - Step 2)	1, 5,73	5,7,47,48	37,38,39,40,43,103,47	19,25,26,92,93,94	92,94,93	19,92,103,49,46

Benefits for coal workers	Trade unions' influence	Political interference	Cost of coal mining	Profitability of coal sector	Exploitation of coal	Shares of coal
Employment in coal sector	Political interference	Exploitation of coal	Profitability of coal sector	Exploitation of coal	Shares of coal	Energy affordability
(+)	(+)	(+)	(-)	(+)	(+)	(-)
49,46	49, 92	92,94,73	63,64,75,3,82	75,77,79,6	5,75,78,79,80,73	82,3, 44

Energy affordability	Natural resources	Cost of RES	Short-term politics	Tasks division	Leadership	Transition planning & implementation
Economy	Cost of RES	Energy affordability	Leadership	Leadership	Transition planning & implementation	Exploitation of coal
(+)	(-)	(-)	(-)	(-)	(+)	(-)
3, 44, 45	53, 54, 72, 109, 107	83, 82, 12, 44	14, 15, 16, 85,91	16,15,9	15,16,14,84,91,93,95	21, 35, 97, 46, 47, 73

State subsidies	Politics interference	EU regulation	EU regulation	Trade Unions' influence	Strikes and disorders	Government's attention towards Trade Unions' requests	Linkage to traditions
Profitability of coal sector	State subsidies	State subsidies	Cost of CO2	Strikes and disorders	Government's attention towards Trade Unions' requests	Trade Unions' influence	Employment in coal sector
(+)	(+)	(-)	(+)	(+)	(+)	(+)	(+)
46, 45, 76	4, 94, 19	64,76	63,76	92,93	92,93	92,93,95,26,49	37,40,49

Argument 2: Just Transition – State of discussion

#2	Argument:	Just Transition - State of discussion						
Causal Structures		Causal variable	EU Green Deal/JTM	Discussion on JT	Involvment of stakeholders in the discussion	Transparent procedures	Clear options & consequences	Trust in institutions
		Effect variable	Discussion on JT	Involvment of stakeholders in the discussion	Transparent procedures	Clear options & consequences	Trust in institutions	Involvment of stakeholders in the discussion
		Relationship type	(+)	(+)	(+)	(+)	(+)	(+)
		Reference code (from Codes - Step 2)	17,18,33,34,97	34,98,99,28,96	20,21,23,24,36,97,30	30,101,35,36,61	60,61,19,14	20,21,23,24,36,97,30,14,95

Involvment of stakeholders in the discussion	Authorative modus operandi of the Government	External players	Perception of intromission	Further EU mechanisms of support	Political transition	Political transition	COVID
Transition planning & implementation	Involvment of stakeholders in the discussion	Perception of intromission	Trust in institutions	Transition planning & implementation	Flexibility to change	Dynamism of the economy	Flexibility to change
(+)	(-)	(+)	(-)	(+)	(-)	(-)	(-)
95,30,100,101,35	30	23,90,24	23,90,24	87,11	60	60, 41	61

Argument 3: Fair solutions to workers

#3	Argument:	Just Transition - Fair solutions for workers						
Causal Structures		Causal variable	Benefits for coal workers	Flexibility to change	Acceptance of reskilling/retraining programs	Job opportunities in new sectors	Demand for construction workers	Demand for health workers
		Effect variable	Flexibility to change	Acceptance of reskilling/retraining programs	Job opportunities in new sectors	Economy (GDP)	Job opportunities in new sectors	Job opportunities in new sectors
		Relationship type	(-)	(+)	(+)	(+)	(+)	(+)
		Reference code (from Codes - Step 2)	48,49,106	39,104,38,41,42,40	104,105,43,66,67	66,67,69	66	67

Acceptance of reskilling/retraining programs	Financial compensations	Same employer/industry	Acceptance of reskilling/retraining programs	Job opportunities in the energy sector	RES labour intensity	Shares of RES	National regulation favourable to RES
Financial compensations	Benefits for coal workers	Acceptance of reskilling/retraining programs	Job opportunities in the energy sector	Same employer/industry	Job opportunities in the energy sector	Job opportunities in the energy sector	Shares of RES
(-)	(+)	(+)	(+)	(+)	(+)	(+)	(+)
38	38,49	42,105	105,42	105,42	43,68,50	68, 50	51, 108

Investments in off-shore wind	National nuclear plans	Public opinion favours nuclear	Public opinion favours nuclear	Investments	National nuclear plans	Shares of RES	Age fo coal workers	Age of retirement in coal industry
Shares of RES	Job opportunities in the energy sector	National nuclear plans	Investments	National nuclear plans	Shares of coal	Shares of coal	N. Coal workers affected by transition	N. Coal workers affected by transition
(+)	(+)	(+)	(+)	(+)	(-)	(-)	(-)	(+)
107, 54	56, 112	56,112	56,112	56,112	56,112	53,51,107	102,37,39	102,37,39

Argument 4: Future perspectives

#4	Argument:	Future perspectives						
Causal Structures		Causal variable	Profitability of coal sector	Money for O&M	Modern and efficient coal fleet	Energy security	Modern and efficient coal fleet	EU market
		Effect variable	Money for O&M	Modern and efficient coal fleet	Energy security	Economy (GDP)	Energy affordability	Energy security
		Relationship type	(+)	(+)	(+)	(+)	(+)	(+)
		Reference code (from Codes - Step 2)	46, 45, 3, 79, 10	2, 11, 71	11, 81	11, 80, 12,81	2, 71	81, 74

Awareness of climate change	Acceptance of costly green energy bills	Young people keen on nuclear	EU regulation	Restructuration plan	EU regulation
Acceptance of costly green energy bills	Shares of RES	Public opinion favours nuclear	Restructuration plan	State subsidies	Energy market trends favourable to transition
(+)	(+)	(+)	(-)	(+)	(+)
65, 113, 62	65, 82, 12	112	45,76	45, 76	45, 76, 6, 80, 79

Energy market trends favourable to transition	Investments in coal	Cost of coal mining	Exploitation of (domestic) coal	Import of coal
Investments in coal	Profitability of coal	Exploitation of (domestic) coal	Import of coal	Economy (GDP)
(-)	(+)	(-)	(-)	(-)
45, 76, 6, 80, 79	3, 75, 76, 79	3, 75	75, 3	75

Argument 1: The current power sector is coal-dominated, aged, unreliable.

#1	Argument:	The current power sector is coal-dominated, aged, unreliable							
Causal Structures		Causal variable	Maintenance	Power plants efficiecy	Capacity availability	Load-shedding	Load-shedding	Customers leaving Eskom	Eskom's revenues
		Effect variable	Power plants efficiency	Capacity availability	Load-shedding	Local economy (GDP)	Customers leaving Eskom	Eskom's revenues	Job security in Eskom
		Relationship type	(+)	(+)	(-)	(-)	(+)	(-)	(+)
		Reference code (from Codes - Step 1)	1,2	1,2	1,2	1,3	3	3	3

Job security in Eskom	Unemployment rate	Energy affordability	Local economy (GDP)	Energy affordability	Access to electricity	Local economy (GDP)	Electricity price allowed by NERSA
Unemployment rate	Energy affordability	Eskom's revenues	Unemployment rate	Access to electricity	Local economy (GDP)	Electricity price allowed by NERSA	Eskom's revenues
(-)	(-)	(-)	(-)	(+)	(+)	(+)	(+)
3,7	3,9	9,3,81	1,3,7	3	1	1, 63	63,81

Power plants efficiency	RES lobby	Politics interference	Coal/diesel lobby	Post-Apartheid resentment	Unequal access to services and opportunities	White workforce leaves Eskom	Skilled black workforce	Skilled workforce employed in Eskom
Energy affordability	Politics interference	Cost of RES	Politics interference	White workforce leaves Eskom	Skilled black workforce	Skilled workforce employed in Eskom	Skilled workforce employed in Eskom	Maintenance
(+)	(+)	(+)	(+)	(+)	(-)	(-)	(+)	(+)
1,9	10, 86, 106	12, 10	11	50	84, 50	50, 84	50, 84	50, 84, 3

Argument 2-a: Unbundling Eskom is a good idea and will favour the transition.

#2-a	Argument:	Unbundling Eskom is a good idea and will favour the transition. Privatization of Generation. Independent System Operator.							
Causal Structures		Causal variable	Pressure to unbundle Eskom	Competitors in the power sector	Performance of Generation	Load-shedding	Pressure to unbundle Eskom	Competitors in the power sector	Competitors in the power sector
		Effect variable	Competitors in the power sector	Performance of Generation	Load-shedding	GDP	Fairly addressing creditors' expectations	Shares of RES	Shares of gas
		Relationship type	(+)	(+)	(-)	(-)	(-)	(+)	(+)
		Reference code (from Codes - Step 1)	4, 82, 6	4, 5, 6	1,2	1,3	81	4, 5, 6, 70, 68, 67	5,6, 67, 108

Argument 2-b: Unbundling Eskom is a bad idea and will not benefit the national economy.

#2-b	Argument:	Unbundling Eskom is a a bad idea and will not benefit the national economy.				
Causal Structures		Causal variable	Pressure to unbundle Eskom	Pressure to unbundle Eskom	Profit for public sector	Pressure to unbundle Eskom
		Effect variable	Profits for private sector	Profit for public sector	Performance of Generation	Job security in the power sector
		Relationship type	(+)	(-)	(+)	(-)
		Reference code (from Codes - Step 1)	83, 79	83, 79	83, 79, 80	83, 7

Argument 3: Power sector: future perspectives.

#3	Argument:	Power sector: future perspectives						
Causal Structures		Causal variable	Shares of RES	Consistent implementation of policies	Nationalise RES value chain	RES: lower labour-intensity	Job opportunities in RES	Shares of RES
		Effect variable	Job opportunities in RES	Nationalise RES value chain	Job opportunities in RES	Job opportunities in RES	Social acceptance of IPPs	Shares of coal
		Relationship type	(+)	(+)	(+)	(-)	(+)	(-)
		Reference code (from Codes - Step 1)	33, 36, 64, 43, 104, 38	35, 36, 47, 107, 46	107, 47, 43, 35	43	32,33, 38, 53	60, 70

Shares of coal	Job opportunities in the coal industry	Social acceptance of IPPs	Awareness of climate change	Public opinion favours RES	RES projects in coal regions	Re-training programs for coal workers	Gas reserves
Job opportunities in the coal industry	Unemployment rate	Public opinion favours RES	Public opinion favours RES	Shares of RES	Social acceptance of IPPs	Social acceptance of IPPs	Shares of gas
(+)	(-)	(+)	(+)	(+)	(+)	(+)	(+)
42, 40, 32, 33	32, 33	37, 38, 104, 53, 57	59, 71	59, 57, 110, 48	40, 105	38, 33	108

Relative price of nuclear power	Public opinion favours nuclear	Relative price of nuclear power	Nuclear lobby	Politics interference	Investments in nuclear power	Natural resources	Cost of RES
Public opinion favours nuclear	Public opinion favours RES	Investments in nuclear power	Politics interference	Investments in nuclear power	Shares of RES	Shares of RES	Social acceptance of IPPs
(-)	(-)	(-)	(+)	(+)	(-)	(+)	(+)
109, 54, 55	54, 55, 110	55, 56, 54	55, 56, 54, 110	56, 110	56, 110	60, 67, 70	70

RES know-how	Decreasing cost of RES technologies	Load-shedding	Shares of RES	Demand for minerals	Natural resources	Consistent implementation of policies	Nationalise RES value chain
Relative price of nuclear power	Public opinion favours RES	Public opinion favours RES	Demand for minerals	Job opportunitites in the mining industry	New job opportunitites in the mining industry	Nationalise RES value chain	Job opportunities in RES
(+)	(+)	(+)	(+)	(+)	(+)	(-)	(+)
55, 56, 54, 70, 68	68, 70	1,2,3	69	69	69	35, 36, 47, 107, 46	107, 47, 43, 35

Nationalize RES value chain	Cost covered by IPPs	Cost covered by IPPs
Public opinion favours RES	Social acceptance of IPPs	Cost of power system management
(+)	(+)	(-)
35, 36, 43, 47, 46, 107	37	37, 9

Argument 4: Just transition: status quo and suggestions.

#4	Argument:	Just transition: status quo and suggestions					
Causal Structures		Causal variable	Centralised discussion	Availability of clear information	Lack of leadership	COVID pandemic	Smooth decision-making process
		Effect variable	Availability of clear information	Trust in institutions	Centralised discussion	Centralised discussion	Rate of plans implementation
		Relationship type	(+)	(+)	(-)	(+)	(+)
		Reference code (from Codes - Step 1)	14, 15, 90, 17, 18	17, 18, 91, 92, 93	20 to 25, 95 to 97	16	28, 30, 101

Trust in institutions	Perception of a long-term vision	Politics interference
Empowerment of NPC, P4C, NEDLAC	Trust in institutions	Perception of a long-term vision
(+)	(+)	(-)
19, 92, 93	27, 25, 49	27, 52

Appendix 4: Coding, Step 3

Poland

Code	Argument # (from Codes - Step 3)	Cause	Effect	(+)/(-)	Words-and-arrow diagrams
1	1	Coal reserves	Exploitation of coal	(+)	Coal reserves -(+)-> Exploitation of coal
2		Exploitation of coal	GDP	(+)	Exploitation of coal -(+)-> GDP
3		GDP	Job opportunities	(+)	GDP -(+)-> Job opportunities
4		Employment in the coal sector	Job opportunities	(+)	Employment in the coal sector -(+)-> Job opportunities
5		Employment in the coal sector	Trade unions' influence	(+)	Employment in the coal sector -(+)-> Trade Unions' influence
6		Political transition	Trade unions' influence	(+)	Political transition -(+)-> Trade Unions' influence
7		Trade unions' influence	Benefits for coal workers	(+)	Trade Unions' influence -(+)-> Benefits for coal workers
8		Benefits for coal workers	Employment in the coal sector	(+)	Benefits for coal workers -(+)-> Employment in the coal sector
9		Trade unions' influence	Political interference	(+)	Trade Unions' influence -(+)-> Political interference
10		Political interference	Exploitation of coal	(+)	Political interference -(+)-> Exploitation of coal
11		Cost of coal mining	Profitability of coal sector	(-)	Cost of coal mining -(-)-> Profitability of coal sector
12		Profitability of coal sector	Exploitation of coal	(+)	Profitability of coal sector -(+)-> Exploitation of coal
13		Exploitation of coal	Shares of coal	(+)	Exploitation of coal -(+)-> Shares of coal
14		Shares of coal	Energy affordability	(-)	Shares of coal -(-)-> Energy affordability
15		Energy affordability	GDP	(+)	Energy affordability -(+)-> GDP
16		Natural resources	Cost of RES	(-)	Natural resources -(-)-> Cost of RES
17		Cost of RES	Energy affordability	(-)	Cost of RES -(-)-> Energy affordability
18		Short-term politics	Leadership	(-)	Short-term politics -(-)-> Leadership
19		Tasks division	Leadership	(-)	Tasks division -(-)-> Leadership
20		Leadership	Transition planning & implementation	(+)	Leadership -(+)-> Transition planning & implementation
21		Transition planning & implementation	Exploitation of coal	(-)	Transition planning & implementation -(-)-> Exploitation of coal
22		State subsidies	Profitability of coal sector	(+)	State subsidies -(+)-> Profitability of coal sector
23		Politics interferences	State subsidies	(+)	Politics interferences -(+)-> State subsidies
24		EU regulation	State subsidies	(-)	EU regulation -(+)-> State subsidies
25		EU regulation	Cost of CO2	(+)	EU regulation -(+)-> Cost of CO2
26		Trade unions' influence	Strikes and disorders	(+)	Trade unions' influence -(+)-> Strikes and disorders
27		Strikes and disorders	Government's attention towards Trade Unions' requests	(+)	Strikes and disorders -(+)-> Government's attention towards Trade Unions' requests
28		Government's attention towards Trade Unions' requests	Trade unions' influence	(+)	Government's attention towards Trade Unions' requests -(+)-> Trade Unions' influence
29		Linkage to traditions	Employment in the coal sector	(+)	Linkage to traditions -(+)-> Employment in the coal sector

30		EU Green Deal/JTM	Discussion on JT	(+)	EU Green Deal/JTM -(+)-> Discussion on JT
31		Discussion on JT	Involvment of stakeholders in the discussion	(+)	Discussion on JT -(+)-> Involvment of stakeholders in the discussion
32		Involvment of stakeholders in the discussion	Transparent procedures	(+)	Involvment of stakeholders in the discussion -(+)-> Transparent procedures
33		Transparent procedures	Clear options & consequences	(+)	Transparent procedures -(+)-> Clear options & consequences
34		Clear options & consequences	Trust in institutions	(+)	Clear options & consequences -(+)-> Trust in institutions
35		Trust in institutions	Involvment of stakeholders in the discussion	(+)	Trust in institutions -(+)-> Involvment of stakeholders in the discussion
36		Involvment of stakeholders in the discussion	Transition planning & implementation	(+)	Involvment of stakeholders in the discussion -(+)-> Transition planning & implementation
37	2	Authorative modus operandi of the Government	Involvment of stakeholders in the discussion	(-)	Authorative modus operandi of the Government -(-)-> Involvment of stakeholders in the discussion
38		External players	Perception of intromission	(+)	External players -(+)-> Perception of intromission
39		Perception of intromission	Trust in institutions	(-)	Perception of intromission -(-)-> Trust in institutions
40		Further EU mechanisms of support	Transition planning & implementation	(+)	Further EU mechanisms of support -(+)-> Transition planning & implementation
41		Political transition	Flexibility to change	(-)	Political transition -(-)-> Flexibility to change
42		Political transition	Dynamism of the ecnomy	(-)	Political transition -(-)-> Dyamism of the economy
43		COVID	Flexibility to change	(-)	COVID -(-)-> Flexibility to change
44		Benefits for coal workers	Flexibility to change	(-)	Benefits for coal workers -(-)-> Flexibility to change
45		Flexibility to change	Acceptance of reskilling programs	(+)	Flexibility to change -(+)-> Acceptance of reskilling programs
46		Acceptance of reskilling programs	Job opportunities in new sectors	(+)	Acceptance of reskilling programs -(+)-> Job opportunities in new sectors
47		Job opportunities in new sectors	GDP	(+)	Job opportunities in new sectors -(+)-> GDP
48		Demand for construction workers	Job opportunities in new sectors	(+)	Demand for construction workers -(+)-> Job opportunities in new sectors
49		Demand for health workers	Job opportunities in new sectors	(+)	Demand for health workers -(+)-> Job opportunities in new sectors
50		Acceptance of reskilling programs	Financial compensations	(-)	Acceptance of reskilling programs -(-)-> Financial compensations
51		Financial compensations	Benefits for coal workers	(+)	Financial compensations -(+)-> Benefits for coal workers
52		Same employer/industry	Acceptance of reskilling programs	(+)	Same employer/industry -(+)-> Acceptance of reskilling programs
53		Acceptance of reskilling programs	Job opportunities in the energy sector	(+)	Acceptance of reskilling programs -(+)-> Job opportunities in the energy sectors
54		Job opportunities in the energy sector	Same employer/industry	(+)	Job opportunities in the energy sector -(+)-> Same employer/industry
55	3	RES labour intensity	Job opportunities in the energy sector	(+)	RES labour intensity -(+)-> Job opportunities in the energy sector
56		Shares of RES	Job opportunities in the energy sector	(+)	Shares of RES -(+)-> Job opportunities in the energy sector

57		National regulation favourable to RES	Shares of RES	(+)	National regulation favourable to RES -(+)-> Shares of RES
58		Investments in off-shore wind	Shares of RES	(+)	Investments in off-shore wind -(+)-> Shares of RES
59		National nuclear plans	Job opportunities in the energy sector	(+)	National nuclear plans -(+)-> Job opportunities in the energy sector
60		Public opinion favours nuclear	National nuclear plans	(+)	Public opinion favours nuclear -(+)-> National nuclear plans
61		Public opinion favours nuclear	Investments	(+)	Public opinion favours nuclear -(+)-> Investments
62		Investments	National nuclear plans	(+)	Investments -(+)-> National nuclear plans
63		National nuclear plans	Shares of coal	(-)	National nuclear plans -(-)-> Shares of coal
64		Shares of RES	Shares of coal	(-)	Shares of RES -(-)-> Shares of coal
65		Age of coal workers	N. Coal workers affected by transition	(-)	Age of coal workers -(-)-> N. Coal workers affected by transition
66		Age of retirement in coal industry	N. Coal workers affected by transition	(+)	Age of retirement in coal industry -(+)-> N. Coal workers affected by transition
67		Profitability of coal sector	Money for O&M	(+)	Profitability of coal sector -(+)-> Money for O&M
68		Money for O&M	Modern and efficient coal fleet	(+)	Money for O&M -(+)-> Modern and efficient coal fleet
69		Modern and efficient coal fleet	Energy security	(+)	Modern and efficient coal fleet -(+)-> Energy security
70		Energy security	GDP	(+)	Energy security -(+)-> GDP
71		Modern and efficient coal fleet	Energy affordability	(+)	Modern and efficient coal fleet -(+)-> Energy affordability
72		EU market	Energy security	(+)	EU market -(+)-> Energy security
73		Awareness of climate change	Acceptance of costly green energy bills	(+)	Awareness of climate change -(+)-> Acceptance of costly green energy bills
74		Acceptance of costly green energy bills	Shares of RES	(+)	Acceptance of costly green energy bills -(+)-> Shares of RES
75	4	Young people keen on nuclear	Public opinion favours nuclear	(+)	Young people keen on nuclear -(+)-> Public opinion favours nuclear
76		EU regulation	Restructuration plan	(-)	EU regulation -(-)-> Restructuration plan
77		Restructuration plan	State subsidies	(+)	Restructuration plan -(+)-> State subsidies
78		EU regulation	Energy market trends favourable to transition	(+)	EU regulation -(+)-> Energy market trends favourable to transition
79		Energy market trends favourable to transition	Investments in coal	(-)	Energy market trends favourable to transition -(-)-> Investments in coal
80		Investments in coal	Profitability of coal sector	(+)	Investments in coal -(+)-> Profitability of coal sector
81		Cost of coal mining	Exploitation of (domestic) coal	(-)	Cost of coal mining -(-)-> Exploitation of (domestic) coal
82		Exploitation of (domestic) coal	Import of coal	(-)	Exploitation of (domestic) coal -(-)-> Import of coal
83		Import of coal	Economy (GDP)	(-)	Import of coal -(-)-> Economy (GDP)

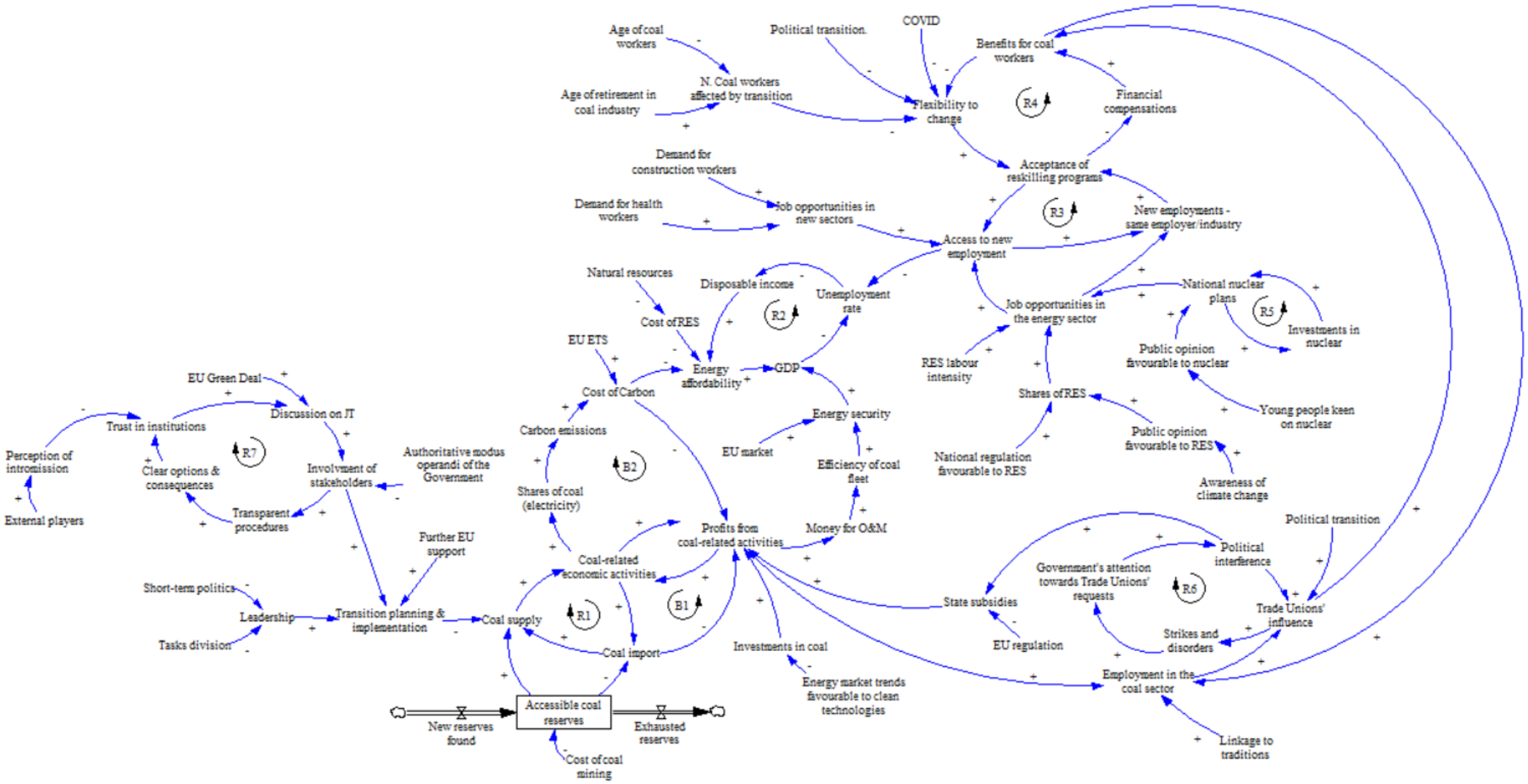
South Africa

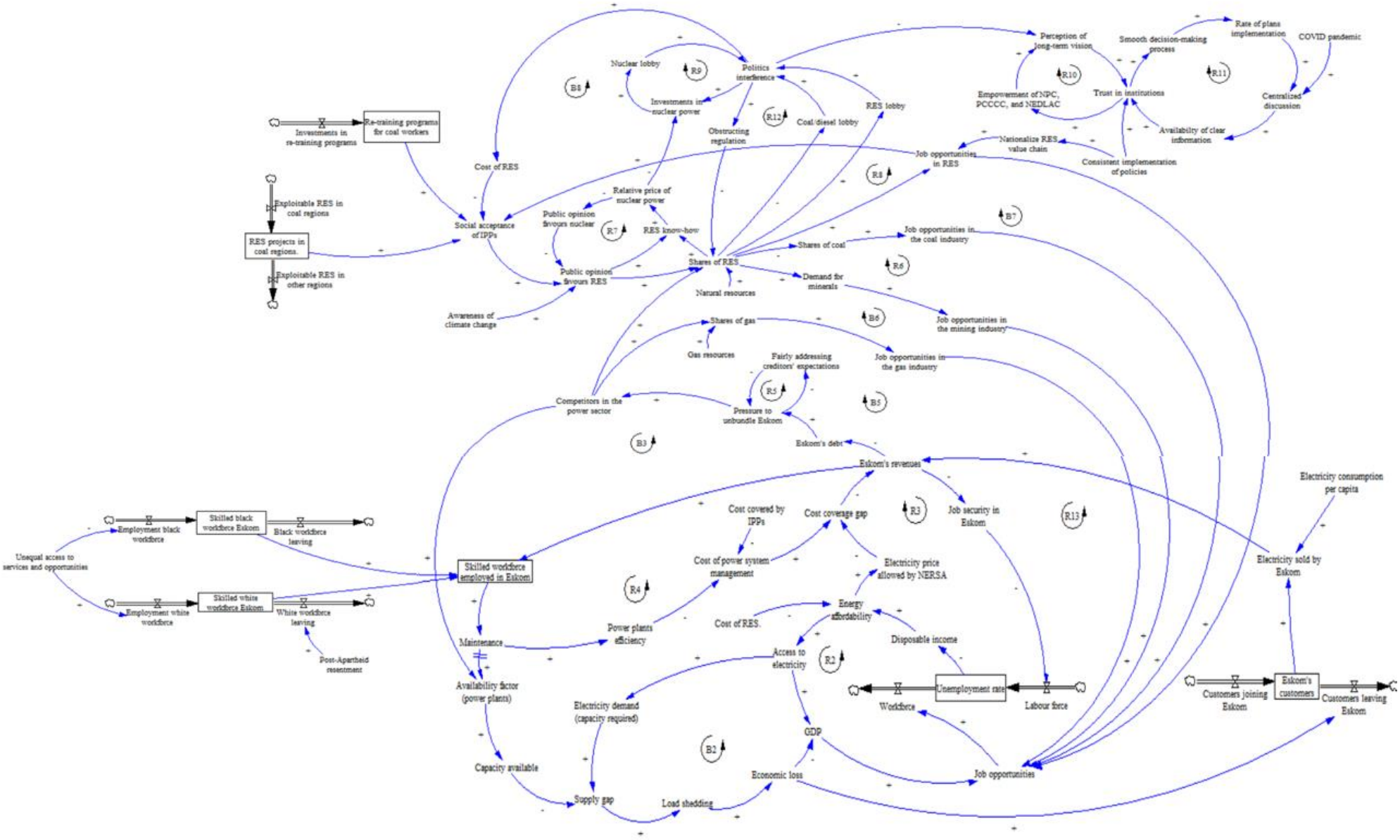
Code	Argument # (from Codes - Step 3)	Cause	Effect	(+)/(-)	Words-and-arrow diagrams
1	1	Maintenance	Power plants efficiency	(+)	Maintenance -(+)-> Power plants efficiency
2		Power plants efficiency	Capacity availability	(+)	Power plants efficiency -(+)-> Capacity availability
3		Capacity availability	Load-shedding	(-)	Capacity availability -(-)-> Load-shedding
4		Load-shedding	GDP	(-)	Load-shedding -(-)-> GDP
5		Load-shedding	Customers leaving Eskom	(+)	Load-shedding -(+)-> Customers leaving Eskom
6		Customers leaving Eskom	Eskom's revenues	(-)	Customers leaving Eskom -(-)-> Eskom's revenues
7		Eskom's revenues	Job security in Eskom	(+)	Eskom's revenues -(+)-> Job security in Eskom
8		Job security in Eskom	Unemployment rate	(-)	Job security in Eskom -(-)-> Unemployment rate
9		Unemployment rate	Energy affordability	(-)	Unemployment rate -(-)-> Energy affordability
10		Energy affordability	Eskom's revenues	(-)	Energy affordability -(-)-> Eskom's revenues
11		GDP	Unemployment rate	(-)	GDP -(-)-> Unemployment rate
12		Energy affordability	Access to electricity	(+)	Energy affordability -(+)->Access to electricity
13		Access to electricity	GDP	(+)	Access to electricity -(+)-> GDP
14		GDP	Electricity price allowed by NERSA	(+)	GDP -(+)-> Electricity price allowed by NERSA
15		Electricity price allowed by NERSA	Eskom's revenues	(+)	Electricity price allowed by NERSA -(+)-> Eskom's revenues
16		Power plants efficiency	Energy affordability	(+)	Power plants efficiency -(+)-> Energy affordability
17		RES lobby	Politics interference	(+)	RES lobby -(+)-> Politics interference
18		Politics interference	Cost of RES	(+)	Politics interference -(+)-> Cost of RES
19		Coal/diesel lobby	Politics interference	(-)	Coal/diesel lobby -(+)-> Politics interference
20		Post-Apartheid resentment	White workforce leaves Eskom	(+)	Post-Apartheid resentment -(+)-> White workforce leaves Eskom
21		White workforce leaves Eskom	Skilled workforce employed in Eskom	(-)	White workforce leaves Eskom -(+)-> Skilled workforce employed in Eskom
22		Unequal access to services and opportunities	Skilled black workforce	(-)	Unequal access to services and opportunities -(-)-> Skilled black workforce
23		Skilled black workforce	Skilled workforce employed in Eskom	(+)	Skilled black workforce -(+)-> Skilled workforce employed in Eskom
24		Skilled workforce employed in Eskom	Maintenance	(+)	Skilled workforce employed in Eskom] -(+)-> Maintenace
25	2-a	Pressure to unbundle Eskom	Competitors in the power sector	(+)	Pressure to unbundle Eskom -(+)-> Competitors in the power sector
26		Competitors in the power sector	Performance of Generation	(+)	Competitors in the power sector -(+)-> Performance of Generation
27		Performance of Generation	Load-shedding	(-)	Performance of Generation -(-)-> Load-shedding
28		Load-shedding	GDP	(-)	Load-shedding -(-)-> GDP
29		Pressure to unbundle Eskom	Fairly addressing creditors' expectations	(-)	Pressure to unbundle Eskom -(-)-> Fairly addressing creditors' expectations
30		Competitors in the power sector	Shares of RES	(+)	Competitors in the power sector -(+)-> Shares of RES
31		Competitors in the power sector	Shares of gas	(+)	Competitors in the power sector -(+)-> Shares of gas
32	2-b	Pressure to unbundle Eskom	Profit for private sector	(+)	Pressure to unbundle Eskom ->(+)-> Profit for private sector
33		Pressure to unbundle Eskom	Profit for public sector	(-)	Pressure to unbundle Eskom ->(-)-> Profit for public sector
34		Profit for public sector	Performance of Generation	(+)	Profit for public sector -(+)-> Performance of Generation
35		Pressure to unbundle Eskom	Job security in the power sector	(-)	Pressure to unbundle Eskom -(-)-> Job security in the power sector

36		Shares of RES	Job opportunities in RES	(+)	Shares of RES -(+)-> Job opportunities in RES
37		Consistent implemetation of policies	Nationalize RES value chain	(+)	Consistent implemetation of policies -(+)-> Nationalize RES value chain
38		Nationalize RES value chain	Job opportunities in RES	(+)	Nationalize RES value chain -(+)-> Job opportunities in RES
39		RES: lower labour intensity	Job opportunities in RES	(-)	RES: lower labour intensity -(-)-> Job opportunities in RES
40		Job opportunities in RES	Social acceptance of IPPs	(-)	Job opportunities in RES -(-)-> Social acceptance of IPPs
41		Shares of RES	Shares of coal	(-)	Shares of RES -(-)-> Shares of coal
42		Shares of coal	Job opportunities in the coal industry	(+)	Shares of coal -(+)-> Job opportunities in the coal industry
43		Job opportunities in the coal industry	Unemployment rate	(-)	Job opportunities in the coal industry -(-)-> Unemployment rate
44		Job opportunities in RES	Unemployment rate	(-)	Job opportunities in RES -(-)-> Unemployment rate
45		Social acceptance of IPPs	Public opinion favours RES	(+)	Social acceptance of IPPs -(+)-> Public opinion favours RES
46		Awareness of climate change	Public opinion favours RES	(+)	Awareness of climate change -(+)-> Public opinion favours RES
47		Public opinion favours RES	Shares of RES	(+)	Public opinion favours RES -(+)-> Shares of RES
48		RES projects in coal regions	Social acceptance of IPPs	(+)	RES projects in coal regions ->(+)-> Social acceptance of IPPs
49		Re-training programs for coal workers	Social acceptance of IPPs	(-)	Re-training programs for coal workers -(-)-> Social acceptance of IPPs
50	3	Gas reserves	Shares of gas	(+)	Gas reserves -(+)-> Shares of gas
51		Relative price of nuclear power	Public opinion favours nuclear	(+)	Relative price of nuclear power -(+)-> Public opinion favours nuclear
52		Public opinion favours nuclear	Public opinion favours RES	(+)	Public opinion favours nuclear -(+)-> Public opinion favours RES
53		Relative price of nuclear power	Investments in nuclear power	(-)	Nuclear lobby is against RES -(-)-> Public opinion favours RES
54		Politics interference	Investments in nuclear power	(+)	Politics interference -(+)-> Investments in nuclear power
55		Nuclear lobby	Politics interference	(+)	Nuclear lobby -(+)-> Politics interference
56		Investments in nuclear power	Shares of RES	(-)	Investments in nuclear power -(-)-> Shares of RES
57		Natural resources	Shares of RES	(+)	Natural resources -(+)-> Shares of RES
58		Cost of RES	Social acceptance of IPPs	(+)	Cost of RES -(+)-> Social acceptance of IPPs
59		RES know-how	Relative price of nuclear power	(+)	RES know-how -(+)-> Relative price of nuclear power
60		Load-shedding	Public opinion favours RES	(+)	Load-shedding -(+)-> Public opinion favours RES
61		Shares of RES	Demand for minerals	(+)	Shares of RES -(+)-> Demand for minerals
62		Demand for minerals	Job opportunitites in the mining industry	(+)	Demand for minerals -(+)-> Job opportunitites in the mining industry

63		Job opportunitites in the mining industry	Unemployment rate	(-)	Job opportunities in the mining industry -(-)-> Unemployment rate
64		Consistent implemetation of policies	Nationalize RES value chain	(+)	Consistent implemetation of policies -(+)-> Nationalize RES value chain
65		Cost covered by IPPs	Social acceptance of IPPs	(+)	Cost covered by IPPs -(+)-> Social acceptance of IPPs
66		Cost covered by IPPs	Cost of power system management	(-)	Cost covered by IPPs -(-)-> Cost of power system management
67	4	Centralised discussion	Availability of clear information	(-)	Centralised discussion -(-)-> Availability of clear information
68		Availability of clear information	Trust in institutions	(+)	Availability of clear information -(+)-> Trust in institutions
69		Trust in institutions	Smooth decision-making process	(-)	Trust in istitutions -(-)-> Smooth decision-making process
70		COVID pandemic	Centralised discussion	(+)	COVID pandemic -(+)-> Centralised discussion
71		Smooth decision-making process	Rate of plans implementation	(+)	Smooth decision-making process -(+)-> Rate of plans implementation
72		Trust in institutions	Empowerment of NPC, P4C, NEDLAC	(+)	Trust in institutions -(+)-> Empowerment of NPC, P4C, NEDLAC
73		Perception of a long-term vision	Trust in institutions	(+)	Perception of a long-term vision -(+)-> Trust in institutions
74		Politics interference	Perception of a long-term vision	(-)	Politics interference -(-)-> Perception of a long-term vision

Poland


Age of coal workers
Political transition
COVID
Benefits for coal workers
N. Coal workers affected by transition
Age of retirement in coal industry
Flexibility to change
R4
Financial compensations
Demand for construction workers
Acceptance of reskilling programs
Demand for health workers
Job opportunities in new sectors
R3
New employments - same employer/industry
Access to new employment
Natural resources
Disposable income
Unemployment rate
R2
Cost of RES
Job opportunities in the energy sector
National nuclear plans
R5
Investments in nuclear
EU ETS
Energy affordability
GDP
RES labour intensity
Public opinion favourable to nuclear
EU Green Deal
Cost of Carbon
Shares of RES
Young people keen on nuclear
Discussion on JT
Trust in institutions
Energy security
Carbon emissions
Public opinion favourable to RES
Perception of intromission
R7
Authoritative modus operandi of the Government
EU market
Efficiency of coal fleet
National regulation favourable to RES
Awareness of climate change
Clear options & consequences
Involvment of stakeholders
B2
Shares of coal (electricity)
Money for O&M
Political transition
External players
Transparent procedures
Profits from coal-related activities
Further EU support
Political interference
Coal-related economic activities
Government's attention towards Trade Unions' requests
R6
Short-term politics
State subsidies
Trade Unions' influence
Leadership
Transition planning & implementation
Coal supply
R1
B1
Strikes and disorders
Tasks division
Coal import
EU regulation
Investments in coal
Employment in the coal sector
Energy market trends favourable to clean technologies
Accessible coal reserves
New reserves found
Exhausted reserves
Linkage to traditions
Cost of coal mining


Perception of long-term vision
Smooth decision-making process
Rate of plans implementation
COVID pandemic
Nuclear lobby
R9
Politics interference
B8
Investments in nuclear power
R12
Obstructing regulation
Coal/diesel lobby
RES lobby
Empowerment of NPC, PCCCC, and NEDLAC
R10
Trust in institutions
R11
Centralized discussion
Availability of clear information
Investments in re-training programs
Re-training programs for coal workers
Cost of RES
Nationalize RES value chain
Consistent implementation of policies
Job opportunities in RES
R8
Exploitable RES in coal regions
Relative price of nuclear power
Public opinion favours nuclear
R7
RES know-how
Social acceptance of IPPs
RES projects in coal regions.
Exploitable RES in other regions
Shares of RES
Shares of coal
Job opportunities in the coal industry
B7
Public opinion favours RES
Natural resources
Demand for minerals
R6
Awareness of climate change
Shares of gas
B6
Job opportunities in the mining industry
Gas resources
Fairly addressing creditors' expectations
Job opportunities in the gas industry
R5
Competitors in the power sector
Pressure to unbundle Eskom
B5
B3
Eskom's debt
Eskom's revenues
Electricity consumption per capita
Cost covered by IPPs
Cost coverage gap
R3
Job security in Eskom
R13
Employment black workforce
Skilled black workforce Eskom
Black workforce leaving
Unequal access to services and opportunities
Skilled workforce employed in Eskom
Cost of power system management
Electricity price allowed by NERSA
Electricity sold by Eskom
R4
Employment white workforce
Skilled white workforce Eskom
White workforce leaving
Post-Apartheid resentment
Maintenance
Power plants efficiency
Cost of RES.
Energy affordability
Disposable income
Access to electricity
R2
Availability factor (power plants)
Unemployment rate
Workforce
Labour force
Customers joining Eskom
Eskom's customers
Customers leaving Eskom
Electricity demand (capacity required)
GDP
B2
Capacity available
Economic loss
Job opportunities
Supply gap
Load shedding

Appendix 6: List of variables

South Africa

Variable	Description	Unit
Unequal access to services and opportunities	Measure of the inequalities perpetuated by the Apartheid regime	To be defined
Employment black workforce	Rate of employment of skilled black workforce in Eskom	Black workforce employed/time
Employment white workforce	Rate of employment of skilled white workforce in Eskom	White workforce employed/time
Black workforce leaving	Rate or black workforce leaving Eskom	Black workforce leaving/time
White workforce leaving	Rate of white workforce leaving Eskom	White workforce leaving/time
Skilled black workforce	Skilled black employees working in Eskom	N. Black employees with an education relevant to the job
Skilled white workforce	Skilled white employees working in Eskom	N. White employees with an education relevant to the job
Post-Apartheid resentment	Intensity of the reaction to the end of the Apartheid regime	To be defined
Skilled workforce employed in Eskom	White + Black skilled workforce	N. employees with an education relevant to the job
Maintenance	Time and resources dedicated to maintenance activities	Hours
Power plants efficiency	The higher the efficiency, the lower the electricity losses. The higher the efficiency, the lower the amount of resources needed to generate the same amount of electricity.	Percentage
Availability factor (power plants)	Hours in which the power plants are available for generating electricity over the total amount of hours in the selected time frame (usually one year)	Parameter
Capacity available	Total generation capacity times Availability Factor	GW
Electricity demand (capacity)	Capacity needed to guarantee that the electricity demand is covered	GW
Supply gap	Electricity demand - Capacity available	GW
Load shedding	Hours of load-shedding: amount of time in which the power system is not able to satisfy the electricity demand	Hours
Economic loss	Economic loss due to an hour of load-shedding times the amount of hours of load-shedding	Rand
GDP	Gross Domestic Product, it measures the health and the productivity of an economy	Rand
Job opportunities	Total workforce that the South African economy is able to absorb	N. Job places
Workforce	Employed labour force in South Africa	People
Labour force	People willing to have a job in South Africa	People
Unemployment rate	(Labour force - Workforce)/(Labour force)	Percentage
Disposable income	The amount of money that an individual or household has to spend or save after income taxes have been deducted	Rand
Energy affordability	Total population - Energy poor people	People or Households
Cost coverage gap	Cost of power system management - Electricity price	Rand
Cost of power system management	Cost of electricity generation (including losses) + Cost of Operation & Maintenance	Rand
Electricity price allowed by NERSA	The electricity price computed by the National Energy Regulator by applying a formula, adjusted according to the status of the economy	Rand
Cost covered by IPPs	Share of the power system O&M cost covered by the IPPs	Percentage
Electricity sold by Eskom	Electricity consumption per capita * Eskom's customers	GWh
Eskom's revenues	Electricity price * Electricity sold - Cost of power system management	Rand
Job security in Eskom	Percentage of Eskom's employees whose job place is not threatened	To be defined
Eskom's customers	Number of households, commercial activities, and industries purchasing electricity from Eskom	To be defined; It might be split in more variables

Electricity consumption pro-capita	Amount of electricity consumed by the average Eskom's customer. A more detailed model would require to distinguish among households, commercial activities, and industries.	GWh
Access to electricity	Percentage of population who has access to electricity	Percentage
Eskom's debt	Money that has been borrowed to Eskom (by the State or by other creditors)	Rand
Pressure to Pressure to unbundle Eskom	The belief that unbundling Eskom is necessary and the decision to pursue this plan.	To be defined
Competitors in the power sector	Number of electricity suppliers involved in the power sector of South Africa	N. Electricity suppliers or N. Utility companies
Fairly addressing creditors' expectations	Creditors' confidence that Eskom will indemnify its debts	To be defined
Shares of RES	Shares of the South African electricity mix covered by RES	Percentage
Job opportunities in RES	Number of job places available in the RES industry	N. Job places
Demand for minerals	This variable aggregates the demand of different minerals raised by the increasing demand for RES and energy storage technologies.	Tonnes
Shares of coal	Shares of the South African electricity mix covered by coal	Percentage
Job opportunities in coal	Number of job places available in the coal industry	N. Job places
Shares of gas	Shares of the South African electricity mix covered by natural gas	Percentage
Job opportunities in gas	Number of job places available in the gas industry	N. Job places
Natural resources	Solar and wind power potentials	kWh/kWp
Gas resources	Gas reserves technically and economically available for exploitation	bcm or bcf
RES know-how	Technical and business RES-related knoweldge in South Africa	To be defined
Relative cost of nuclear power	The cost of nuclear power in relation to the cost of RES technologies	Rand
Public opinion favours nuclear	Percentage of people who support an energy transition towards nuclear power	To be defined
Public opinion favours RES	Percentage of people who support an energy transition towards RES	To be defined
Awareness of climate change	Level of understanding and interest towards the issue of climate change	To be defined
Investments in nuclear power	Amount if investments mobilised towards nuclear technologies	Rand
Nuclear lobby	Measure of the influence exerted by the nuclear lobby	To be defined
Politics interference	Frequency of unjustified interventions by prominent figures	To be defined
Social acceptance of IPPs	Percentage of people whit a positive or neutral attitude towards the spread of IPPs	To be defined
Cost of RES	It includes the technology development, the implementation, the operation, and the maintenance costs	Rand
Investment in re-training programs	Cost of designing and delivering re-training programs	Rand
Re-training programs for coal workers	Number of coal workers involved in a re-training program	People
Exploitable RES in coal regions	Exploitable solar or wind power potential located in those regions that rely the most on the coal industry	kWh/kWp
RES projects in coal regions	Number of RES projects planned and developed in those regions that rely the most on the coal industry	GW
Exploitable RES in other regions	Exploitable solar or wind power potential located in regions different from those that rely the most on the coal industry	kWh/kWp
Consistent implementation of policies	Rate of implementation of the designed policies	To be defined
Nationalize RES value chain	This variable aggregates the shares of different steps of the value chain that are managed by national companies. E.g. Manufacturing, assembling, installation, ...	To be defined
Obstructing regulation	Presence of regulations that hinder the dissemination of RES technologies	To be defined
Coal/diesel lobby	Measure of the influence exerted by the traditional energy lobby (coal, diesel)	To be defined
RES lobby	Measure of the influence exerted by RES lobby	To be defined
Perception of long-term vision	Percentage of people who believe that decision-makers act in pursuit of the best possible long-term outcome for the population	To be defined
Trust in institutions	Level of trust the population has in institutions acting in their best interests	To be defined

Empowerment of NPC/P4C	This variable aggregates: the measure of influence exerted by the NPC and the P4C; the rate of implementation of plans designed by the NPC and the P4C.	To be defined
Smooth decision making process	This variable measures how simple decision-making processes are in South Africa, taking into account the number of stakeholders involved, the length of the discussion, the degree of	To be defined
Rate of plans implementation	Rate of implementation of the designed plans	To be defined
Centralized discussion	Level of centralisation of the discussion. A centralised discussion favours direct exchange between the parties involved and ensures a deeper understanding of the topic.	Percentage
COVID pandemic	Severity of impacts on the economy	Rand
Availability of clear information	Transparency and ease of finding information about the work of the institutions	To be defined

Poland

Variable	Description	Unit
Coal reserves	Coal reserves in Poland	Million tonns
Exploitation of coal	Coal extracted in Poland	Million tonns/year
GDP	Gross Domestic Product	PLN/year
Job opportunities	Number of job places	N. Job places
Employment in the coal sector	Number of employees working in the coal sector	N. Job places
Trade union's influence	Ability of the trade unions to exert a power or an influence	To be defined
Political transition	Influence gained by the trade unions due to their role during the political transition	To be defined
Benefits for coal workers	Benefits obtained by the employees working in the coal sector	PLN/worker
Political interference	Frequency of unjustified interventions by prominent figures	To be defined
Cost of coal mining	Cost sustained for conducting coal mining activities	PLN/tonn
Profitability of coal sector	Net profit gained by the coal industry in Poland	PLN
Shares of coal	Shares of the Polish electricity mix covered by coal	Percentage
Energy affordability	Total population - Energy poor people	People or Households
Natural resources	Solar and wind power potentials	kWh/kWp
Cost of RES	It includes the technology development, the implementation, the operation, and the maintenance costs	PLN
Short-term politics	Frequency of decisions that decision-makers take for immediate benefit while compromising better outcomes in the long term	To be defined
Leadership	Ability of the decision-makers to lead major transformations in Poland	To be defined
Tasks division	Number of institutions/entities in charge of a task	N. Entities
Transition planning & implementation	Rate of plans developed & implementation of the designed plans	To be defined
State subsidies	Funds that the State allocates to support the coal sector	PLN
EU regulation	Constraints imposed by the EU authorities. This variable might be unbundled into different regulations/constraints.	To be defined
Cost of CO2	Cost of carbon imposed by the EU ETS	PLN/tonn
Strikes and disorders	Frequency of protests and disorders with a relevant (e.g. Above a minimum threshold) number of participants	To be defined

National nuclear plans	Development of plans for installing nuclear power capacity in Poland	MW
Public opinion favours nuclear	Percentage of people favourable to nuclear power	Percentage
Investments	Funds mobilised to finance nuclear power projects	PLN
Age of coal workers	Average age of employees in the coal sector	Number (age)
N. Coal workers affected by transition	Number of employees in the coal sector who will need to displace or retrain	N. Employees
Money for O&M	Money available to conduct Operation & Maintenance activities in the coal power plants	PLN
Modern and efficient coal fleet	Number of coal power plants that fulfill set efficiency standards	MW
Energy security	Reliability of the power grid	Parameter
Government's attention towards Trade Unions' requests	Number of trade unions' requests satisfied by the Government	To be defined
Linkage to traditions	Number of coal workers who feel connected to the industry since their communities have been involved in it for generations	To be defined
EU Green Deal/JTM	Funds offered by the EU to support the green transition	PLN
Discussion on JT	Attention and resources directed towards the topic of Just Transition at a local and national level	To be defined
Involvment of stakeholders in the discussion	Number of steps of the discussion and planning activities where a great variety of stakeholders are involved	To be defined
Transparent procedures	Easiness of finding information concerning the discussion and planning of a just transition for the power sector of Poland	To be defined
Clear options & consequences	Clear communications concerning the possible transitional paths and their implications	To be defined
Trust in institutions	Level of trust the population has in institutions acting in their best interests	To be defined
Authoritative modus operandi of the Government	Tendency that the Government has to centralise the decision-making without involving the stakeholders affected	To be defined
External players	Number of non-Polish agents involved in the discussion and planning of a just transition for the power sector of Poland	N. Agents
Perception of intromission	Percentage of people who believe that enternal agents are influencing the internal decisions with no right to do so and for their own benefit	To be defined
Further EU mechanisms of support	Funds offered by the EU that might support the green transition and that are not included in the JTM/Green Deal	PLN
Flexibility to change	Percentage of coal workers who are open to dialogue on possible changes in their working conditions	To be defined
EU market	Cross border grid connections	MW
Awareness of climate change	Level of understanding and interest towards the issue of climate change	To be defined
Acceptance of costly green energy bills	Percentage of electricity consumers willing to pay higher tariffs for elctricity generated from RES	Percentage
Young people keen on nuclear	Percentage of people in the younger generations (to be defined) favourable to nuclear power	Percentage
Restructuration plan	Restructuration plan proposed by the Polish Government to reform the coal and energy sectors	PLN
Energy market trends favourable to transition	Energy market trends favourable to investments in low-carbon power supply technologies	To be defined
Investment in coal	Funds mobilised to finance new coal power plants	PLN
Import of coal	Amount of coal imported from foreign countries	Million tonns/year

Dynamism of the economy	Variety of profitable economic sectors in Poland	To be defined
COVID	Economic and social impacts of the COVID pandemic	To be defined
Acceptance of reskilling programs	Percentage of coal workers willing to undertake a reskilling program	Percentage
Job opportunities in new sectors	Number of job opportunities available in economic sectors different from the energy one	N. Job places
Demand for construction workers	Vacancies in the construction sector	N. Job places
Demand for health workers	Vacancies in the healthcare sector	N. Job places
Financial compensations	Number of gold handshakes distributed among the coal workers	PLN
Same employer/industry	Number of coal workers who find a new job in the same company	N. Job places
Job opportunities in the energy sector	Number of job opportunities available in the energy sector	N. Job places
RES labour intensity	Number of workers needed in a RES power plant	N. Job places/MW
Shares of RES	Shares of the Polish electricity mix covered by RES	Percentage
National regulation favourable to RES	Presence of regulations that favour the dissemination of RES technologies	To be defined
Investments in off-shore wind	Funds mobilised to finance off-shore wind projects	PLN

Appendix 7: Sectoral System of Innovation

Poland

Landscape

A. Political framework

Poland has been governed by a communist administration until 1989, when URSS faded and Poland adopted a democratic regime and a free-market economy. It is a member of the European Union since 2004: as such, it has to comply with the EU policies on many areas, like energy and environment; on the other hand, the country can also benefit from several financial supports (see the *Energy policy* chapter). Since the last national elections in 2019, the ruling party has been Law and Justice (PiS): right-winged, conservative, and Eurosceptic, this party has often shown its support to the coal sector and its antagonism towards several EU directives (The World Bank, 2018b, 2019d). According to the surveys, the PiS is still the most favoured party in Poland with the support of 37,4% of the population as of February the 13th, 2021 (Ewybory, 2021). The next elections will take place in 2023 (Nordea, 2021).

B. The economic state of play

Poland has a GDP of 532'329 M€ or 631'833 US$ million (13'870 € per capita or 16'463 US$ per capita) as of 2019 (Eurostat, 2020a). The Polish GDP per capita is quite below the EU average of 31'160 € per capita (Eurostat, 2020a), although the Polish economy is one of the fastest-growing: it has been growing during the past 30 years, closing the gap with the other European countries (Bogdan, 2015). While the GDP grew by 4,1% in 2019, the economic growth is now expected to decelerate due to the global outbreak of COVID-19, although different sources estimate different percentages of GDP contraction: -7,4% to -9,5% according to OECD (OECD, 2020), -4,5% according to the European Commission (European Commission, 2020b). The unemployment rate is about 5%: it has been decreasing during the past years, although the COVID-19 pandemic is reversing the trend (Statistics Poland, 2021).

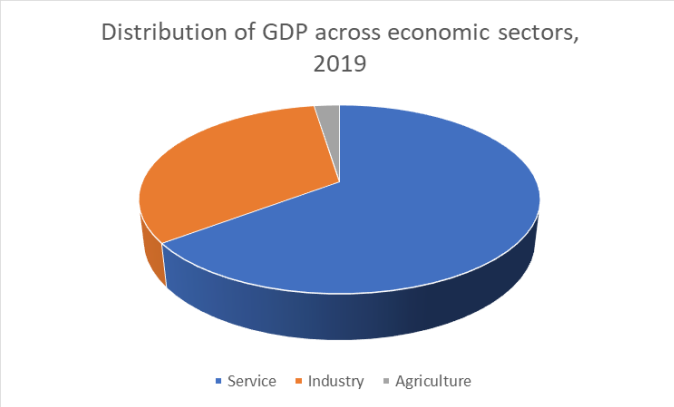


Figure 37 - Distribution of GDP across economic sectors in Poland, 2019 (O'Neill, 2021a)

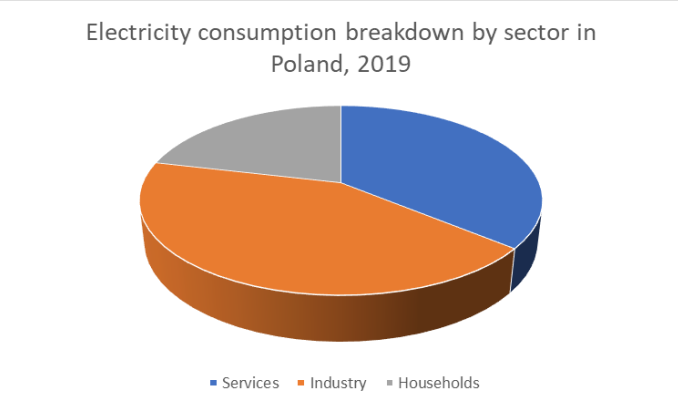


Figure 38 - Electricity consumption breakdown by sector in Poland, 2019 (Enerdata, 2019a)

C. Pressures on the power sector

i. External cost

The CO_2 emissions connected to the power sector have been equal to 150 million tonnes of CO_2 equivalent in 2018, about 50% of the total CO_2 emissions (Baran et al., 2018; Szpor & Ziółkowska, 2018): there has been no significant reduction in this value during the past years (Macuk, 2019). As of 2019, Poland is responsible for 11,2% of the energy-related CO2 emission in Europe (Eurostat, 2020b).

The low ambient air quality impacts on Polish health and quality of life: the World Bank estimates the external cost of pollution to amount to 31-40 US$ billion (6,4-8,3% GDP in 2016), which is coherent with the 26-30 €

billion estimated by the European Commission (European Commission, 2020d). Most of this external cost is actually due to residential heating (Baran et al., 2018), however, the external cost related to electricity generation amounts to around 7-13 US$ billion/year[35].

ii. Coal sector

Poland has long time been considered as a coal country: however, coal production has been steadily decreasing during the past decades, as well as the employment in the coal sector (European Commission, 2020d). Mining activities contribute by 1,5% to the Polish GVA[36] (Baran et al., 2018), and employ only 0,36% of the population (European Commission, 2020i). However, mining contribution to GVA raises to 6,9% if looking at the region of Silesia, where the bulk of the Polish coal sector concentrates (DG Climate Action, 2017; European Commission, 2015; ICAP, 2021). Although the coal sector's efficiency improved since the 1990s (further details in *Coal & Lignite* chapter), the production costs are still high compared to other countries and the sector has been achieving negative financial results since 2013, reaching a 1,1 billion € loss in 2015 (Baran et al., 2018; European Commission, 2020d).

D. International pressure

In 2015, all EU Member States signed the Paris Agreement, committing to containing the global temperature raise (Rutkowski et al., 2018).

With the European Green Deal presented in 2019, the EU commits to become carbon neutral by 2050 (European Commission, 2020f). The EU acknowledges that the transition towards a greener economy will require a great effort from certain countries and regions: to overcome the challenge, the Green Deal includes a Just Transition Mechanism that is expected to mobilise about €65-75 billion: €17,5 billion of which (in 2018 prices, or €19,3 billion in today's prices) constitute the Just Transition Fund, which will be distributed among the Member State according to the entity of the challenges they will need to face for undergoing the energy transition (DG for Communication, 2021b, 2021a; European Commission, 2020f). Poland will benefit most of all MSs from this program and will receive €3,5 billion (European Commission, 2020f, 2021).

The European Parliament and the European Council are currently discussing a reform for the EU Emission Trading System (ETS). More sectors will be included in the fourth ETS phase (2021-2030), and stricter rules will be applied to those already involved, such as the power sector (Ministry of Climate, 2020; Paska et al., 2020). For instance, probably, the number of allowances available in the market will yearly decrease by 2,2%, instead of by 1,74%/year as it has been for round three (Ministry of Climate, 2020; Paska et al., 2020). This restriction aims to support the goals to reduce carbon emissions by 40% within 2030, and then reach carbon neutrality by 2050. This fact reaffirms that MSs cannot postpone the transition towards a sustainable economy anymore.

Agents

Utility companies

f. PGE Polska Grupa Energetyczna S.A.

PGE is one of the main electricity utility companies in Poland and one of the largest in Central and Eastern Europe and produces about 40% of the electricity consumed in the country (PGE GiEK SA, n.d.; Statista, 2019). The PGE Group involves numerous companies dealing with different tasks. Among those more relevant for the scope of this research:

[35] Electricity Generated x External Cost due to Electricity Generation = (164 x 10^9 kWh) x (0,041 to 0,082 US$/kWh) (Szpor, 2018)

[36] GVA: Gross Value Added. GVA is a measure of the contribution to GDP made by an individual producer, industry or sector. GVA= GDP + Subsidies on products – Taxes on products.

- **PGE GiEK SA** (PGE Górnictwo i Energetyka Konwencjonalna Spółka Akcyjna) (PGE GiEK SA, n.d.): The company's core business is lignite mining and electricity generation. PGE GiEK consists of 7 branches located in 5 provinces. It is the greater energy producer in Poland, meeting over 36% of domestic demand in some months (data as of September 30, 2018) (PGE GiEK SA, n.d.).

The companies generating electricity are required to publish the structure of the fuels used to generate electricity (PGE GiEK SA, n.d.):

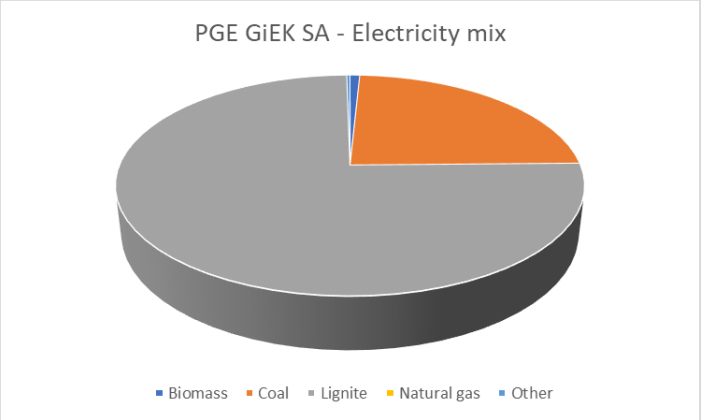


Figure 39 - PGE GiEK SA electricity mix (2019)

- **PGE Energia Ciepla**: it is one of the main producers of electricity and heat in Poland, produced in the process of high-efficiency cogeneration. It owns approximately 25% share in the heat market from cogeneration (PGE Ciepla SA, n.d.; Polish Information and Foreign Investment Agency, 2012).

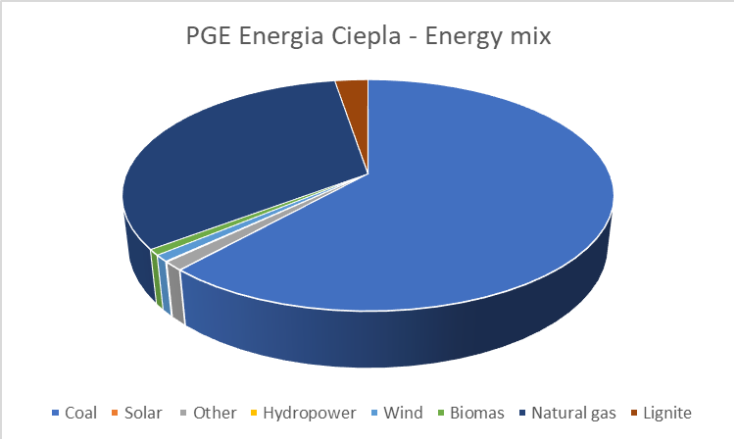


Figure 40 - PGE Energia Ciepla - Energy mix

- **PGE Energia Odnawialna SA**: manages the hydropower, solar, and wind power plants that PGE Groups uses for generating 2% of its sold electricity. The total installed capacity of the generating units belonging to the Group (hydro and wind power plants) is 2'326,251 MW (PGE Energia Odnawialna SA, n.d.).
- **PGE Baltica**: PGE Baltica was established in January 2019 as the company responsible for the implementation of the Offshore Program in the PGE Capital Group, which provides for the construction of three wind farms (PGE Baltica, 2020):
    - *Baltica-1 Wind Power Plant (EWB1)*, which in June 2020 received technical conditions for connection to the transmission network for a capacity of up to 896 MW.
    - *Baltica-2 Wind Power Plant (EWB2)*, which in January 2019 received a proposal for technical conditions for connection to the NPS from the transmission grid operator for 1489 MW.
    - *Baltica-3 Wind Power Plant (EWB3)* with a connection agreement for a maximum of 1045 MW.

The Offshore program involves the construction of two offshore wind farms by 2030 with a total capacity of up to 2,5 GW, and another with a capacity of 0,9 GW after 2030, which makes the PGE Capital Group the leader of the future offshore wind energy sector (PGE Baltica, 2020).

Overall, the energy mix of the **PGE Group** is strongly dominated by coal and lignite: however, the company is increasing its investments in renewables, particularly in wind power. This strategy is aligned with the RES investment tendencies in Poland: offshore wind is expected not only to play an important role in the energy transition, but it might as well become a growth driver for the Polish economy (Innogy, 2019b).

g. ENEA SA:

ENEA SA is one of the largest energy groups in Poland. The group produces and sells to householders and to businesses about 18% of the electricity consumed in the country (ENEA SA, n.d.-b; Statista, 2019). ENEA Group, as PGE Group, is vertically integrated. Within the group, key companies are (ENEA SA, n.d.-a):

- **Enea Operator**, responsible for the distribution of energy
- **Enea Wytwarzanie**, in charge of electricity and heat generation. Its main asset is the power plant in Kozienice, one of the largest in the country and responsible for most of the electricity generation of the company. The electricity mix is largely dominated by coal and heating oil: only around 1% of the electricity mix (298 GWh in 2018 (ENEA Group, 2018)) comes from hydropower and wind power together. Enea Wytwarzanie partially recurs to renewables for the generation of heat (around 40% of the total heat generation, all coming from biomass (RWE, 2019)), in the plants of Oborniki, Białystok, and Piła (ENEA Group, 2017).
- **LW Bogdanka SA**: one of the leading manufactures in the hard coal market in Poland. Its mining activities cover 20,8% of the Polish fuel coal market with 445 tons of extraction potential from 3 licenced areas and 9,5 tons of net coal production in 2019.

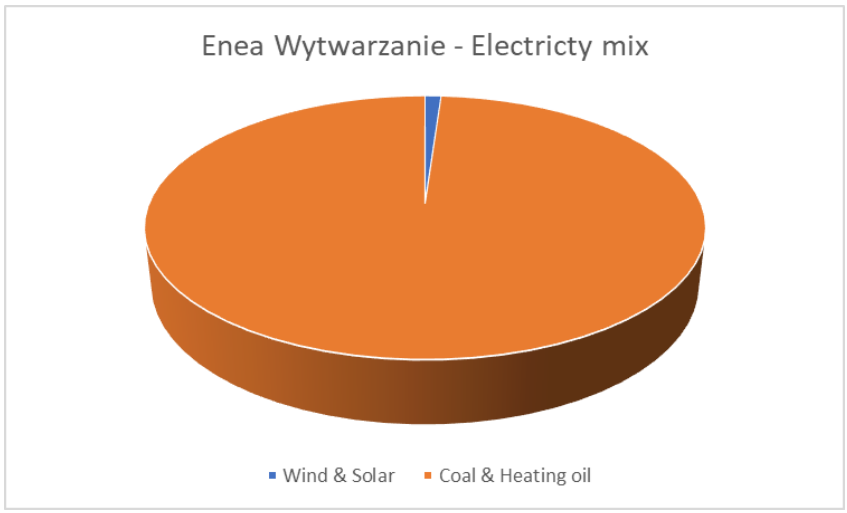


Figure 41 - Enea Wytwarzanie - Electricity mix

h. Tauron Polska Energia SA:

Like its main competitors, Tauron Polska Energia SA is a vertically integrated utility company. Although it generates only 8% of the Polish electricity, it is the main distributor in the country: it distributes more than 50 TWh per year to 34,7% of the Polish electricity consumers. The Tauron Group is composed of 30 business entities linked by a capital group.

The upstream part of the value chain, mainly includes mining, enrichment, and sale of hard coal. TAURON owns 3 mining plants covering about 29% of the national balance energy resources of hard coal. These activities are conducted by **TAURON Wydobycie SA**.

The electricity generation is managed by **TAURON Wytwarzanie SA**, **TAURON Ciepło sp. Z oo** and **TAURON Ekoenergia sp. Z oo**. The electricity is produced by conventional sources, including cogeneration, as well as from renewable sources, including combustion and co-firing of biomass, hydro, and wind power plants (TAURON, 2020).

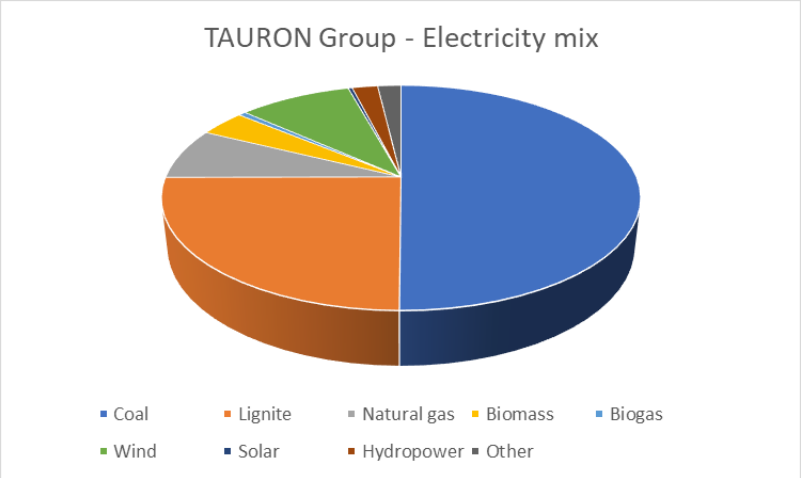


Figure 42 - Tauron Group - Electricity mix

i. ENERGA

One of the four big energy companies in Poland. Its activities include the generation, distribution, and trading of electricity, heat, and gas. Unlike its main competitors, Energa does not include coal mining and coal refinery in its business lines. The generation leader is **ENERGA OZE**. The electricity produced in 2019 was 2,7 TWh, of which about 1,5 TWh coming from renewable sources. The installed capacity is approximately 1,34 GW, including 560 MW of renewable energy sources: therefore, Energa's electricity mix has a share of renewables equal to 40%, much higher compared to the other main utility companies in Poland (ENERGA, 2020b).

The distribution leader in the Group is **Energa Operator**, while for the sales it's **Energa Obròt** (ENERGA, 2020c). Energa supplies electricity to ¼ of the area of Poland, in the northern and central parts of the country.

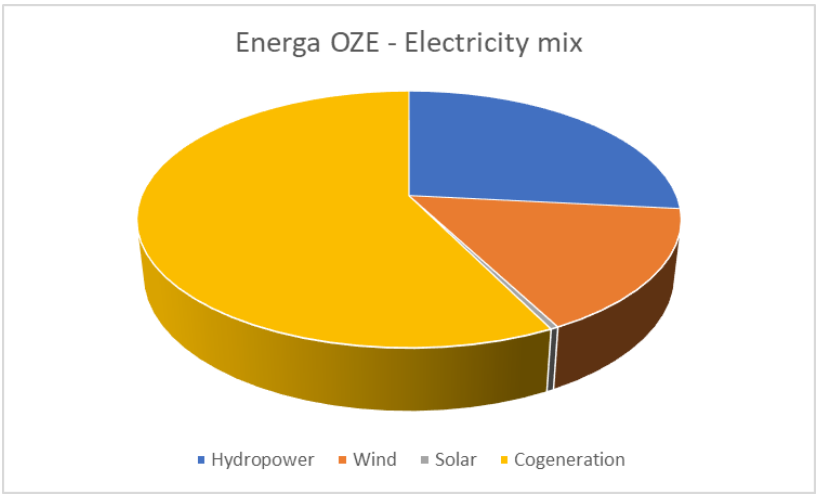


Figure 43 - Energa OZE - Electricity mix

j. Innogy

Innogy Stoen Operator Sp. z o. o. manages the Warsaw electricity network since 2007. **Innogy Polska Solutions** provides services in the field of energy and electricity: for instance, the implement projects to construct or retrofit energy systems in buildings, relying mainly on cogeneration and PV installations (Innogy Polska Solutions, n.d.).

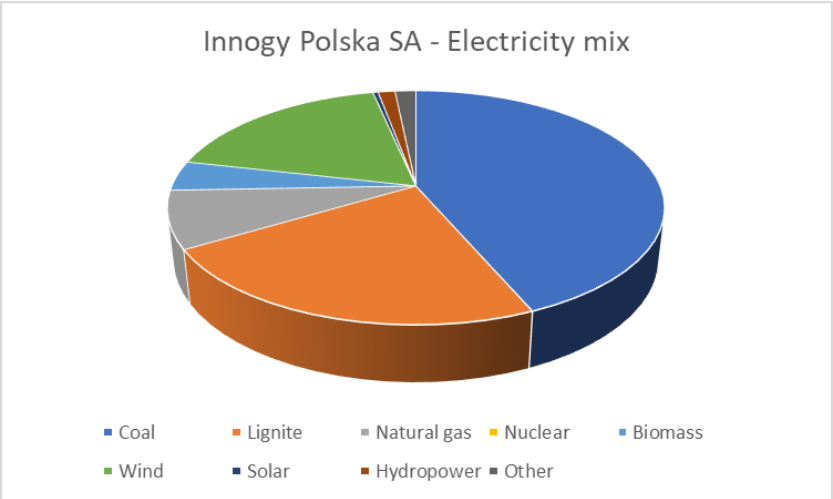


Figure 44 - Innogy Polska SA - Electricity mix

The company generates in Poland a portion of the electricity sold and imports the rest from its partner companies operating in other European countries (mainly Germany, the United Kingdom, and the Netherlands). In Poland, the Innogy Group operates wind farms with a total capacity exceeding 240 MW and a solar park of 600 kW. The company has recently won an auction launched by the Polish government for the installation of 42 MW of PV panels (IEEFA, 2020; Renewables Now, 2021).

Trade Unions

a. NSZZ Solidarnosc:

The Independent Self-governing Free Trade Union “Solidarity” was founded in 1980 and was the first independent trade union in a Warsaw Pact country to be recognised by the State (Solidarnosc, 2018).

In 1981, the Polish Government emitted a martial law (1981-1983), restricting many aspects of daily life. As a consequence, the NSZZ Solidarnosc trade union should have stopped its activity, but it was favoured by the support of international public opinion. NSZZ continued clandestinely its activity and was officially re-registered in 1989 (Solidarnosc, 2018).

It is estimated that NSZZ counts 722'000 workers, namely 4,35% of the total unionisation workforce in Poland (12 to 14% of the total workforce). There are union members in every industry and service. Membership includes managers, administrators and professional staff as well as scientists and technicians; skilled workers and labourers; full-time workers and those who work part-time; pensioners/retirees, school students in factory-run vocational schools doing sub-contracting work for factories or receiving vocational training in such schools; persons contracting for work at home, unemployed, disabled and persons who are performing alternative military service (Solidarnosc, 2018).

NSZZ "Solidarność" has a territorial-branch structure. 8105 thousand enterprise Union organisations (locals) are associated with 34 regions (data of 2006) (Solidarnosc, 2018). Enterprise Union organisations are associated at the same time in the national branch sections which form 16 national branch secretariats (Solidarnosc, 2018). The National Congress of Delegates is the union's supreme authority which elects the National Commission (100 members), consisting among others of the chairs of 34 regions and 16 national branch secretariats and the President of the National Commission (in separate balloting) (Solidarnosc, 2018).

The current operations of the Union are controlled by 16 members of the Presidium of the National Commission. The National Commission implements the Programme Resolution and other resolutions adopted by the National Congress of Delegates (Solidarnosc, 2018).

b. OPZZ:

The All-Poland Alliance of Trade Unions (OPZZ) was founded in the early 80s as a consequence of the trade union act which made trade union pluralism illegal (1982) (Trappmann, 2012). It was part of the pro-government Patriotic Movement for National Revival and tied very closely to the Polish United Worker's Party (Trappmann, 2012). Today OPZZ associates 90 trade union organizations, grouped in 12 different branches such as Raw materials and power industry, Manufacturing, Health care, and so on. It counts 550'000 members in total: the branches in which it counts more affiliated are *Mining, chemical & energy* and *Education & science* (as for 2012) (Trappmann, 2012).

c. FZZ:

The Trade Unions Forum (FZZ) was founded in 2002 as a result of consolidation attempts by some independent trade unions. Indeed, between the late 80s and 2010, estimated trade union density in Poland fell from 38% to 16%: this was the result of their incapacity to effectively transform their strategies in the new reality of a privatised market (Macuk, 2019). FZZ composes of 75 branches and involves 420'000 members (Szpor & Ziółkowska, 2018).

Electricity mix

Coal and lignite

Mining activities contribute by 1,5% to the Polish GVA[37], although the mining contribution to GVA raises to 6,9% if looking at the region of Silesia, where the bulk of the Polish coal sector concentrates (Brauers & Oei, 2020; Şahin, 2018; Schwartzkopff & Schulz, 2017; Szulecki, 2018).

The number of active coal mines fell from 70 in 1990 to 30 in 2014, the yearly coal production was decreased by half, from 147,7 million to 73,3 million tonnes, and the employment fell by 60% in 1989-2000 (Brauers & Oei, 2020; Şahin, 2018; Schwartzkopff & Schulz, 2017; Szulecki, 2018). A significant number of coal mines are still expected to close due to economic problems, exacerbated by the phase-out coal mine subsidies mandated by the EU: Poland will lose around 85% of its current domestic coal production by 2030 (Brauers & Oei, 2020; Şahin, 2018; Schwartzkopff & Schulz, 2017; Szulecki, 2018).

There are strong ties between the coal industry and the national government. The energy sector was spared by the large-scale privatisation of the Polish economy in the 1990s. As a result, the energy sector is an oligopoly, and the main coal mining companies are fully or partially owned by the Polish state (Baran et al., 2018). The major party in Poland is the right-wing PiS (Law and Justice) party, which does not strongly support the low-carbon transition. Decision-making processes in coal and energy companies are heavily influenced by the government, which exerts control through ownership and executive appointments. Because this gives the state a direct financial stake in their survival, however, companies' interests tend to determine policy thereby creating a powerful nexus of entwined interests (Baran et al., 2018).

[37] GVA: Gross Value Added. GVA is a measure of the contribution to GDP made by an individual producer, industry or sector. GVA= GDP + Subsidies on products – Taxes on products.

There are three main types of coal produced in Poland: thermal coal, coking coal, lignite. The total volume produced in 2015 was 73 million tonnes of hard coal, of which 59 million tonnes of thermal coal and 13 million tonnes of coking coal. The lignite produced was 63 million tonnes (unlike coal, its production level remained almost constant over the years) (Szpor, 2018).

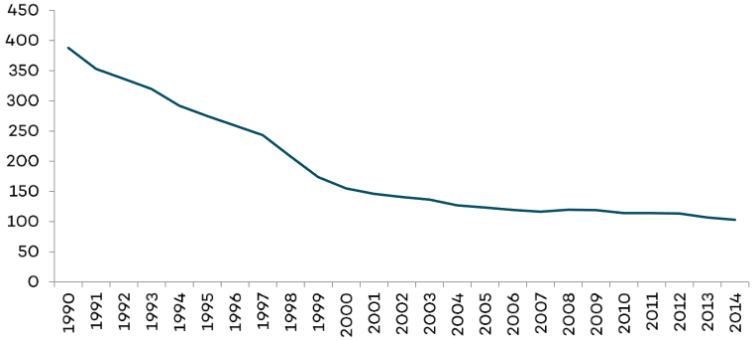


Figure 45 - Employment in the hard coal mining sector in Poland (Szpor & Ziółkowska, 2018, p. 3)

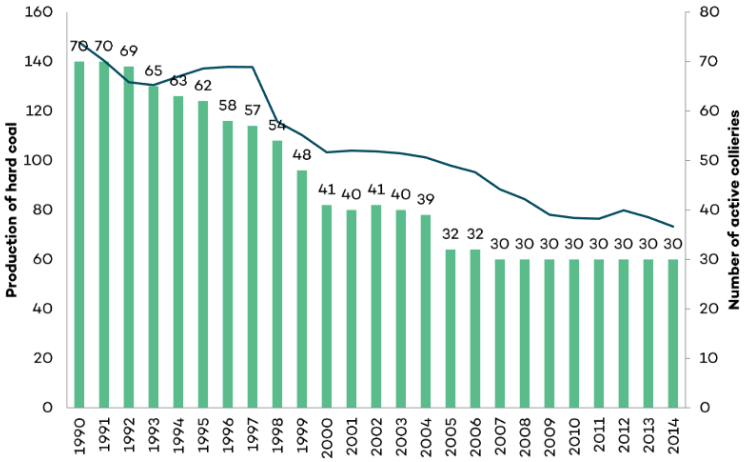


Figure 46 - Production of hard coal (millions of tonnes) and number of collieries (Szpor & Ziółkowska, 2018, p. 4)

South Africa

Landscape

A. Political framework

South Africa became a Republic in 1961, but it was not until 1994, the end of the Apartheid, that all its citizens had access to vote. The country is a member of both the Commonwealth of Nations and of the Southern Africa Development Community – an inter-governmental organization among southern African countries to strengthen socio-economic, political and security cooperation (SADC, 2012).

Since the end of the Apartheid, the African National Congress (ANC) has kept being re-elected and has ruled the country (ANC, 2019; GCIS, 2019; Kirby, 2019; Santander, 2021). The party was originally born to oppose the Apartheid regime and to defend the rights of all South Africans. The last national elections took place in 2019: the ANC won with 57% of the votes, while the second party, the Democratic Alliance, only got 20% of the votes (ANC, 2019; GCIS, 2019; Kirby, 2019; Santander, 2021). However, this has been the lowest that ANC scored since 1994. The next elections will take place in 2024 (ANC, 2019; GCIS, 2019; Kirby, 2019; Santander, 2021).

B. The economic state of play

South Africa's GDP was equal to 5291,91 R billion (351,4 US$ billion or 292€ billion) in 2019 (The World Bank, 2019c): it has been increasing by about 1% per year during the past few years but has been decreasing during the last three quarters of 2020 due to the impact of the COVID-19 pandemic (-0,8%, -1,4%, -2%) (Department: Statistics South Africa – Republic of South Africa, 2020). Given the population growth, the GDP per capita has been almost constant since 2014 (around 90'272 R or 6000 US$ or 4985 €), leaving little room to reduce poverty (The World Bank, 2020a).

According to the World Bank, progress toward poverty reduction has slowed in recent years: people living below the 1,90$/day international poverty line increased from 16,8% to 18,8% between 2011 and 2015. 57,10% of the people lived with less than 5,50$/day in 2014 (+0,9% compared to 2010) (Macrotrends, 2020). The South African economy is one of the most inequal in the world with a consumption expenditure Gini coefficient of 0,63 in 2015 (The World Bank, 2020a).

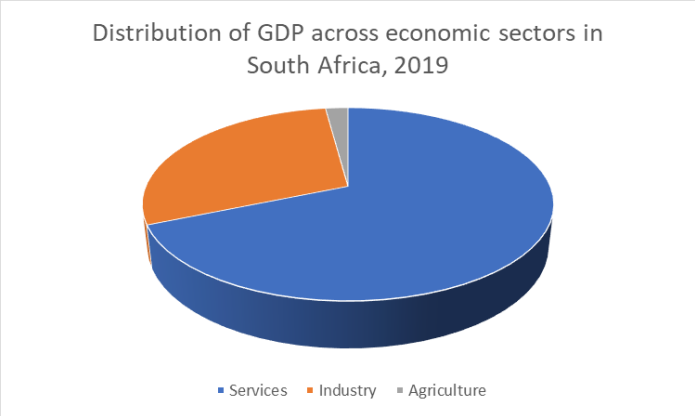


Figure 47 - Distribution of GDP in South Africa (2019) (Plecher, 2020)

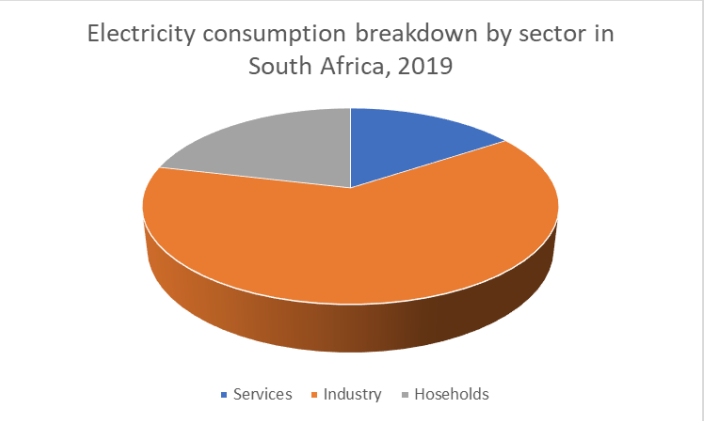


Figure 48 - Electricity consumption in South Africa (2019) (Enerdata, 2019b)

C. Pressures on the power sector

i. External cost

South Africa is the 14th greenhouse gas emitter in the world and its energy sector was responsible for 428 Mt of CO_2 in 2018 according to IEA (IEA, 2018b). The UNFCCC provides similar results since it estimates that the gross greenhouse gases emissions[38] have been equal to 541 Mt CO_2-eq in 2015, of which about 80% (therefore, around 432,8 Mt CO_2-eq) due to the energy sector (Department of Environmental Affairs, 2015; South African Government, 2020). Electricity generation alone accounts for 42% of gross national emissions (South African Government, 2020).

The external cost related to electricity generation has been estimated between 4,3 and 29 US$ billion/year[39].

ii. Coal sector

The coal mining activities constitute around 1,5% of the South African GDP (Minerals Council SA, 2018). Around 70% of the annual production (250-260 Mtpa) is consumed domestically, mainly by the energy sector, while the remaining 30% is exported. The coal exports are more profitable than the domestic sales and amounted to 45% of the total sales in 2016 (Burton et al., 2018). However, the production costs in South Africa are raising, since the most accessible coal resources have already been exploited. The increasing cost of coal is affecting the energy security and the energy affordability of the country (Burton et al., 2018). Furthermore, the global trends are pushing for the decarbonisation of the economies, due to the urgency to cope with climate change: in the immediate near future, though, the coal exports are not expected to shrink (Makgetla et al., 2019).

D. International pressure

In 2016, South Africa signed the Paris Agreement and committed to achieve a significant emissions' reduction by 2050 (Marquard & McCall, 2019; Modise, 2016).

South Africa has been re-admitted to the Commonwealth association after the end of the Apartheid regime. The Commonwealth is a mutually supportive community of 54 independent and sovereign states which share goals like development, democracy, and peace. One of the Commonwealth goals is to encourage environmental protection and the sustainable use of natural resources. One of the most notable initiatives in that sense is the Commonwealth Climate Finance Access Hub, which supports the most vulnerable states

[38] 85% of the greenhouse gases in South Africa are in the form of CO_2 (South African Government, 2020)
[39] Electricity Generated x External Cost due to Electricity Generation = (204 x 10^9 kWh) x (0,021 to 0,144 US$/kWh) (Szpor, 2018)

secure funding to tackle climate change: 34 US$ million have already been mobilized and 650 US$ million are in the pipeline. However, South Africa has not been involved in any of these projects so far. Furthermore, the Commonwealth's mandate does not include biding regulations concerning climate and the environment. (The Commonwealth, 2020a, 2020b)

South Africa is a member of the Southern Africa Development Community (SADC), gathering 16 southern African countries to strengthen socio-economic, political, and security cooperation. The SADC has recently claimed its intention to strengthen climate change resilience and mitigate climate change effects among its member states. However, the association has not developed any binding law on environmental and climate-related topics. (SADC, 2020a, 2020b)

Thus, the pressures experienced by the South African power sector seem to be mainly economic rather than political.

Product

The electricity consumption in South Africa has been slightly decreasing during the past years (Burton et al., 2018; Enerdata, 2019b), from 214 TWh in 2010 to 204 TWh in 2019: this is because Eskom has not been able to deliver a secure electricity supply in the past decade. The electricity export amounted to 14,9 TWh in 2019 (The Global Economy, 2019). The average electricity price in 2019 was 0,126 US$/kWh for households and 0,06 US$/kWh for businesses (Global Petrol Prices, 2020). The electricity price for households has risen by 344% from 2003 to 2019, and by 569% for businesses over the same time frame (Eskom, 2020b, 2020a). The inflation rate in South Africa has not been as high (O'Neill, 2021b; Statistics South Africa, 2021): the main drivers of the tariff increase have been the cost of coal and the construction of new coal power plants (Medupi and Kusile) (Jahed et al., 2017; Kessides, 2020). Coal is no longer a cheap and bountiful resource that can ensure security, and this contributed to rapidly increasing electricity prices that have put the economy under increasing pressure (Burton et al., 2018). Electricity demand has thus stagnated over the past decade even as Eskom continues to bring new coal-fired generating capacity online (Burton et al., 2018).

The electricity price is expected to keep rising since it has not reached cost-reflectivity yet, due to the historical tendency of the National Regulator to adopt "pro-poor measures" rather than "cost-reflective tariffs" (Kessides, 2020; Maphosa & Mabuza, n.d.). Thus, the electricity price has for a long time been kept artificially low: Eskom, the only utility company in the country, had to seek government support, which led to government interference in its day-to-day activities and a further loss of efficiency (Kessides, 2020; Maphosa & Mabuza, n.d.). 90% of the electricity is generated by Eskom, a public utility company. Eskom employs 7928 people in its coal-fired power stations, which are mainly located in the province of Mpumalanga (SAWEA, 2018; Winkler et al., 2020).

10% of the South African population still does not have access to electricity (The World Bank, 2019a). 47% of the households are considered energy poor according to the usual definition for which households are energy poor when spending 10% of their income on energy (Heinrich Boll Stiftung SA, 2016). In 2007, South Africa has been hit by an electricity crisis, which is still going on: the supply falls behind the demand, causing severe power outages (Kessides, 2020). To date, Eskom has not been able to solve the issue definitively: load shedding[40] is applied whenever the grid is at risk, while what would be needed is the construction of new power stations (Kessides, 2020). Eskom has cumulated a massive debt – 440 billion Rand (30 US$ billion) as of October 2019 –. It is today dependent on state bailouts and is effectively bankrupt (Kessides, 2020).

[40] Load shedding: the deliberate shutdown of electric power in a part or parts of a power-distribution system, generally to prevent the failure of the entire system when the demand strains the capacity of the system.

Agents

Utility companies

The electricity sector of South Africa is dominated by one vertical integrated utility company: Eskom Holdings takes care of the electricity generation, transmission, and distribution. It generates 90% of the electricity in South Africa and it is 100% State-owned since 2002: the Government of the Republic of South Africa is its sole shareholder and is represented by the Minister of Public Enterprises (Eskom, 2018). The company has enjoyed a near-monopoly in both generation and transmission since its creation in 1923. It is an energy giant even by international standards: it accounts for 40% of the electricity generated in the entire African continent (DoE, 2019a).

Eskom has long time been able to provide cheap electricity to South Africa thanks to the large and unexpensive coal reserves of the country. However, since early 2000, South Africa has been facing an electricity crisis: the electricity system has had a tight and declining reserve margin, and thus the adequacy of and reliability of the supply have been placed in jeopardy (Kessides, 2020). Demand has frequently exceeded supply, and since 2008 load-shedding has been experienced across the country (Kessides, 2020). Despite the sharp escalation in the price of electricity, Eskom has been operating at a loss, accrued a massive debt load, and has failed to perform the necessary preventive maintenance on its generation, transmission, and distribution assets (Kessides, 2020).

The main causes of the crisis have been identified as (Kessides, 2020):

- Indecision and paralysis in government policy: building a power plant is long and costly. Largely before the beginning of the electricity crisis, it was clear the need to expand the power capacity and Eskom asked for permissions to build new power plants. However, the Department of Minerals and Energy released the Energy White Papers in 1998: the paper proposed to vertically unbundle Eskom and introduce competition into the electricity sector, which had so far been a monopoly. To encourage new independent power producers to enter the generation market, the Government announced that 30% of the electricity generation should have been sourced by new utility companies, independent from Eskom, and prohibited Eskom to build any new power plant. However, very few independent power producers were attracted into the market, and no power plant was installed between 1998 and 2003. Eventually, the Government had to allow Eskom to build new power plants since the electricity demand was growing: the permission, though, came in too late. Eskom tried refurbishing its older power stations, but this could not close the demand gap.
- Artificially low prices, underinvestment, and lack of proper maintenance: Eskom kept the electricity prices artificially low, and perceived subsidies from the South African government. Artificially low prices can discourage investment in the electricity sector, thus precipitate supply shortages; encourage wasteful use of electricity, thus contributing to South Africa's becoming one of the largest contributors to global greenhouse emissions; Eskom was chronically short of revenue, thus unable to finance maintenance and new investment from internal funds. Such dependence on government bailouts inevitably led to an increased lack of autonomy and political interference in its day-to-day affairs, and thus to a further loss of efficiency. The low prices have not allowed Eskom to reach cost-reflectiveness, and fail to cover the increasing costs of coal mining, which constitutes the largest share of the electricity mix (Jahed et al., 2017; Maphosa & Mabuza, n.d.).

Load-shedding is causing significant disruption of civic and economic life. For South Africa's industrial, manufacturing, mining, commercial, and agricultural users, the costs of the upsurge in power shortages have been enormous (Kessides, 2020). Electricity shortages are now a powerful constraint on South Africa's fragile economic recovery: by some estimates, load-shedding has cost South Africa's economy an extraordinary R1,4 trillion over the past decade (Kessides, 2020). Despite the reduced electricity demand due to the impact of Covid-19, load-shedding in 2020 surpassed that of 2019, the country's previous worst record (Steyn & Renaud, 2020).

In 2019, following the recommendation of a team appointed by the President the previous year, it was announced that Eskom will be unbundled. There will be three separate subsidiaries, covering generation, transmission, and distribution, each with its management team, and with a holding company to oversee everything (Kessides, 2020; Mboweni, 2019; Power Futures South Africa, 2019; The Presidency, 2019).

The Eskom Holdings group includes (Eskom, n.d.-a):

- Eskom Enterprises: it is the investment arm of Eskom Holdings. It aims to grow Africa's energy industry and so doing improve the quality of life in South Africa. It composes of different businesses and, through the combined power services of these entities, it assists clients in the construction, maintenance, and repair of generation and transmission equipment.
- Eskom Rotek Industries: it was established to construct, maintain and transport equipment to support Eskom to meet and exceed South Africa's electricity needs.
- Eskom Uganda Limited: it has been operating in Uganda for the past 15 years. Experienced in hydropower generation and backed by the expertise of Eskom Enterprises, this concession is poised for growth-supporting Uganda's vision to give 80% of the population access to electricity by 2040.
- Trans African Projects: it specializes in design "fit for purpose" solutions for transmission and distribution projects in Africa, Middle East, and China.

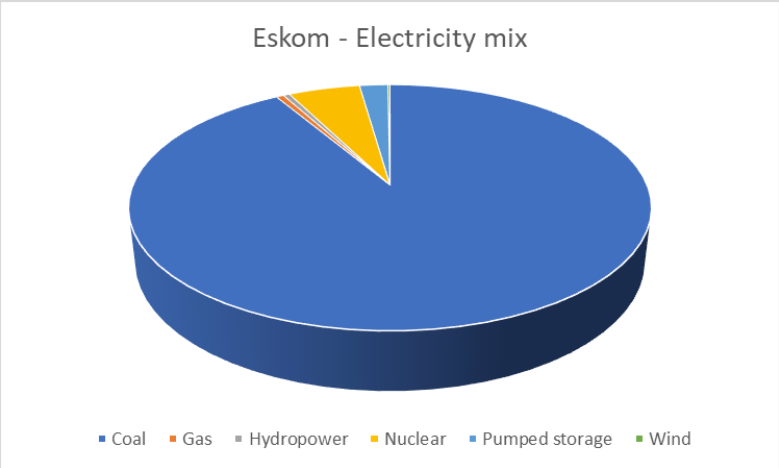


Figure 49 - Electricity mix Eskom (Eskom, 2019; Kessides, 2020)

Trade unions

a. COSATU (Congress of South African Trade Unions): founded in 1985, this union had close links with opposition parties such as the African National Congress (ANC) and the South African Communist Party (SACP), representing a credible and powerful anti-apartheid movement (Ludwig, 2008). The ANC-COSATU-SACP alliance contributed to the Nationalist Party's loss in the 1994 elections which meant the end of the apartheid regime (Ludwig, 2008). COSATU plays a predominant role in the trade union movement and counted around 57% of all union members in 2005 (Ludwig, 2008).

   COSATU has played an important role in introducing a discourse on just transition in South Africa. In 2011, it adopted a Policy Framework on Climate Change, which prioritises the interests of the working class in the changes necessary to reduce carbon emissions (Barret et al., 2012). The framework composes of 15 principles and is meant to thoughtfully guide COSATU's affiliates in implementing the transition towards a low carbon economy. The principles remind that the new policies on climate change should guarantee equal access to energy, water, and food resources, as well as safeguard those workers whose jobs are being threatened (Barret et al., 2012). COSATU keeps an international perspective and stresses the need for African solidarity, for instance asking that new technologies could be transferred within the continent without the constraints of intellectual property rights. The trade union also demands that

developed countries take responsibility for their climate debt, cumulated since the industrial revolution (Barret et al., 2012).

b. FEDUSA (Federation of Union of South Africa): FEDUSA emerged only in 1997 and therefore was not instrumental in the collapse of the apartheid regime. FEDUSA is the second central trade union organization in the country and counted about 17,6% of unionized workers in 2005 (Ludwig, 2008). FEDUSA is not associated with any political party, thus the union relied on the National Economic Development and Labour Council (NEDLAC) as a means of communication to assert its ideas (Ludwig, 2008). Established in 1994 by the Government, NEDLAC is a platform for social and economic negotiations, composed of government, businesses, and trade unions, and operates under the Department of Employment and Labour (National Government of South Africa, 2018).

c. NACTU (National Council of Trade Unions): NACTU is the third-largest trade union in South Africa in terms of membership. Like FEDUSA, NACTU refuses to be affiliated with a political party to retain its independence (Ludwig, 2008). Together with COSATU, in 2011 NACTU launched the One Million Climate Jobs (OMCJ) campaign, which aims to pressure the Government to implement just transition strategies and to create new job opportunities in the coming years, while facing the climate emergency: 259'000 in electrical installation and manufacture, 390'000 in public transport, 150'000 – 200'000 in construction, up to 100'000 in agriculture and around 100'000 in other branches (Ashley et al., 2016; Galgòczi, 2018).

Electricity mix

Coal

Loss of coal export revenues is frequently invoked as a risk to the South African economy if it moves away from coal. Total sales values in 2016 were R112bn, of which R50,5bn (45%) were export sales (Burton et al., 2018). Importantly, several of Eskom's power stations depend on mines where export revenues support low-cost coal contracts for Eskom. The state benefits via taxes and royalties associated with coal mining (Burton et al., 2018). Coal royalties are around 18% of total mining royalties (Burton et al., 2018).

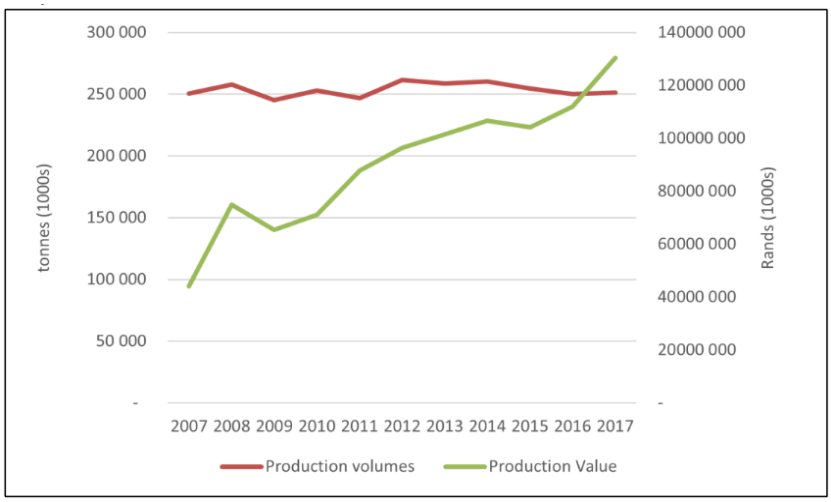


Figure 50 - Production volume and value in thousands of current rand of coal, 2007 to 2017 (Makgetla et al., 2019, p. 8)

In the short term, up until 2023, coal exports are forecast to remain fairly stable and possibly increase to its main export partners: India (44%), Pakistan (11%), and South Korea (10%). Still, the coal sales declined by 4% between 2012 and 2017 (Makgetla et al., 2019). There is a global shift away from coal that manifests acutely in the Western developed nations: while several domestic and broader macroeconomic impacts may affect the ability of South Africa to export coal in the future, an important determinant depends on the national energy policy dynamics in these countries (Makgetla et al., 2019).

Coal mining accounted for 2,3% of GDP in 2012. Roughly 1% of GDP in 2015 (Baker et al., n.d.) and 1,5% in 2018 (Minerals Council South Africa, 2018). Its importance to South Africa's energy economy can be attributed to the availability of abundant and low-cost resources and a history of exploiting low-cost labour to extract it, and state support for low-cost electricity generation and energy-intensive mining and industry (Burton et al., 2018; Kessides, 2020). In the past 10-15 years, however, domestic prices have risen rapidly, especially for power generation (Burton et al., 2018).

Renewables

	Coal	Coal (Decommissioning)	Nuclear	Hydro	Storage	PV	Wind	CSP	Gas & Diesel	Other (Distributed Generation, CoGen, Biomass, Landfill)
Current Base	37 149		1 860	2 100	2 912	1 474	1 980	300	3 830	499
2019	2 155	-2373					244	300		Allocation to the extent of the short term capacity and energy gap.
2020	1 433	-557				114	300			
2021	1 433	-1403				300	818			
2022	711	-844			513	400 1000	1600			
2023	750	-555				1000	1600			500
2024			1860				1600		1000	500
2025						1000	1600			500
2026		-1219					1600			500
2027	750	-847					1 600		2000	500
2028		-475				1000	1 600			500
2029		-1694			1575	1000	1 600			500
2030		-1050		2 500		1 000	1 600			500
TOTAL INSTALLED CAPACITY by 2030 (MW)	33364		1860	4600	5000	8288	17742	600	6380	
% Total Installed Capacity (% of MW)	43		2.36	5.84	6.35	10.52	22.53	0.76	8.1	
% Annual Energy Contribution (% of MWh)	58.8		4.5	8.4	1.2*	6.3	17.8	0.6	1.3	

Installed Capacity
Committed / Already Contracted Capacity
Capacity Decommissioned
New Additional Capacity
Extension of Koeberg Plant Design Life
Includes Distributed Generation Capacity for own use

- 2030 Coal Installed Capacity is less capacity decommissioned between years 2020 and 2030
- Koeberg power station rated / installed capacity will revert to 1926 MW (original design capacity) following design life extension work.
- Other / Distributed generation includes all generation facilities in circumstances in which the facility is operated solely to supply electricity to an end-use customer within the same property with the facility
- Short term capacity gap is estimated at 2000 MW

Figure 51 - Integrated Resources Plan 2019 (DoE, 2019b, p. 47)

Research & Development

As a consequence of the 2008 National Energy Act, the South African National Energy Development Institute was established in 2011 (SANEDI, n.d.). This public entity directs, monitors, and conducts energy research and development, promotes energy research and technology innovation as well as undertakes measures to promote energy efficiency throughout the economy. SANEDI's applied energy research, development, and innovation programme focuses on 6 sub-areas that include Renewable Energy, Cleaner Fossil Fuels, Data and Knowledge Management, Cleaner Mobility, Smart Grids, Working for Energy (SANEDI, n.d.). SANEDI has established several centres of research to support its activity, among which the Renewable Energy Centre Of Research and Development (RECORD). RECORD strives to be recognised as the foremost institution for renewable energy research coordination and collaboration in SA: it supports research, project implementation, and knowledge dissemination (SANEDI, n.d.).

The Cleaner Fossil Fuel Programme of SANEDI mainly focuses on Carbon Capture and Storage (CCS): this is considered as one of the priority programs for addressing climate change in South Africa. However, the technology is still fairly new and there is a need to build capacity in the country (SANEDI, n.d.).

Appendix 8: Suggestions for interventions

South Africa

Elements of Just Transition: Job security

Element	Description	REI4P	
		Threshold %	Target %
Job Creation	South Africa-based employees who are citizens	50	80
	South Africa-based employees who are black people	30	50
	Skilled employees who are black people	18	30
	RSA-based employees who are citizens and from local communities	12	20
Local Content	Value of local content spending	40 (45 for solar PV)	65
Ownership	Shareholding by black people in the seller (bidder)	12	30
	Shareholding by local communities in the seller	2.5	5
	Shareholding by black people in the construction contractor	8	20
	Shareholding by black people in the operations contractor	8	20
Management Control	Black people in top management	-	40
Preferential Procurement	B-BBEE procurement, as percentage of total procurement spend	-	60
	Qualifying small enterprises and SME procurement, as percentage of total procurement spend	-	10
	Women-owned vendor procurement, as percentage of total procurement spend	-	5
Enterprise Development	Enterprise development contributions, as a percentage of revenue	-	0.6
	Adjusted enterprise development contributions, as a percentage of revenue	-	0.6
	Enterprise development contributions on SMEs	N/A	N/A
Socioeconomic Development	Socioeconomic development contributions, as a percentage of revenue	1	1.5
	Adjusted socioeconomic development contributions, as a percentage of revenue	1	1.5
SME Participation	Key components and/or equipment and balance-of-plant spend on SMEs	N/A	N/A

Figure 52 - Economic development criteria applied in the REI4P bid rounds (Filipova et al., 2019, p. 31)