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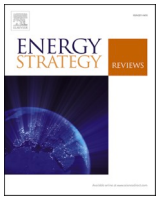

An unjust and failed energy transition strategy? Taiwan's goal of becoming nuclear-free by 2025

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ABSTRACT

Taiwan launched an energy transition agenda to pursue a nuclear-free homeland by 2025 after the anti-nuclear party won the 2016 presidential and parliament elections. In 2016, the 2025 electricity mix target was set to 50% gas-fired power, 30% coal-fired power, and 20% renewable electricity (RE), and thus, no nuclear power. Despite many efforts, the electricity mix remained far from these targets at the end of 2020: coal-fired power, 43.5%; gas-fired power, 38%; RE, 7.1%; and nuclear power, 8.5%. This study evaluates the possibility of achieving the 2025 targets and the barriers to reaching each target. It also uses the concept of a 'just' energy transition to assess whether this vision meets the related criteria and why.

1. Introduction

Energy transition has become a trend in global energy policy [1]. This trend has persisted even during the COVID-19 pandemic [2]. For instance, the European Union (EU) has recently pushed the agenda of cleaner energy transition and green deals [3]. Certain Asian countries such as Japan and South Korea are enacting energy transition policies [4,5]. Taiwan's government decided to launch the energy transition agenda and pursue a nuclear-free homeland by 2025 after the anti-nuclear party won both the presidential and parliamentary elections in 2016 [6]. The ongoing transition is different from past practices, and the lengthy process of changing the national energy policy and electricity mix has already lasted several months. Under this, many initiatives were implemented, from collecting public opinion on the new policy change online to hosting several regional workshops and a national energy conference. Five days after the President's inauguration ceremony on May 20, 2016, the Ministry of Economic Affairs (MOEA) published a four-page power-point presentation highlighting the 2025 electricity mix vision, which set targets of 50% gas-fired power, 30% coal-fired power, and 20% renewable electricity (RE), an implicit target of 0% for nuclear power [7]. This vision sought to transform the electricity mix of 45.90% coal, 31.56% gas, 4.82% RE, and 11.99% nuclear power as of the end of 2016 to a new mix within a tight timeframe of less than ten years. If successful, this sudden 15% jump in the share of RE in less than ten years will make Taiwan the world's fastest-growing RE economy. The sudden drop in coal power and increase in gas-fired power within less than ten years will be a unique global case of rapid changes in the electricity mix.

Substantial planning efforts have been made to pave the way to achieve these targets. The Guidelines on Energy Development in April 2017 served as general policy guidelines to realise this ambition [8]. The detailed planning for solar photovoltaics (PV), the two-year solar PV promotion plan [75], and the four-year Wind Power Promotion Plan (2017–2020) were adopted in October 2016 and August 2017, respectively, by Taiwan's cabinet. After a long discussion, the 117-page white paper outlining the careful planning of Taiwan's energy transition was announced by the MOEA in November 2020 [9].

Despite these efforts, the electricity mix by the end of 2021 remains far from the planned targets: coal-fired power is at 43.5%, nuclear power remains unchanged at 8.5%, and gas-fired power and RE have slightly increased to 38% and 7.1%, respectively. Although pandemic outbreaks have impaired economic growth and energy project development in many countries, they have not strongly affected Taiwan. Even during the COVID-19 crisis, seven days in July 2020 were among the top ten days of peak electricity consumption in Taiwan's history. Therefore, now (i.e., 2022) seems to be the right moment to evaluate whether such quantitative goals will be met and, if not, what will cause such failure.

Few studies have evaluated Taiwan's recent energy transition. The use of a narrower parameter to evaluate Taiwan's energy transition was

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Abbreviations

CCS	Carbon Capture and Storage
ETS	Emission Trading Scheme
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency –
EU	European Union
FIT	Feed-in tariff –
IEA	International Energy Agency
LNG	Liquefied Natural Gas
LCR	Local Content Requirement
MOEA	Ministry of Economic Affairs –
NGOs	Non-government organisations
PV	Photovoltaics
RPS	Renewable Portfolio Standard –
SEA	Strategic Environmental Assessment
SDGs	Sustainable Development Goals
TFD	Taiwan Foundation for Democracy
TSMC	Taiwan Semiconductor Corporation

identified by those who evaluated Taiwan's situation. Huang and Chen evaluated Taiwan's energy transition from the political science perspective of regime resistance [10]. Other researchers have used sustainable development goals (SDGs) or multi-scalar approach for assessment [74,106].

This study evaluates the possibility of achieving the 2025 electricity mix vision on time and the barriers to reaching individual targets. Further, this study is the first attempt to apply the concept of 'just' energy transition to assess if this policy meets related criteria and why. The main reason is that transition or energy justice has been identified in the literature as an important decision-support tool for policymakers [11,12]. Recently, the parameters of five types of justice have been identified in studies on this subject [13]. Based on this literature, first, we provide a general review of what the general policy setting of Taiwan is and evaluate the cross-sector implementation problems of this transition. Second, this outline is applied to assess whether it is just to achieve the individual goals of 50%, 30%, 20%, and 0% for gas-fired power, coal-fired power, RE, and nuclear power, respectively. We also assessed the barriers to achieving these goals. Moreover, the study provides final remarks, especially highlighting how an unjust energy transition in Taiwan is expected to fail to achieve the energy transition targets. Finally, we have to admit the research limitation of this study that while we have considered the data till mid-2022, there may be a dramatic change in the development of electricity mix before 2025. That said, we have already tried our best to incorporate the data from 2016 to mid-2022.

2. General review of energy transition policy in taiwan

2.1. An unjust transition

A just transition is considered as an application of energy justice to energy transition. Energy justice, as a framework involving the guiding tenets of recognition, procedure, and distribution, allows for the assessment of energy transition [14]. Thus, substantive design and due process (procedural justice) should be respected [15]. However, such thinking is missing in Taiwan's government planning regarding the 2025 energy vision.

2.1.1. Lack of thoughtful deliberation process: violation of energy democracy

The formulation of a new energy transition policy should be different from the old-style top-down approach. A certain extent of bottom-up deliberative democracy is necessary, particularly for nationwide debates on different energy options [16]. However, this process has not been implemented in Taiwan. Taiwan set the 2025 vision of 50–30-20 on May 25, 2016, *five days* after the new President's inauguration ceremony on May 20, 2016. Such dramatic changes to the existing electricity mix (gas 36%; coal 37%; RE 5%; nuclear 13%) [17] via this new vision will pose a great threat to the national energy security and electricity price.

The new energy policy was announced as *4 pages 'slides'*. It is not currently available under the current policy on the official website and can only be retrieved from a newsletter on a non-MOEA website [76]. Comparing the usual practice of energy decision-making, previous governments hosted the National Energy Conference with several regional and topic groups to formulate opinions from the bottom up by collecting opinions online and responding to them for several months [77]. Despite such public participation, the 2015 National Energy Conference was heavily criticised for generating limited interest and public participation [78].

To correct such procedural flaws in just transition, a similar structure to collect opinions from Taiwan's four main regions (north, south, middle, and east) was launched in July 2017 [18]. However, this was one year after the announcement of the 2025 targets. An online platform was commissioned to demonstrate the entire process [19]. This website serves as a platform to receive support from industry, non-government organisations (NGOs), and experts in formulating the Taiwan Energy Transition White Paper. However, facing the challenge of a big nationwide blackout in mid-August 2017 [79], the schedule for finalising the white paper was delayed. The cabinet approved it on November 18, 2020 [9]. Taiwan had just held a new presidential election in January 2020. Thus, it took more than one president term of four years after the 2025 vision was first announced. Due to this, the white paper has only a 'symbolic' meaning. More importantly, *the presumption of 50-30-20 by 2025* cannot be challenged during the public participations process. Thus, public participation seems merely decorative.

2.1.2. Bypassing the Strategic Environmental Assessment procedure

To deal with environmental effects at a higher-level policy/plan/program beyond the project level, Taiwan followed the global trend and established the Strategic Environmental Assessment (SEA) in 2000 [20]. According to Article 3 of the Ordinance on Environmental Impact Assessment of Governmental Policy, governmental policies likely to have significant effects on the environment should be subject to SEA requirements. Of the nine policies listed, the energy policy is one. The Ordinance on the Policy of Compulsory SEA was provided to specify the above-mentioned 'policies' and exclude unnecessary policies. The energy development framework was listed as a compulsory SEA policy [20]. For instance, before the 2016 planning, the SEA Report of the draft Energy Development Framework in 2010 [21] and 2015 [22] were prepared. Usually, the electricity mix changes in this framework are the main focus of SEA.

Dramatic changes in the electricity mix on May 25, 2016 were not subject to this scheme. This was investigated and warned against by the Control Yuan, which plays a similar role to that of the Parliamentary Ombudsman in Sweden and may initiate disciplinary procedures against an official for a misdemeanour. In a correction report, it indicated on the lack of this SEA mandate and the carelessness of the MOEA in revising the electricity mix [80]. Such negligence or ignorance also leads to unjust issues (e.g., the lack of consideration of likely significant environmental impacts from the new electricity mix) and failure issues, such as land-use conflicts with more ambitious RE targets, which will be elaborated on later.

2.1.3. Lack of provisional energy conservation target and a fixed emission reduction target

Under transition, the target setting should embrace different aspects of energy and climate change policies. For instance, the EU set the

targets of a 40% reduction in greenhouse gas emissions (from 1990 levels), 32% share for renewable energy, and 32.5% improvement in energy efficiency under its 2030 Climate and Energy Framework [23]. These targets should provide legally binding goals for the overall EU and EU countries. The rule of law is a fundamental element of transition [24].

However, in response to 50-30-20 targets, only a new updated RE 'installation' target in Article 6 of 2019 revision of Renewable Energy Act was made: 'the promotion objectives for the total amount of electricity generated by renewable energy power generation facility by 2025 is set to be more than 27, 000, 000 kW' [25]. The 20% 'ratio' goal can be only seen in policies, such as the energy transition white paper of 2020 [26].

Emission reduction target remained the same as that set before 2016 in the GHG Reduction Act of 2015, with only a lenient and long-term goal: 'Long-term national GHG emission reduction goal shall be to reduce GHG emissions to no more than 50% of 2005 GHG emission by 2050'. However, this goal does not reflect the recent Asian trend of net-zero emissions by 2050 in Japan and South Korea [27]. Changing this legal goal does not require parliament's scrutiny. However, it can be easily changed by the Environmental Protection Agency (EPA): 'The goal pursuant to the foregoing Paragraph shall be timely adjusted by the central competent authority' [28]. Moreover, under the current energy transition in Taiwan, low priority is given to the role of climate change. This is evident, as under the implementation of the GHG Reduction Act of 2015, the emission trading scheme (ETS), the most important carbon pricing scheme in this Act, has not been implemented or introduced since 2016. Only recently, the President announced consideration of the 2050 carbon neural target. However, whether this goal will be embedded in the law remains to be seen [81].

The role of the energy conservation target is missing from the energy transition agenda. There is only a qualitative indication of 'Strengthen Energy Saving on the Demand Side' in the Guiding Principles under the Guideline on Energy Development of 2017 [8], while there is a lack of nationwide quantitative energy conservation targets in any policy initiative.

2.1.4. Underestimating the impact of electricity price rise

An energy transition should consider the price rise impact of the policy on citizens and the economic operation of the industry. As the share of RE is expected to increase from the current 5%–20% by 2025 due to mainly expensive PV and offshore wind power, and increased expensive liquefied natural gas (LNG), combined with the phase-out of cheap nuclear power, the price of electricity is expected to hike [10]. Facing such criticism, the Minister of the MOEA continued to argue that electricity prices in Taiwan will increase by no more than 10% if the country phases out nuclear power by 2025 [29]. In 2019, the MOEA changed this to a 30% increase compared to the 2017 electricity price [105]. An MOEA report submitted to the Legislature in March 2019 indicated a price of 3.08 NTD/kWh by 2025 from 2.55 NTD/kWh in 2017 if the electricity consumption rises by 1.26% annually. The price is expected to increase to 3.39 NTD/kWh if the yearly consumption increases by 1.86% [101]. However, according to a recent analysis by Bloomberg, the electricity price may increase by 25% in five years, which will become a major threat to Taiwan's high technology industry's exports [30].

2.2. Failure

To achieve such an ambitious target, the mobilisation of instruments such as policy and law is very important, as observed in developing countries [31]. However, the lack or insufficient consideration of these key tools may lead to failure in Taiwan.

2.2.1. Lack of good overall policy

The Guideline on Energy Development of 2017 to implement the new energy policy was published. However, only general principles and directions were highlighted in this *six-page* policy [8]. A more comprehensive plan on the 123-page Taiwan Energy Transition Paper came in November 2020. However, due to COVID-19, the construction of RE projects, including the free movement of foreign technical staff in offshore wind power projects, faced serious delays [32]. The lack of a comprehensive policy for the past four years and difficulty in implementing comprehensive policies during COVID-19 did not help achieve the targets.

The sectoral RE policy includes the two-year solar PV promotion plan of 2016 [75] and the four-year wind power promotion plan of 2017. However, owing to the lack of general planning and legislation to facilitate implementation, despite the scheduled official target of approximately 520 MW of offshore capacity by 2020, only 237 MW was realised by May 2022. The remaining RE targets also face serious delays. The original 2020 PV target set by the Premier in 2019 was 6.5 GW [82]. However, of that, only 5817.2 MW has been achieved so far.

Finally, the industrial policy is problematic and may not meet the needs of energy transition goals. The Taiwan Semiconductor Corporation (TSMC), the world's largest semiconductor company, is projected to consume approximately one-third of Taiwan's total electricity in the foreseeable future [33]. This rapid increase in electricity consumption will create pressure to reach 50-30-20 goals.

2.2.2. Lack of sufficient legal instruments

To lead the energy transition, a wide range of legal instruments should be adopted to accommodate the need to realise such ambitious goals. Legislation on climate change, renewable energy promotion, energy conservation, and efficiency can be seen as triangular legislation under energy transition. For instance, the EU has adopted eight legislative proposals in the Clean Energy for All Europeans package, including the Renewable Energy Directive, the Directive on Energy Efficiency, and the regulation on the Governance of the Energy Union and Climate Action, etc. [34].

However, in Taiwan, this balanced triangle approach is lacking. Electricity liberalisation was prioritised. Despite the rapid promulgation of the Electricity Liberalisation Act in January 2017, it did not play a role in facilitating RE development [6]. Therefore, a favourable feed-in tariff (FIT) scheme under the Renewable Energy Act of 2009 continues to play a key role in attracting RE investment. The revision of the 2009 RE Act came late and was finally passed in April 2019. Again, this amendment adopted a unique approach by introducing the world's first renewable portfolio standard (RPS) for large-electricity users. Studies show that such legislation is not helpful for further RE growth, as large-electricity users may prefer buying RE from existing projects developed under the FIT or tendering scheme [35].

Apart from RE promotion legislation, the other two legal tools in triangular legislation remain missing. The government proposed a revision of the Energy Conservation Bill only in March 2018. However, it is still getting deliberated in the Parliament [83]. However, the process to revise the 2015 GHG Act remains slow. The bill began to get revised in mid-2020, but still awaits approval from the Parliament [84].

In addition to legislation to achieve energy transition, the requirement under Article 91 of the Electricity Act of 2017 would play a valuable role in supervising energy security and progress during the energy transition process: 'The central competent authority shall present the annual report on the current supply and demand of electricity in the country, the progress of the development of electricity and the status of the energy-saving and carbon reduction policy; the report shall be open for public access.' However, in reality, the government presented this yearly self-review in the form of an annual report only in 2017, 2018, and May 2021. Soon after the protests by NGOs, the government published the 2019(+)2020 report online [36]. The main reason for this delay seems to be related to failing to reach 50-30-20 goals, elaborated individually in Section 3.

3. Evaluation of individual targets of energy transition by 2025

3.1. 50% gas-fired power target

3.1.1. An unjust transition

3.1.1.1. Environmental injustice of a controversial LNG terminal. Before becoming the president in 2016, the presidential candidate, Tsai, visited the site of three LNG terminals and promised to set up a 'natural reserve zone' to protect the algal reef. The candidate also attacked the government's LNG terminal plan on April 20, 2013 [37]. However, this attitude changed after its inauguration in 2016. In October 2018, the project suddenly cleared an environmental impact assessment (EIA) review with a terrible vote of 7 (yes): 2 (no response). The review commission failed twice because of insufficient attendance and avoidance of decision-making by the academics. Eight out of 21 EIA commissioners in the third meeting were again absent; all absentees were from academic backgrounds, including biodiversity [85]. In particular, the EPA's deputy minister resigned right before the meeting to protest against this project [86]. Thus, the commissioners only presented five government representatives. The rubber stamp function of this meeting could not have been more apparent. The media described this meeting as the darkest EIA committee in history [87]. Such a flawed resolution would lead to environmental injustice owing to the expanding use of LNG during the energy transition.

3.1.1.2. Disrespecting citizens' choice in the 2018 referendum. In 2018, Taiwan had a nationwide referendum on the use of thermal power electricity, asking: 'Do you agree "To reduce by 1% year by year" the electricity production from thermal power plants?'. An overwhelming number of people agreed (7,955,753 or 79.04%) compared to those who disagreed (2,109,157 or 20.96%) [38]. The MOEA promised to respect the results by implementing a 1% yearly reduction in the electricity production from thermal power plants in the next two years, as the referendum was binding for only two years [100]. Subsequently, the share of thermal power was reduced from 84.14% in 2018 to 81.47% in 2019 and 82.23% in 2020.

This 2-year validity claim for the referendum results cannot be justified. The MOEA claims that the Article 30 of the referendum act justifies this interpretation.

'The initiated legislative principles shall not be altered by the legislative agencies; the law or autonomous regulation shall not be amended or rescinded within 2 years after implementation. The same law cannot be enacted by the legislative agencies within 2 years after the rescission of the law or autonomous regulation through referendum'.

However, if one looks closely at the statue, this is a completely incorrect interpretation. According to the referendum results, the share of thermal power is expected to be less than 80% (79.14%) by 2023. However, the government will maintain an 80% thermal power mix by 2025.

3.1.1.3. Neglecting carbon emissions from gas-fired power plants. The government continued to claim that RE would replace nuclear power under a nuclear-free homeland policy [39]. However, owing to the slow progress of RE (from 4.82% in 2016 to 7.1% in 2021), the most likely replacement would come from thermal (gas- or coal-fired) power plants. Either of these choices would lead to an increase in carbon emissions. Decarbonisation is important under the just transition [40]. Therefore, Taiwan's approach may be unjust by replacing low-carbon-emission nuclear power with gas-fired power.

3.1.2. Failure

3.1.2.1. Time strain to reach the goal. As the 50% target for gas-fired power was announced in 2016, efforts have helped increase the share of gas-fired power from 31.56% in 2016 to 35.7% in 2020 [41]. However, this increase may not be sufficient to meet the increasing demand. After recent nationwide electricity blackouts on 13 and May 17, 2021, the annual report on the current supply and demand of electricity in the country highlighted the estimated net increase of 14,500 MW in the installation of gas-fired power plants over 2021–2027 and the desire to reach 2,7460 MW by 2025 [36]. However, it is unclear how the ratio and installed capacity can rapidly increase within such a short timeline. Delayed LNG terminal projects is also a challenge.

3.1.2.2. Controversy over the construction of the third LNG terminal and referendum. To expand the import capacity of gas-fired power plants, the government has promoted the idea of a third LNG terminal by the state-owned petroleum company, CPC. The Executive Yuan approved the previous government's plan in September 2015 [42]. However, due to the aforementioned environmental issues of algae reefs, the EIA review process did not proceed smoothly and was adopted late in October 2018 [85]. Subsequently, environmental NGOs initiated a lawsuit to challenge the procedural flaws of this EIA permit. The NGOs also launched a referendum to veto this project by asking people: 'Do you agree [with] the construction of a receiving terminal for natural gas energy production on Taoyuan's Datan Algal Reef?' This was scheduled to be voted on in August 2021 [98] but was postponed to December 2021 due to the COVID-19 outbreak. According to a recent poll on this issue by the Taiwan Foundation for Democracy (TFD), 41.1% of people would vote for vetoing the project, while only 27.5% would support it [88]. If the majority in August denies this terminal project, it will cast a shadow over the gas-fired power target. However, due to the low voter turnout and the number of Yes votes not exceeding the threshold of 4.9 million [Yes: 3,901,171 (48.37%); No: 4,163,464 (51.63%)], there is no legal effect of this referendum [43]. The delay in construction of this terminal and the lawsuit may still cast a shadow over the prospect of reaching the target of 50% gas-fired power.

3.2. 30% coal-fired power target

3.2.1. An unjust transition

3.2.1.1. Lack of schedule to phase out coal. The coal phase-out has become a key global policy agenda of just transition [44]. Many European countries are aiming to phase out coal by announcing targets that are scheduled to be achieved before 2030; the UK and France have set such targets to be met by 2025 and 2021, respectively [89]. Even countries phasing out nuclear power such as Germany promised a 2038 schedule by promulgating the Law on Phasing-Out Coal-Powered Energy [45].

However, the 2025 vision of Taiwan only envisages a 30% target for coal-fired power. There was no further elaboration of the coal phase-out schedule. The lack of a coal phase-out schedule may have rendered Taiwan's energy transition unjust.

3.2.1.2. Disregarding the 2018 referendum on coal-fired plants. In the 2018 referendum, two questions related to the fate of coal-fired power plants were asked directly and indirectly. The direct one was, 'Do you agree to establishing an energy policy to "Stop construction and expansion of any coal-fired thermal power plants or generator units (including the Shen Ao Power Plant currently under construction)"?'. The indirect one was 'Do you agree "To reduce by 1% year by year" electricity production from thermal power plants?'. There was overwhelming support for these two issues, with 76.41% and 79.04% of votes saying yes to them, respectively. Then, the new Number 3 plant in Linkou (800 MW) and Number 2 plant in Dalin (800 MW) should not come into operation in 2019 [36], as the former question means that these two power plants should 'stop construction'. Finally, due to strong opposition from citizens to the third LNG terminal, there are discussions

on postponing the decommissioning schedule of certain coal-fired power plants to fill the gap [46].

3.2.1.3. Replacing nuclear power with coal? The lack of development of carbon capture and storage. Under a just transition, the pace of energy development mainly follows the route of replacing nuclear power with 'cleaner' electricity, which may include clean coal but not traditional coal-fired plants [44]. However, even after the 2025 Energy Vision announcement, three coal-fired plants with a total capacity of 2400 MW (Dalin #1, Dalan #2, and Linkou #2) came into operation in 2017 and 2018 [47]. This may be related to the decommissioning of the first nuclear power plant (604 MW in December 2018 and 604 MW in July 2019) and the first reactor of the second nuclear power plant (985 MW in December 2021), with a total capacity of approximately 2183 MW. Thus, replacing nuclear power with traditional coal and not clean coal plants will be an unjust transition.

Finally, under the International Energy Agency's (IEA) technology roadmap, carbon capture and storage (CCS) is usually favoured to improve emission performance [48]. However, there is only a qualitative direction without a fixed target to develop CCS in Taiwan in the 2017 Guidelines on Energy Development published in April 2017: 'Introduce clean coal and carbon reduction-related technologies based on technological progress assessment and enhance the efficiency of coal-fired power generation to reduce the carbon emissions from coal consumption' [8]. Without CCS, the development of new coal-fired power plants cannot be justified.

3.2.2. Failure

3.2.2.1. Standstill of coal-fired plants in the electricity mix. After the announcement of the ambition in 2016 to reduce coal-fired power to 30%, ironically, the share of coal-fired power in the electricity mix increased in the following two years (45.90% in 2016 to 47.34% and 47.65% in 2017 and 2018, respectively). Ironically, the main contributor to the reduction in coal-fired power in 2019 (46.13%) and 2020 (45.02%) is the increase in nuclear power (from 8.31% to 10.05% in 2016 and 2017, respectively, to 11.79% and 11.24% in 2019 and 2020, respectively), which is unfavourable for the current government [41]. With less than five years to the end of 2025, reducing the share of coal-fired power plants in the electricity mix by 15% would pose similar challenges as increasing the share of RE by 13% (from 7.1% in 2021) or 12% (from 38% in 2021) gas-fired power plants.

3.2.2.2. Challenge after the LNG terminal referendum. Under the government's 2025 vision, gas-fired power plants will play a key role in replacing nuclear power. However, as noted above, if the referendum vetoed the LNG terminal project successfully, the faster way to fill in the role would be to add extra coal-fired power plants on the existing site or the development of new coal-fired power plants, which would make it impossible to reduce coal-fired power to the 30% target by 2025. As noted above, this referendum did not pass, but a shadow has been cast due to the delay in this LNG terminal project. In addition, after the referendum and early this year, the Minister of MOEA publicly admitted that achieving 20% RE by 2025 is impossible, and perhaps only 15.2% could be reached by 2025 [49]. In addition, with likely electricity shortages from 2023 due to high economic growth during the COVID-19 pandemic (6.09% in 2021; 4.15% in 2022 [50]), the reserve margin of power generation in 2021 and 2022 is below 7% and is expected to drop to 4.38% by 2023. The quickest way to fill this gap would be to add coal-fired power plants, which would jeopardise the target of reducing them.

3.3. 20% RE target

3.3.1. An unjust transition

3.3.1.1. Lack of land/marine planning based on SEA. In general, the lack of SEA also leads to environmental injustice in implementing the 20% RE target. The lack of careful land planning in advance will lead to conflicting land use and affect the environment; for example, issues like the conflicting use of wetlands [51] and concerns over the effects of solar panels on bird habitats have already cropped up [52].

Taiwan has already witnessed conflicts between PV developers and farmers [53], small-scale aquaculture farmers [54], and indigenous people [55]. These land-use changes from the original economic purpose are related to the unreasonably high FIT for photovoltaics. This led to a dramatic increase in rent prices, causing changes in existing RE use [56]. For instance, small-scale aquaculture farmers cannot compete with PV developers, as rent prices have increased more than ten times [90]. Even offshore wind power projects faced a lack of involvement from main stakeholders, the angler, before allocating zones in 2015. This has led to endless unresolved controversies over fishers' compensation [57].

The lack of land-use-based SEA to involve stakeholders as early as possible when conducting land or zonal planning ignores the procedural rights of the interested parties and renders such RE developments unjust.

3.3.1.2. Lack of consideration for cheap RE in Taiwan's roadmap to 2025. To promote RE and avoid very high electricity bills for citizens, an appropriate mix of inexpensive and expensive RE is necessary, as observed in different countries [58]. However, this was not the case in Taiwan. Since 2016, the main focus of RE has changed from low-cost onshore wind power to mainly pricy PV and offshore wind power. For instance, for projects in 2021, the PV electricity rate is 3.79–5.67 NTD/kWh for almost 20 years. Moreover, Taiwan's highest offshore wind power FITs, awarded in 2018 at 6.2795 NTD/kWh for the first ten years plus 4.1422 NTD/kWh for the next ten years, will develop 3.8 GW by 2025. This rate is almost double that of recent projects in the US and Europe [91].

Tendering schemes have seldom been used to reduce costs. For example, the PV tendering scheme effectively reduced the power purchase price in two large areas; under the scheme, the bidding prices were kept at just 2.6 and 3.5 NTD/kWh in these two areas [59]. Offshore wind power tendering was launched two months after the selection process in 2018. The rates (2.2 and 2.5 NTD/kWh) tendered by the two developers were much lower than those under FIT.

Therefore, the government's preference for *expensive* RE could lead to much higher electricity bills by 2025. The production of cheap RE, such as onshore wind power, is scheduled to increase slightly from 850 MW in 2019 to 1.2 GW by 2025. Over-reliance on favourable FIT schemes instead of cost-saving tendering schemes may burden the general public excessively. Note that the original justification for such high FITs for offshore wind power is related to developers' mandatory local content requirement (LCR). However, recently, due to the lack of experience in Taiwan's industry, the government agreed to allow developers to use Korean-made (Samkang M&T) undersea foundations and still be qualified for LCR and higher LCR FIT [104]. This is an awkward situation, as Taiwanese consumers pay extra, but there are no impacts on the local industry.

3.3.1.3. Citizens are unable to reap the benefits of green electricity liberalisation. To support RE development, subsidies are inevitable in the initial phase, which will lead to increased electricity prices [60]. However, as the RE technology matures and its cost gets reduced, customers are expected to benefit from low-cost RE, such as the aforementioned low-cost, land-based PV and offshore wind power under the tendering scheme.

Intriguingly, Taiwanese electricity customers do not enjoy these

benefits. Under the Electricity Liberalisation Act of 2017, all RE developers were granted the right to freely choose whether to sell electricity to the public grid or other private industries [6]. The original design intended to allow RE developers to be eligible for favourable FIT to sell to industries and alleviate the burden on citizens, which would have met the objective of the transition. However, RE developers tried to sell the electricity developed under the tendering scheme at unfavourable rates to private industries during implementation. This has prevented the general public from reaping the benefits of low-cost RE. For instance, developers used this clause to sell their RE at a higher rate to the TSMC rather than at a low tendered rate to the general public [61].

3.3.1.4. Unjust to large electricity users. Due to the slow progress towards meeting the RE target, the reform in the 2019 Renewable Energy Act began targeting large-electricity users. Taiwan introduced the world's first renewable portfolio standards (RPS) by requiring large electricity users (with a contract capacity over 5000 kW) to fulfil 10% of their electricity consumption from RE and/or storage obligations [35]. Such schemes shifted half of the 2025 national RE burden (20%) to these users. Such a scheme may help increase RE installations, but is it just, and why should the large users bear this burden?

These large-electricity users have played an important role in contributing to RE surcharges to promote RE through their electricity consumption, that is, approximately 5–6% RE in the national grid system. Thus, it is unknown why they have to bear an extra 10% to facilitate the green energy transition.

The calculation of RE obligations is interesting. If RE already forms 5–6% of power consumed by such consumers, they should only have to increase its consumption by an extra 4–5% to fulfil the 10% obligation. However, this was not the case here. As there is no electricity bill disclosure system in Taiwan, the government still requires these users to fulfil the 10% RE obligation separately. Although this RPS may promote RE, such schemes cannot be justified under the transition concept.

3.3.2. Failure

3.3.2.1. Slow progress. The share of RE in overall electricity generation increased from 4.82% in 2016 to 5.56% in 2019, then to 7.1% in 2021, despite the continued expansion in installed PV and wind capacity [41]. The drop in RE's share and slow progress in 2020 was due to low rainfall and low hydropower output. Therefore, despite the large PV installation capacity expansion in recent years (4725.7 MW by 2016 and 7700 MW by 2021), the RE increase is less than 1% each year. Following this trend and the effects of COVID-19, it appears impossible to increase the capacity by 4–5% every year to reach the 20% target by 2025.

Perhaps, due to this challenge, the Renewable Energy Act adopted in 2019 only provides an easier and updated installation target of 2025 (27 GW installation capacity by 2025) and ignores the policy target of 20% [25]. With the current development pace of RE, achieving three times that number by 2025 seems unlikely.

3.3.2.2. RE development focusing on unstable PV and wind power. Compared with the balanced focus on dispatchable and undispatchable RE in countries that are promoting RE such as Germany, Taiwan's government focused mainly on the undispatchable RE from PV and wind power. There is a need to develop coal- or gas-fired power plants to tackle the intermittency of such RE. Such factors also offset the growth of RE in the overall electricity mix.

The lack of consideration to biomass electricity may also lead to failure in achieving RE targets by 2025. The installed capacity of dispatchable RE of biomass electricity and waste incinerators remains unchanged in 2016 and 2020: biomass 80.0 MW and 77.9 MW, respectively; waste 629.1 MW and 631.9 MW, respectively [62]. The size and output of these biomass units are usually large and can contribute faster to RE installation capacity and higher capacity factors. Thus, the lack of consideration of the important role of biomass electricity may lead to failure in achieving 2025 RE targets.

3.4. 0% nuclear power

3.4.1. An unjust transition

3.4.1.1. Against the referendum results of 2018. In 2018, a referendum on the nuclear-free homeland clause was held, whose question was 'Do you agree to repeal Article 95 Paragraph 1 of the Electricity Act: "Should Nuclear-energy-based power generating facilities stop running by 2025"?'. The voting results agreed with repealing; 5,895,560 (59.49%) voters said yes and 4,014,215 (40.51%) said no. However, after the referendum, the government continued to proceed with the agenda by narrowly interpreting the result of removing this clause [92]. The government claimed that citizens remained supportive of its 2025 policy agenda and included the 2025 nuclear-free homeland vision in the key policy, like the 'Taiwan Energy Transition White Paper' of 2020 [9]. The advocated measures included decommissioning all nuclear plants by 2025, followed by no life extension issuance for the six reactors, and aggressive removal of the fuel rods and shipping back to the US to avoid the fourth power plant from commissioning after 2025 [93]. This disregard for the referendum made these government actions unjust.

3.4.1.2. Continuing the use of safety concerning nuclear power till 2025. The government and ruling party have continued to warn the general public on the unexpected Fukushima disaster, such as the danger of using nuclear power by protesting on the street and via official announcements. For example, the President's participation in the 2019 anti-nuclear accident protest on the Fukushima accident's anniversary was the first in Taiwan's political history [94]. If there were dangers due to unexpected large earthquakes and tsunamis, as claimed by the government, why were state-owned generators allowed to switch on reactors and Why did the share of nuclear power in overall electricity generated increase from 8.31% in 2017 to 11.79% in 2019 and 11.24% in 2020? In contrast, if nuclear safety can be human-controlled, why can nuclear power not be used beyond 2025? Why will the existing six reactors become dangerous only after the first day of their 40 years of operational life? Why is the new and more advanced fourth nuclear power plant unsafe and unsuitable for construction and operation? Interestingly, as deputy premier in 2007, the President approved the budget to continue constructing this fourth plant [63].

3.4.1.3. Lack of the rule of law and due process. Facing the challenge of a nuclear referendum in November 2018, the government did not wait until the results were obtained and sent out fuel rods in June 2018 [95]. The government sent out the last batch of nuclear fuel rods in May 2021, even though there was a referendum on the operation of the fourth nuclear power plant [96].

The total sunk cost of the fourth plant is extremely high, at NT$280 billion (US$9.4 billion). According to an ordinary rule of law in a democratic country, such decisions to abandon a plant by sending out fuel rods should be made by either *legislation* or at least a *parliament decision*. However, in Taiwan, none of these procedures was performed before shutting the fourth plant.

3.4.1.4. Ignoring nuclear safety when dealing with the blackout crisis. Other evidence of such unjust is evident from the big nationwide blackout on 13 May and May 17, 2021, the first time in history that blackouts of this scale occurred within one week. To maintain electricity security, the first reactor of the third nuclear plant was originally scheduled to be maintained until 26 May, but it was forced to restart on 15 May when the length of the reviewing process for the Atomic Energy Council was shortened from seven days to three days [102]. Even the

pro-nuclear group criticised the current ruling government for this fast restarting process and its ignorance of nuclear safety issues. This also cast a shadow over Taiwan's struggles to decommission all its nuclear power plants by 2025 [64].

Finally, another serious violation of the nuclear safety protocol was the frequent use of emergency generators in four nuclear power plants during the peaking hours in 2017, which led to safety issues [65].

3.4.1.5. Lack of responsibility: taking no effort to deal with nuclear legacy and the sunk cost. In a country that intends to phase out nuclear power responsibly, such as Germany, nuclear legacy should be adequately tackled by promulgating suitable legislation to facilitate the site selection process for both low and high radioactive waste [66]. However, Taiwan's site selection process for low radioactive waste has stalled since 2008 due to the lack of a local referendum [67]. In August 2008, three potential sites were selected: Taitung County Daren Township, Pingtung County Peony Township, and Penghu County Wangan Township. However, due to the lack of a local referendum, the site selection procedure has been stalled. There is no site selection legislation for highly radioactive waste. Since 2016, even the Premier has protested against nuclear power and particularly warned about the difficulty of handling hazardous, radioactive nuclear waste [97]. Therefore, the energy transition in Taiwan is unjust and irresponsible. On the one hand, there is reluctance to deal with nuclear legacy. On the other hand, there is continuing use of nuclear power and production of nuclear waste in the country.

Finally, the government also turned a blind eye to the allocation of the fourth plant's sunk cost. When the government removed all fuel rods, all costs should have been considered in the balance sheet of TaiPower, according to the International Financial Reporting Standards. The company would then have had no choice but to file for bankruptcy under the Company Act [99]. The government turned a blind eye to avoid bankruptcy, reflecting the sunk cost in Tai-Power's balance sheet. This can be seen as an irresponsible attitude.

3.4.2. Failure

3.4.2.1. Inability to replace nuclear power with other electricity sources. We have observed that the 50-30-20 energy vision of 2025 is unlikely to be achieved. Therefore, switching away from all nuclear power sources by 2025 should be considered an irresponsible energy policy.

The indirect evidence of such failure is visible from the reliance on nuclear power since 2018 and after the national blackout in mid-May. Further, despite continued warnings about nuclear risks, the government planned to squeeze the second reactor of the third nuclear power plant to the last minutes of May 2025 [36].

Another indirect evidence of this replacement failure is the reliance on relatively small emergency diesel plants (approximately 40 MW each) in nuclear power plants to resolve the electricity supply crisis. For instance, in one afternoon of hot summer day, the outputs of the diesel emergency plants for the four reactors were 101.25%, 101.5%, 95.5%, and 89.5%, respectively [68]. Suppose there is no supply security situation now. Why does the government risk the abuse of emergency plants for its daily use, which may also create danger when an accident in nuclear power requires emergency power?

3.4.2.2. Referendum on the fate of nuclear power. While narrowly interpreting the 2018 referendum, the pro-nuclear group tried to launch two further referenda to extend the operational life of the existing nuclear power plants beyond 40 years and to start the fourth nuclear power plant [69]. However, the former could not pass the review of the Central Election Commission, whereas the latter was scheduled to occur in August 2021 [98].

According to a recent poll, the number of people disagreeing with starting a fourth nuclear power plant (44%) slightly exceeded those agreeing (43.5%) with it [103]. If the referendum succeeds, it may be a big loss to being 'a nuclear-free homeland' by 2025, as the operation life of the fourth nuclear power plant is at least 40 years. However, similar to the low voter turnout in the LNG terminal referendum, this referendum failed to reach the legal threshold for adoption [in favour 3,804,755 (47.16%) votes, against 4,262,451 (52.84%) votes]. Thus, only the 0% nuclear power goal may be reached under this energy transition. However, it remains unclear how Taiwan can meet its promise of 2050 net-zero emissions.

4. Conclusion and policy implications

In general, there is a huge gap between the original plan and the reality in terms of achieving these four key energy transition targets in 2025. Firstly, annual average achievement since 2017 in four sectors fall behind the annual scheduled average target to achieve 2025 goals (2017–2025), which leads to huge pressure on the required annual achievement for 2025 goals (2022–2025). Moreover, for some targets like coal-fired and nuclear power, the backlash and step back and deviation can be found. (see Table 1).

Energy transition has been considered a new paradigm for energy policy in recent decades [70]. Considering the multiple perspectives of energy, environment, and climate, the concept of a just transition has recently received much attention [13,71]. Since 2016, Taiwan has followed this trend by introducing an energy transition mainly embracing dramatic RE promotion and a nuclear-free homeland by 2025, with a supplementary agenda of reducing coal-fired power and increasing gas-fired power. However, this study shows that this energy transition is proceeding without considering justice appeals, which is its main weakness.

Achieving the 2025 vision at all costs is a suitable way to describe the government's attitude towards this energy transition since 2016. The lack of public participation and deliberation or proper assessment (e.g., SEA) to decide and evaluate the targets has planted the seeds of failure since the beginning. Such flaws could have been rectified or fine-tuned by responding to the results of the three energy referenda in 2018. However, the government and ruling party's insistence on its position now leads to an irreversibly failed situation. None of the planned 50-30-20 targets are likely to be realised by 2025. The minister of MOEA admitted such failure earlier this year [49] and blamed it on excessive electricity consumption due to the rapid economic growth of Taiwan during the pandemic and the prosperity of the semiconductor industry. However, she ignored the fact that the central doctrine of the energy transition was to decouple economic growth from increased energy consumption and emissions [1].

Taiwan's experience could be a lesson for the rest of the world. First, it demonstrates that a transition that considers multiple interests, such as climate change, the environment, economics, land justice, would not hamper the energy transition itself but would smoothen the transition. However, an old fashioned, top-down manner with too little engagement with affected communities is unlikely to reach its original objective. Despite being time-consuming, energy democracy may do more good than harm to achieve energy transition goals [72]. Careful planning by adopting multiple policies and legal instruments will contribute to the success of the energy transition goals. These goals cannot be realised simply by setting them. Tailor-made measures, including proper incentives and regulations, will be helpful in gradually achieving the targets [73]. Laws and policies should be responsive to the updated situation and the results of energy democracy to reflect the dynamic and complex policy situation. For instance, Taiwan's lessons can be attributed to the government's unwillingness to engage in time-consuming comprehensive policy and legislation processes and public participation. In fact, the government's unwillingness stalled the achievement of the targeted goals. Therefore, a transition and the energy transition goals can come together for mutual benefits. Finally, compared with the EU's three pillars (emission reduction, energy efficiency, and renewable

Table 1
Dream and reality of the evolution of Taiwan's electricity mix towards 2025 energy transition targets.

	Results in 2016	Up and/or down by 2021	Annual scheduled average target to meet 2025 goals (2017–2025)	Annual average achievement (2017–2021)	Required annual achievement to meet t 2025 goal (2022–2025)
50% gas-fired power target	31.56% (2016)	↑: 35.7% (2020); 38% (2021)	+2.05%	+1.288%	+3%
30% coal-fired power target	45.90% (2016)	↑: 47.34% (2017), 47.65% (2018) ↓: 46.13% (2019), 45.02% (2020), 43.5% (2021).	−1.77%	−0.48%	−3.375%
20% RE target	4.82% (2016)	↑: 5.56% (2019), 7.1% (2021)	+1.69%	+0.456%	+3.225%
0% Nuclear power	8.31% (2016)	↑:10.05% (2017),11.79% (2019), 11.24% (2020) ↓:8.5% (2021)	−0.92%	−0.038%	−2.215%

(source: compiled by the authors)

energy), Taiwan's 2016 energy transition seemed narrow to respond to the needs of the Paris Agreement and the Global SDGs. Taiwan depends only on RE and ignores European countries' main approach to simultaneously maintain nuclear power and increase RE. After Taiwan achieves the nuclear-free homeland target by 2025, fossil fuels are expected to account for more than 90% of electricity generation in the country. If this happens, Taiwan's energy transition may become *unsustainable* and cause *climate injustice* [74].

Credit author statement

Anton Ming-Zhi Gao: Writing – original draft, Writing – review & editing, Project administration, Formal analysis, Formal analysis Tsung Kuang Yeh: Supervision, Conceptualization, Jong-Shun Chen: Methodology, Investigation

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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