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Energy Transition Trends 2019

China, Europe, USA

Implementing Unit

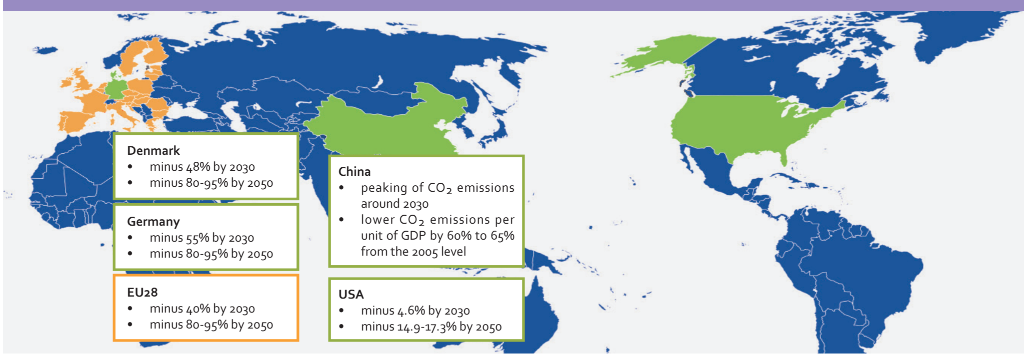
Financial Support

Technical Support

International Trends in Energy Transition

Global warming affects all countries and can only be tackled in a joint international effort. The Paris agreement was a crucial milestone in the fight against climate change. For the first time, virtually all countries worldwide acknowledged the threat of global warming and commonly agreed on "holding the increase in the global average temperature to well below 2 degree above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 degree above pre-industrial levels." To date, over 180 countries have submitted their so-called Nationally Determined Contributions (NDCs) to the United Nations and published national greenhouse gas (GHG) reduction targets.

Figure 1: Overview of Key cCountries' GHG Reduction Targets [a]



[a] The data shown in the graphic are based on either Nationally Determined Contributions (NDCs) submitted to the United Nations (UN) or, in the case of Denmark and Germany, additional national targets. Unless stated otherwise, the base year for all targets is 1990. In order to allow for comparability, for the U.S., official NDC targets with base year 2005 have been converted to a base year 1990 using data from the Environmental Protection Agency (EPA). The Danish GHG reduction target for 2030 is based upon the preliminary Danish non-ETS reduction target of 39% compared to the 2005 level and is not an official Danish target.

Key Elements for a Successful Energy Transition Worldwide:

- International exchange of experiences and mutual learning.
- Clear long-term vision, elaborated and regularly revised mid-term targets and flexible mind-sets for short-term adjustments.
- An integrated approach that allows for a cross-sectoral optimization of the energy

In the past years, many countries have begun to transition their energy systems towards a more sustainable energy supply based on renewable energies (RE). The transition of the Chinese energy system takes place in the context of similar developments around the world. The paths all these countries have undertaken so far vary and depend on a number of variables, such as their different starting points, geographical locations, or political and social setting. This report provides a short summary of the current status of the energy transition in China, followed by case studies to illustrate this variety:

- **The European Union (EU)** as the world's biggest market is a leading global player and a strong advocate for the fight against climate change. With the "Clean Energy for all Europeans" package, significant legislation for the European energy transition has currently been passed.

- **Germany,** as Europe's biggest economy and most populous country, is a particularly good example of a highly industrialised nation that aims at decarbonising its economy. The results of the so-called coal commission setting the way for a coal phase-out are being observed worldwide.

- **Denmark** is widely considered a pioneer when it comes to RE, particularly wind energy, and the transition of its electricity and heating system. Recently, Denmark's political parties reached an ambitious new energy agreement.

- **The United States,** being a vast territorial state with a complex political system, is another example for the wide variety of the variables mentioned above.

These countries all have in common the experience of acting in a highly dynamic and internationally intertwined context while transforming their energy systems from a rather centralised approach with continuous energy generation based on fossil fuels to a more decentralised system with fluctuating energy generation from thousands of energy production facilities (wind, solar, and biomass). This requires that politics and regulation are governed by a clear long-term vision, with elaborated and regularly revised mid-term targets and continuous concrete adjustment steps on a short-term basis.

1. China

Building a Clean, Low Carbon, Safe and Efficient Energy System

China is in the beginning of an energy transition with the aim of building an energy system for the future. At the 19th National Congress of the Communist Party of China, President Xi Jinping confirmed that China will promote a revolution in energy production and consumption. The country's plans emphasize shifting economic development from high growth to high-quality growth, a paradigm shift that also applies to the energy sector. With the important milestones for 2020, 2035 and 2050, China plans to develop a "clean, low carbon, safe and efficient energy system".[1]

This chapter summaries the energy transition achievements of China in 2018 and future trends towards 2030. After a brief review of 2018 energy consumption, carbon emissions and power mix changes, we review recent changes and newly announced policies, especially concerning renewable energy and the upcoming phase-out of subsidies. China has begun to introduce a renewable energy obligation, renewable tendering policies, and subsidy-free wind and solar pilots. Chinese policy-makers have faced delays in building out the national Emissions Trading System (ETS) and regional spot power markets. The chapter concludes by summarizing challenges facing China's energy transition overall.

China is Still under Pressure of Carbon Reduction

China's carbon dioxide emissions intensity (CO_2 emission per unit of GDP) fell by 4.0% and energy intensity (energy consumption per unit of GDP) decreased by 3.1% in 2018. Although both intensities decreased, electricity generated from thermal power plants grew 6.7% and secondary industry's energy consumption grew 7.6%, implying that carbon- and energy-intensity improvements are primarily the result of economic output outpacing growth in carbon emissions and energy use. Growing secondary industry energy consumption could pressure China's policies on coal caps and carbon reductions.

Energy Consumption Continues to Transform

China has seen progress in its efforts to transition away from coal, which includes scaling up other energy sources as well as restricting coal use in key regions. In 2018, China had total primary energy consumption of roughly 135.98 PJ, representing annual growth of 3.3%. Although raw coal production increased by 4.5%, its share in total primary energy consumption declined below 60% for the first time. Meanwhile, 2018 consumption of crude oil rose 6.5% and natural gas consumption grew 17.7%. China is increasingly reliant on imports of oil and gas: imports accounted for 70.9% of oil consumption and 45.3% of gas consumption in 2018.

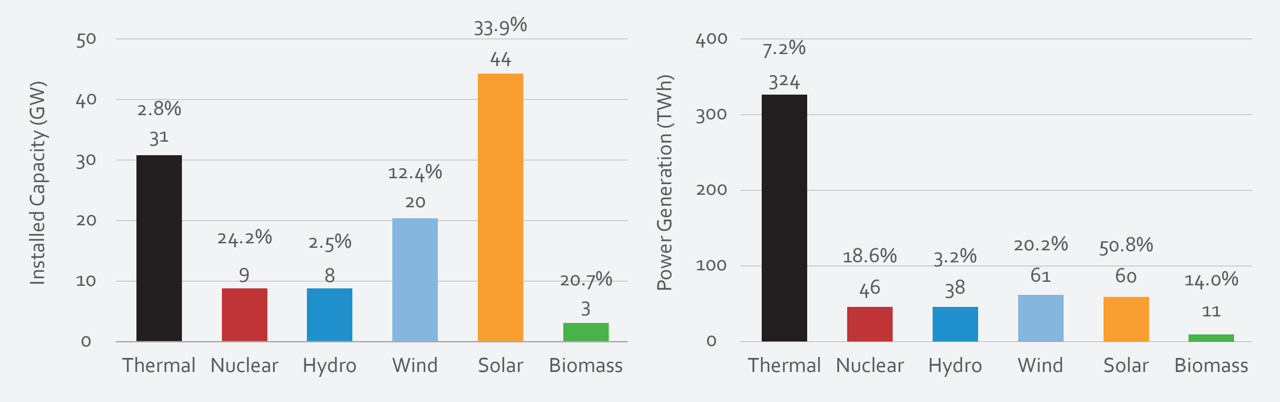
Electricity Consumption Continued to Increase

China's total electricity consumption in 2018 reached 6846 TWh, an 8.5% annual increase, the highest annual growth since 2012. Secondary industry contributed five percentage points of this growth, led by high technology and equipment manufacturing industries, whose electricity consumption grew 9.5%. Tertiary industry consumption also increased sharply, led by telecom, software, and information technology. As the trends of urbanization, electrification of heating, and rising living standards continue, residential electricity consumption as also continued to show strong growth.[2]

Renewable Energy Continues to Grow, Though Coal Power Rebounded

In 2018 China added 120 GW of new power capacity, reaching 1,900 GW total capacity. Non-fossil energy resources took up 73% of this newly added capacity. In 2018, the power sector in China generated 6,990 TWh, 30.9% of which was from non-fossil energy sources, of which 26.7% was renewables and the remainder from nuclear.[3] China added 20.59 GW of new wind capacity, of which 47% was in East Central and South China, diversifying wind power development across more of the country.[4] China added 44 GW of new solar PV, 17% below the amount added in 2017 but above market expectations. The proportion of incremental power capacity of distributed solar PV accounts for 47% which shows parallel development of centralized and distributed solar PV markets.

Figure 2: 2018 Incremental Installed Capacity (Left); 2018 Incremental Power Generation (Right)



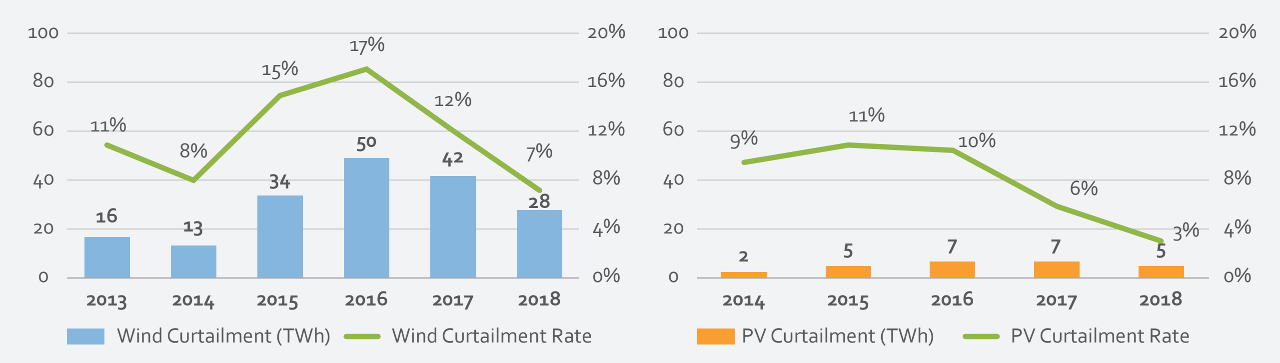
Renewable Energy Curtailment Decreasing

China has improved uptake of renewable energy in the past two years. In 2018, China experienced wind power curtailment of 27.7 TWh, a rate of 7%, a 5-percentage-point improvement versus 2017. In 2018, China saw solar power curtailment of 5.49 TWh, or 3%, 2.8 percentage points lower than in 2017. Officials cited various explanation for high curtailment in certain regions, including high proportion of renewable energy concentrated in certain provinces, competition with large scale thermal power plants for operating hours, and inadequate transmission capacity.[7]

Figure 2
Notice: Thermal power = thermal in CEC datasheet – biomass in NEA datasheet.
Source: Biomass data - China National Energy Administration, January 20195; the rest date - China Electricity Council, December 2018[6]

Figure 3
Source: China National Energy Administration, from March 2014 to February 2019[8]

Figure 3: China 2018 Curtailment of Wind (Left) and Solar PV (Right)



Release of Renewable Energy Obligation Draft

China plans to adopt provincial level targets for renewable electricity consumption in 2019. The implementation mechanisms consist of a renewable obligation enforced by provincial grid companies, and green certificates that enable compliance entities to meet their obligation. The government kicked off the development of China's renewable energy obligation policy in 2001.[9] Due to provincial objections and other factors, the policy has experienced delays lasting nearly two decades. In 2017, National Energy Administration (NEA) relaunched the process and issued a third renewable obligation policy draft in November 2018.[10] The policy sets an explicit goal of encouraging renewable electricity consumption, especially to increase short-term uptake of existing wind and solar. It also aims to address wind and solar curtailment, inadequate transmission of renewable energy between provinces, and bilateral power trading that might discourage large customers from purchasing clean energy. NEA sets renewable electricity consumption targets by province and provides measures to achieve them. Those entities include provincial grid companies, stated-owned and private distribution grid companies, electricity retail companies, industrial enterprises owning their own power plants, and large end-users participating in bilateral electricity trading. Present plans call for the policy to go into effect in 2019.

New Wind Power Projects Required to Participate in Tenders Since 2019

As NEA pushes to wind down feed-in tariffs for new projects, since the beginning 2019 China has required all new provincial centralized onshore wind and offshore wind power projects to participate in tenders to receive construction quotas and feed-in tariff subsidies. The weight of price in assessing bids is at least 40%. In December 2018, wind-rich Ningxia province announced the bidding results for its first wind power auction.[11] The auction results show that price was not the only factor in determining winning bids.

Figure 4: Ningxia Onshore Wind Power Auction Results

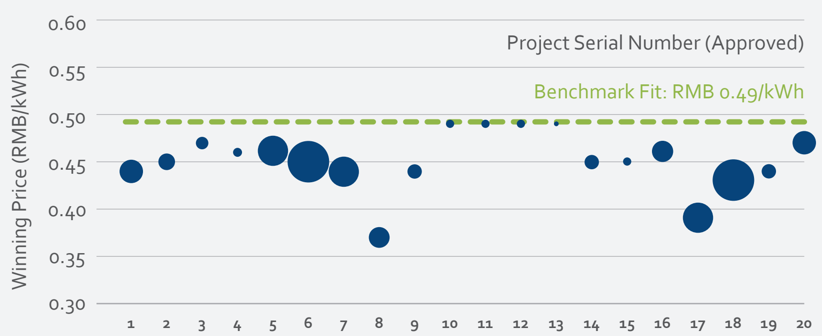
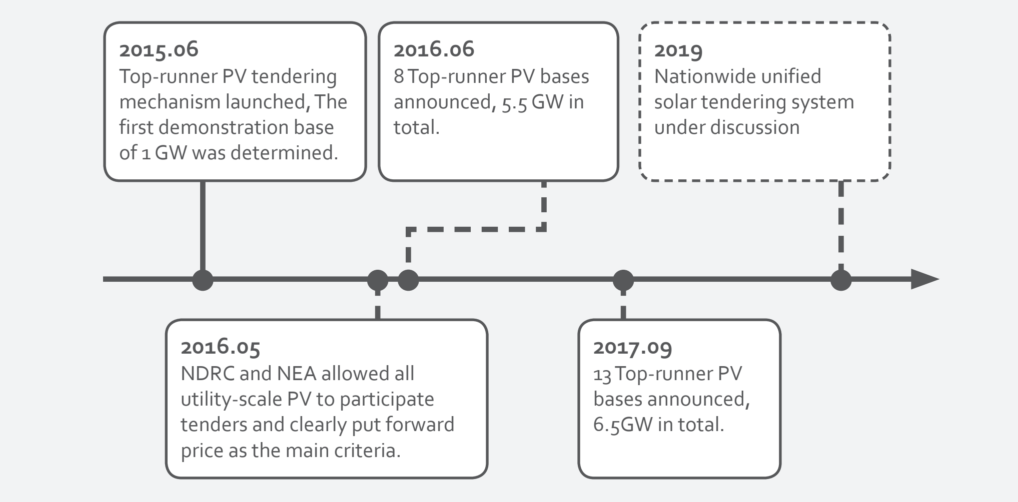


Figure 4
Note: Dots scaled by approved project size.
Source: Ningxia DRC[12]

A Nationwide Unified Solar Tendering System is under Discussion

China has long experience with renewable energy tenders: NDRC launched the first renewable tender in 2003.[13] Since 2016, the government allowed all utility-scale PV projects to participate in tenders. As a reward for regions that have used competitive bidding to reduce FiT subsidy payments, the government grants proportionally higher annual provincial PV construction quotas.[14] This policy, designed to lower costs and reduce the subsidy burden, has partially achieved these objectives.[15] Policymakers are now discussing a nationwide solar tendering system to replace provincial feed-in tariff capacity quotas. One possibility is an annual national tendering process, in which provincial governments would provide a list of local tendering projects to NEA, and NEA would select projects based on accepting projects starting from the lowest price until the amount of annual subsidies is used up. Provincial governments would have to confirm that local consumption is adequate to integrate the added capacity.

Figure 5: Solar Tendering Policies in China



Plans to Scale up Subsidy-free Wind and Solar Projects

In January 2019, NEA and NDRC jointly announced a plan to launch subsidy-free wind and solar pilots in regions with superior wind or solar resources and high local electricity consumption.[16] Since these pilots will not receive national government subsidies, their capacity won't affect the annual provincial wind and solar feed-in tariff project construction quotas. The tariff of the pilots must be the same or lower than the local benchmark feed-in tariff for coal plants.[17] By providing another tool to promote renewable energy and bring down costs, the pilot policy should help scale up wind and solar in the most cost-effective regions, and thereby accelerate the phase-out of subsidies. China anticipates wind and solar will generally no longer receive subsidies in the early part of the 14th Five-Year Plan period (2021 to 2025).

China's National ETS Marks First Anniversary

China's national ETS was officially launched at the end of 2017. At the time, the schedule for establishing the ETS called for a preparation phase, followed by trial operation, and then official operation. The ETS currently remains in the preparation period; China has been making efforts on regulation system building, infrastructure construction, verification of historical emission data from major emissions entities, capacity building, and initiating carbon trading in the power generation industry. A national data reporting system has been established with industrial emissions data from 2016 and 2017. Although the design of the allocation system has yet to be published, an anonymous expert cited by Energy Observer stated that policymakers plan to tighten carbon allowance allocation principles and put into place an allowance distribution mechanism using baselines.[18]

Spot Power Market Pilots Delayed

NDRC and NEA jointly announced the first batch of spot power market pilots in August 2017. These pilots covered eight regions and aimed to complete market designs by the end of 2018.[19] Almost all pilots have faced delays due to various difficulties in 2018. For instance, the pilot in Zhejiang saw disagreements among policymakers and grid officials concerning grid participation in market organization and annual account settlement. Provincial restraint of coal use will also affect the market position of thermal power plants.[20] The government has required the eight spot market pilots to accelerate the research and preparation for initiating spot markets and drafting market operation regulations.[21] Pilots should start commissioning by the end of June 2019 provided no special obstacles arise, and provinces should report progress monthly to responsible government departments. At present, three pilots have already started the process: Guangdong, Gansu and Shanxi.[22] The spot market in Guangdong is well underway, although electricity from outside the province cannot participate in trading, influencing its capability of reflecting actual power demand and supply information. The system also lacks support mechanisms such as ancillary services markets and financial futures.[23]

Spot Market Situation Affecting Competitiveness of Wind and Solar

During the first operating period of spot power markets, renewable power may face a bigger challenge to be competitive with coal power. The 13th Five-Year Plan (2016 to 2020) stipulates that without subsidy, wind power should be competitive with coal benchmark tariffs and solar PV should be competitive with retail electricity prices by 2020.[24] While wind and solar are likely to easily reach current benchmark coal tariffs, market trading may result in still lower prices for coal power, reducing the competitiveness of wind and solar. Environmental taxes and prices for other externalities are currently too low to have a major impact on the price of coal power relative to renewables.[25]

Outlook: Three Revolutions are the Future Development Trends in China Energy Sector

At the 19th CPC National Congress, the central government proposed three revolutions to promote economic development, covering economic quality, efficiency, and dynamics.[26] NEA applied this concept to the energy sector in its 2018 work guidance as follows.[27] Quality Revolution is about the optimization of existing and incremental energy mix by coal phase out and renewable expansion. Efficiency revolution promotes synergetic development of energy industries, as a result to improve the efficiency of the whole energy system. The dynamics revolution relies on technological and market-oriented innovative strategies to drive and diversify energy sector development.

Based on the projection of China National Renewable Energy Centre (CNREC), China should add 150-350 GW wind and solar power capacity annually in 2020's, of which 65-183 GW for wind and 71-183 GW for solar, in order to achieve the below 2 degree target. In the long-term, wind and solar will dominate power supply in the power sector, under this scenario.[28]

Figure 6: Annual Growth of Wind and Solar Capacity from 2017 to 2050 under the Below 2 Scenario

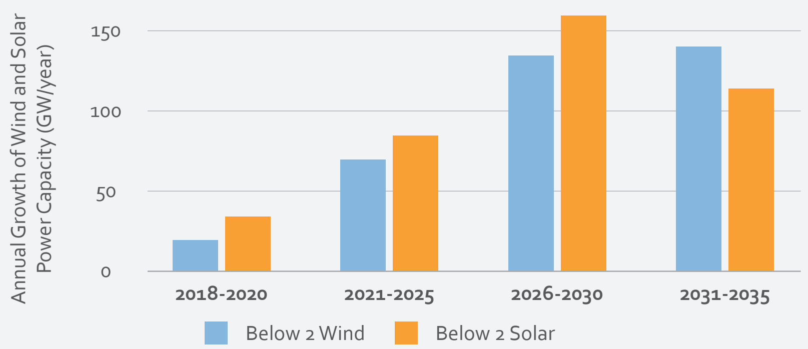


Figure 6
Source: China National Renewable Energy Centre, December 2018[29]

Conclusion

In 2018, China saw various changes in energy transition process as well as in renewable energy policy formulation. The energy consumption of the country continued to gradually shift away from reliance on coal, but carbon emissions rose due to strong growth of secondary industry. Electricity consumption also grew faster due to the improved economy. In power sector, wind and solar power generation rose rapidly, and the longstanding problem of curtailed energy from these sources began to improve.

To build a clean, low carbon, safe and efficient energy system, the government adopted a series of new policies and regulations for the sustainable development of renewable energy. In 2018, NEA required all new wind power projects to participate in tendering since 2019, and it kicked-off subsidy-free wind and solar power pilots that will receive incentives. Currently the renewable obligation mechanism and a nationwide solar tendering system are under discussion. These efforts will be helpful for a cost-effective renewable power expansion. In the future, China's energy transition will focus on quality, efficiency and dynamics' improvement.

2. European Union (EU)

Main Drivers and Long-term Energy Targets for a European Energy Transition

The EU has ambitions to be the leading force in the fight against climate change. The EU has agreed to spend at least 20 percent of its budget for 2014-2020 – as much as €180 billion – on climate change-related actions.[30] An EU-wide energy system transition is seen as an important driver for the decarbonisation of the economy. Decarbonisation could be achieved by implementing common targeted policies and advancing the structural integration of the EU.

In addition to the decarbonisation of its economy, the EU pursues two other important goals with its energy transition: first, reducing the EU's dependency on energy imports, which currently amount to more than 50% of total energy consumption[31], by increasing the share of renewable energies while also increasing energy efficiency. Second, bolstering growth and employment in new industries considering the developing global need for clean energy supply and the development of new technologies for a sustainable energy system.

The long-term goal of reducing GHG emissions by 80-95% by 2050 compared to 1990 levels was set in October 2009 by the European Council. In October 2014, the EU agreed on more concrete, EU-wide targets for 2030. In August 2018, the targets for both energy efficiency (non-binding) and the share of renewable energy (binding at EU-level) were reviewed and increased (see table below) according to this strategy update.

The targets are to achieve a more competitive, secure and sustainable energy system and to meet the long-term 2050 greenhouse gas reduction target. The targets are set at EU level, but do not prevent Member States from pursuing their own, more ambitious targets.

Table 1: EU Energy Targets for 2030 and 2050

	2030	2050
GHG Emissions Reduction Compared to 1990 Levels	>40%	80-95%
Energy Efficiency Increase Compared to "Business-as-usual"-Projections	>32.5%	--
Share of Renewable Energy of Total Energy Consumed	>32%	--

The "Clean Energy for all Europeans" Package

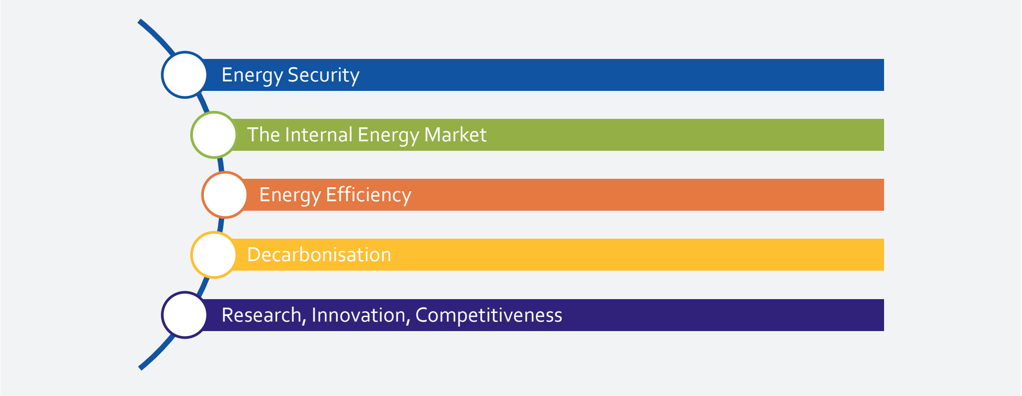
Arguably the most far-reaching change in European energy policy currently comes from the Clean Energy for all Europeans legislative package (also called the Winter Package): Eight legislative acts aim at shaping a new framework for the European energy policy in order to reach the EU energy targets for 2030 and 2050. They are grouped into the following three topics: the governance of the Energy Union after 2020, the design of the electricity market, and the market conditions for renewable energies and energy efficiency.[32]

Governance of the Energy Union after 2020

Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action[33]

The regulation introduces a reporting mechanism for all Member States, obliging them every ten years to set out national objectives, targets and contributions for the five dimensions of the Energy Union (see figure below) in their respective "integrated national energy and climate plan". Every two years, each Member State shall report to the European Commission on the status of implementation of that plan. Updates to the plan can be made if the result is an increase of the level of national ambition. In addition, the new regulation contains detailed provisions on public consultation and regional cooperation and in particular establishes a formal multi-level climate and energy dialogue.

Figure 7: Five Dimensions of the EU Energy Union



Furthermore, every ten years each Member State shall submit its long-term national energy and climate strategy with a perspective of at least 30 years and update that strategy every five years.

The role of the EC is to monitor and assess the progress made by the Member States on a biennial basis. If the national targets and/or actions of the Member States prove to be insufficient to reach the EU targets and if recommendations by the EC to fill this gap are not considered by the Member States, the EC shall be able to introduce measures on EU level in order to make sure the EU targets are reached.

Design of the Electricity Market[34]

Recast of the Regulation Establishing an EU Agency for the Cooperation of Energy Regulators (ACER)[35]

The new regulation reforms and reinforces the Agency for the Cooperation of Energy Regulators (ACER) as an independent European regulator that can counterbalance national (political) interests, creating a more powerful agency that oversees the integrated energy market and decides on regulatory issues with cross-border relevance. This includes adopting and implementing electricity network codes as well as amending and approving methodologies developed by the European network of transmission system operators (ENTSO-E) for generation adequacy assessments and electricity supply crisis scenarios.

Recast of the Directive on Common Rules for the Internal Market in Electricity[36]

The new directive lays down key rules relating to the organisation and functioning of the European electricity sector, in particular rules on consumer empowerment and protection, on open access to the integrated market, on third party access to transmission and distribution infrastructure, unbundling rules, and on independent national energy regulators. Several measures are included to empower consumers and prosumers to actively take part in the internal electricity market, such as by introducing the right for consumers to demand dynamic price schemes from their energy supplier. The directive also defines the roles of aggregators and specifies the tasks and responsibilities of both transmission system operators (TSOs) and distribution system operators (DSOs) and sets out modes of cooperation among Member States, regulatory authorities and TSOs towards the creation of a fully interconnected internal electricity market.

Recast of the Regulation on the Internal Market in Electricity[37]

The new regulatory framework for the European internal electricity market sets fundamental principles for well-functioning, integrated electricity markets as well as fair rules for cross-border exchanges in electricity. By that competition shall be enhanced within the internal market in electricity while taking into account the particular characteristics of national markets.

The regulation contains:

- General rules for balancing markets, day-ahead and intraday markets;
- A framework for a more market-based dispatching of power plants, limiting priority dispatch for renewables and high-efficiency cogeneration to small installations, pre-existing installations and demonstration projects;
- A process for defining regional electricity markets (bidding zones) in order to improve cross-border trading and hence economic efficiency and security of supply;
- New rules on network tariffs that shall prevent discrimination against energy storage and demand response;
- Tasks and responsibilities of the European Network of Transmission System Operators for Electricity (ENTSO-E) and the framework for so-called Regional Coordination Centres with the goal to further develop the regional coordination of TSOs and to increase reliability and efficiency of cross-border grid and system operation;
- A framework for a new European entity for DSOs in order to raise efficiencies in the electricity distribution networks in the EU and ensure close cooperation with TSOs/ENTSO-E.

New Regulation on Risk-preparedness in the Electricity Sector[38]

An assessment of the earlier Security of Supply Directive revealed significant shortcomings regarding the interconnectedness of national energy systems. The EU has thus replaced the directive with a new regulation that lays down rules for the cooperation between Member States in view of preventing and preparing for managing electricity crises (such as due to extreme weather conditions, cyberattacks or shortage of fuel) in a spirit of solidarity and transparency. It also takes into account the requirements of a competitive internal market for electricity.

Notably, the new regulation contains the following measures:

- Establishing a methodology for identifying cross-border electricity crisis scenarios at a regional level (to be developed by ENTSO-E);
- Developing a European methodology for short-term and seasonal adequacy assessments in order to regularly assess the security of supply (to be developed by ENTSO-E);
- Implementing mandatory national risk-preparedness plans including mechanisms for cross-border exchange of information and reporting obligation in case of crisis;
- Developing an approach to utilize all market-based options before triggering other measures of crisis prevention.

Renewable Energies and Energy Efficiency

Directive (EU) 2018/2001 on the Promotion of the Use of Energy from Renewable Sources[39]

The directive establishes an EU-wide 32 % binding target for the share of RES in final energy consumption by 2030. Different to the 2020 strategy, individual targets per Member State were not defined. However, the national targets for RES share for 2020 have now become a binding baseline. By 2023, the EC is required to re-evaluate the 32 % target and, in case of need, to introduce gap-fillers—additional measures to reach the common target.

Furthermore, a number of concrete measures are set, such as:

- Opening of RES support schemes to cross-border capacity providers as an option for Member States while setting indicative targets (2023-2026: 5 % of the newly-supported capacity per year; 2027-2030: 10% of the newly-supported capacity per year);
- Setting a binding EU minimum target of a 14% RES share in the transport sector with advanced biofuels rising from low levels to a minimum share of 3.5 % by 2030;
- Reducing existing barriers for prosumers to consume their self-produces energy and to participate in the energy market;
- Increasing the Member States' share of heating and cooling from RES by 1.3 % per year (non-binding), with a lower target (1.1 %) set for Member States where waste heat and cold is not used;
- Establishing higher GHG emissions savings criteria for biofuels and bioliquids.

Member States are required to transpose the revised directive into their national legislation by 30 June 2021.

Directive (EU) 2018/2002: Amended Directive on Energy Efficiency[40]

A key element of this directive is the replacement of the current non-binding target of at least 27% reduction of energy consumption by 2030 (compared to projections made in 2007) with a more ambitious target of 32.5 %. This headline target may be revised upwards (but not lowered) on the basis of a new legislative proposal in 2023. Additionally, indicative targets for all Member States shall be formulated. The revised directive sets the new yearly energy savings obligation of 0.8 % of annual final energy consumption between 2021 and 2030. The EC is required to assess whether the EU as a whole has achieved its 2020 headline targets in energy efficiency and to evaluate the functioning of the revised directive.

Further measures included are:

- Introducing a new methodology for calculating energy savings as well as more far-reaching energy-savings obligations covering more sectors than under the previous directive;
- Strengthening existing provisions on individual metering and billing based on real consumption, and introducing a new remote reading requirement;
- Introducing requirements for new, advanced meters for district heating, cooling and domestic hot water to be remotely readable by 2020 (old meters will have to be replaced by 2027 unless this is proven not to be cost-efficient);
- Improving transparency regarding the personal energy consumption of energy consumers by setting clear rules for better billing information and by strengthening the consumers' rights to receive accurate information.

Directive (EU) 2018/844: Amended Directives on the Energy Performance of Buildings and on Energy Efficiency[41]

The revised directive contains a number of concrete steps for the buildings sector, such as:

- Expanding the provisions for Member States to establish a long-term renovation strategy to support the renovation of the national stock of residential and non-residential buildings, both public and private. Long-term renovation strategies will need to be accompanied by a roadmap for a highly efficient and decarbonised national building stock by 2050, with indicative milestones for 2030, 2040, and 2050;
- Formulating more clear requirements for the minimum energy performance of new buildings;
- Introducing e-mobility requirements for new non-residential buildings (as well as those undergoing major renovation): Generally, buildings with more than ten parking spaces should have at least one charging point, while pre-cabling should apply to at least one in five parking spaces. In addition, the EC is required to publish a report on the promotion of e-mobility in buildings by 1 January 2023, which could lead to further measures being introduced;
- Establishing a common scheme for rating the smart readiness of buildings. The rating shall be based on an assessment of the capabilities of a building or building unit to adapt its operation to the needs of the occupant and the grid and to improve its energy efficiency and overall performance;

- Setting various thresholds (and some exemptions) for determining the needs for regular inspection of heating and air-conditioning systems.

The EC should review the revised directive by 1 January 2026, with the possibility of proposing further changes. Member States will be given until 10 March 2020 to transpose the revised directive into national legislation.

Transfer to China

Subsidiarity – a Political Decision-making Process that Allows for Regional Differences

As set out in the Paris Agreement, China and the EU both have the same overarching goal: to develop a low-carbon, clean and efficient energy system as a basis for economic development.

The inherent value of a comprehensive policy approach for the whole of Europe is now clear. This is a very important conclusion that can be drawn from the past years of energy policy in the EU which now culminated in the Winter Package. Instead of looking separately at the different sectors and fields of action, the Winter Package has aligned all policy measures regarding energy efficiency, RE development, energy market development as well as R&D and innovation under one umbrella.

In addition, the example of the Winter Package highlights the role of the EU institutions in the pursuit of defining common policies of Member States that may come from rather different starting points. Similarly, China faces the challenge how to do two things at a time: following a consistent energy policy and at the same time taking into consideration the differences between its regions and take into account geographical or climate conditions due to historic developments of the structure of energy supply.

The general approach of the EU is following the principle of subsidiarity: on the one hand, the EC as a central entity focuses on setting and monitoring clear common targets and on making sure that the general framework (market structures, regulations, infrastructure etc.) allows for a dynamic development towards a new energy system. On the other hand, the Member States have both the right and the duty to implement such policies that contribute to the common targets while at the same time respecting their specific national conditions and potentials.

Besides obvious differences between the political and administrative systems of China and the EU, it should be highlighted that integrated energy markets are the key instrument for a successful energy transition. Regional and/or sector specific characteristics can and should be taken into account within the general framework of such energy markets.

The EU-China Energy Cooperation Platform (ECECP)

The ECECP is a €3.5 million project funded by the EU with the overall objective to enhance the mutual understanding between EU and China in each other's energy sector and to contribute to a global transition towards clean energy. Guided by the draft Joint Statement on the Implementation of the EU-China Cooperation on Energy (July 2018), the main theme of the platform's activities is the transformation of the energy system. It will include exchanges in energy system modelling, energy efficiency, LNG market development, and how to accelerate the commercialization of innovative energy technologies. ECECP will also support EU energy businesses regarding market access in China (communicating common market entry barriers; showcasing of EU competencies; information on known issues and work-arounds, new regulations, incentive policies, standards, compliance requirement etc. related to the energy sector).

The project is being implemented over three years by a consortium led by ICF Consulting, Energy Research Institute of China (ERI) and China Energy Conservation and Environmental Protection Consulting (CECEP). ECECP is financed under the Partnership Instrument which underpins new relationships with countries that have graduated from bilateral development aid and for which the EU has a strategic interest in promoting links with. Overall steering is provided by the European Commission and in co-operation with the National Energy Administration (NEA) in China.

3. Germany

Status 2018: RE Power Production Caught up with Power Production from Hard Coal and Lignite[42]

38.2 percent of the power consumed was generated by wind, photovoltaics, biomass and hydropower. Among the renewables, especially photovoltaics has seen above-average power production, thanks to a very long and sunny summer. The increases in PV power production offset a below-average year for wind and hydro energy. Especially the capacity expansion of wind power fell back behind previous years' track record.

In 2018, renewables produced 228.7 TWh electricity, which is 12.4 TWh or 5.6 percent more than in the previous year. Largest increase showed the power production from photovoltaics with 17.5 percent compared to 2017, now at 46.3 TWh. This is mainly due to a very sunny year with around 30 percent more sunshine hours than on average. The increase in power production from wind fell back behind due to less capacity additions and a less windy year: wind onshore produced 93.9 TWh electricity and wind offshore 19.4 TWh. Power production from hydropower decreased by 20 percent to 16.9 TWh, mainly due to drought.

Power production from conventional energy sources decreased to 420 TWh. Hard coal decreased the most, by 11 percent or 10.6 TWh, reaching 83 TWh. The reasons for this were unit shut-downs, increasing commodity prices for hard coal and CO_2 emissions, and an increased rate of renewables feed-in. Power production from gas also decreased by 4.3 percent, now at 83 TWh. Here, decreasing factors include increased import prices for gas, as well as in increased renewables power production. The higher CO_2 prices in the EU-ETS, however, partially led to a substitution of hard coal power production with gas power production, due to gas power's beneficial position in the merit order at times of high ETS prices. Nuclear power production remained on the same level as in the previous year, contribution 76.1 TWh electricity. The shut-down of one plant at the end of 2017 was compensated with higher full-load hours for the remaining fleet of nuclear power plants. The next power plant will shut down in December 2019 in line with the German nuclear phase-out plan, in which all nuclear plants will phase-out until December 2022.

Lignite power production remained on a high level with 146 TWh, decreasing only by 2.4 TWh or 1.6 percent.

Due to a lower energy consumption because of a warm winter, high commodity prices and a slight decline in production, the share of renewables in total energy consumption increased from 13 percent to 14 percent. Furthermore, Germany's greenhouse gas emissions declined significantly by 5.7 percent or 51 million tonnes CO_2-equivalent. Additional to the low primary energy consumption in industry, heating and transport sectors, due to the increased prices for emissions certificates in the EU-ETS, power production from hard coal decreased and now contributes to 14.3 percent of the power production.

The Grand Coalition is Expected to Advance the Framework for Further Transformation of the Energy System

Politically, Germany looks back at the first year of the newly reinstated grand coalition between the conservative parties CDU and CSU and the social democrats SPD. In this new government, some cornerstones for the future of the energy system are to be set: the coalition treaty agreed to increase the target for the expansion of renewables in power consumption to 65 percent in 2030. Further, grid expansion was made a priority by introducing a new law that allows accelerated approvals for power lines.

Most public attention focused on the Commission on Growth, Structural Change and Employment – the so-called Coal Commission.

Germany's Coal Phase-out According to Recommendations from the Commission for Growth, Structural Change and Employment[43]

The Commission for Growth, Structural Change and Employment was initiated in the coalition treaty of the coalition among CDU, CSU and SPD. The commission's mandate was to agree on a phase-out for coal and the necessary measures to be taken in coal (lignite) mining regions, namely Lusatia and the Rhineland. It was set up with stakeholders from mining regions, science, business and industry, energy industry, unions and civil society and accompanied by the board of state secretaries.

Currently, about 22 percent of the German primary energy consumption is covered by hard coal and lignite. Nearly all of lignite is mined domestically, while 7 percent of hard-coal was mined domestically in 2018. Hard coal mining, however, has been phased-out end of 2018, so that all hard coal consumed has to be imported starting 2019.

Four Pillars of the Coal Compromise

In January 2019, the commission concluded its work with a proposal which has yet to be transferred into legislative measures. The proposal includes four pillars: phasing out coal, building strong and sustainable regions, modernizing the power and energy system as well as absorbing negative effects on vulnerable affected groups.

Phasing out Coal

Phasing out coal includes renouncing new coal-fired power plants as well as opening new mines. It further concludes a step-by-step phase-out of coal until 2038 with two intermediate step stones in 2023, where only 30 GW coal (15 GW lignite, 15 GW hard coal) remain in the system and 2030, where the coal capacity is reduced to 17 GW (9 GW lignite, 8 GW hard coal). In the commission's base year 2017, Germany had 43 GW coal capacity (23 GW lignite, 20 GW hard-coal).

In order to prepare the affected regions for the future, the commission established three pillars for structural development: building strong and sustainable regions, modernizing the power and energy system as well as reducing negative effects on vulnerable interest groups.

Building Strong and Sustainable Regions

The commission proposes to incentivize the creation of new jobs by modernizing the affected regions as energy regions with a focus on research and development in future energy technology such as power-to-X and storage. Additionally, modernized infrastructure such as railways and mobile internet infrastructure help to make the regions attractive locations for new businesses and could help attract new private investment.

Modernizing the Power and eEnergy System

Modernizing the power and energy system in Germany ensures system stability and security of supply with reserves and new gas capacity. To allow effective climate mitigation, the expansion of renewable energy is crucial as well. Making the energy system more flexible allows for efficient integration of variable renewables.

Absorbing Negative Effects on Vulnerable Affected Groups

Transitioning vulnerable affected groups is eased by securing competitiveness with the compensation of grid costs for affected industries as households. Additionally, a non-dismissal clause and labor market measure are to ensure a smooth transition for workers in the affected industries and businesses.

Implementation of Suggested Measures

Short-term measures are suggested to be implemented until 2021, so that effects of the structural management are immediate. The commission further suggests that the government frees financial means to help especially large infrastructural measures. They assume an amount of 1.3 billion euros to be invested over the course of 20 years.

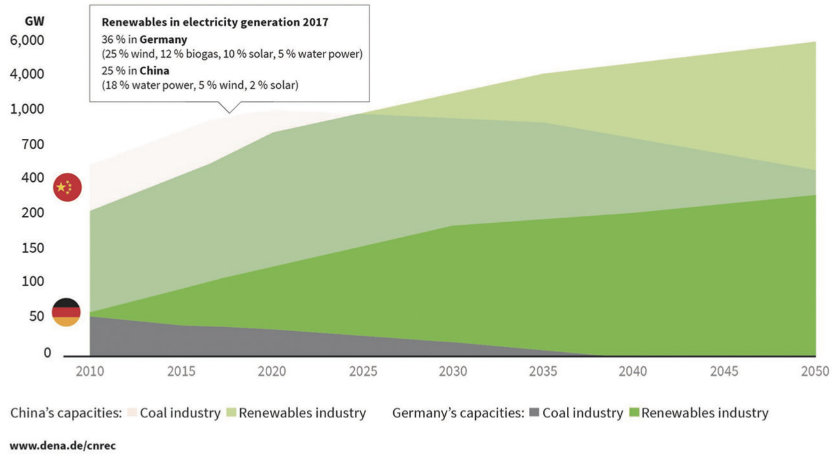
To monitor, evaluate and adapt the phase-out plan as well as the structural measures, the commission suggests continuous monitoring and progress reports as well as evaluations in 2023, 2026 and 2029 by an independent expert panel. The commission's proposal shall be translated into legislative measures in the first half of 2019.

Transfer to China

Energy Generation Capacities in Germany and China

Germany and China face similar challenges regarding the fulfilment of their climate protection targets: CO_2 emission-intensive lignite is the dominant domestic energy source and important heavy industries need access to reliable and affordable energy. Both countries are increasing their renewable energy capacities considerably. In contrast to Germany, coal capacities in China were further expanded in recent years due to the high level of economic growth. However, similar to the suggestions of the German coal commission, the China Renewable Energy Outlook 2018 (CREO) shows how coal power generation in China can be significantly reduced by 2035 and be compensated by further dynamic installation of renewables.

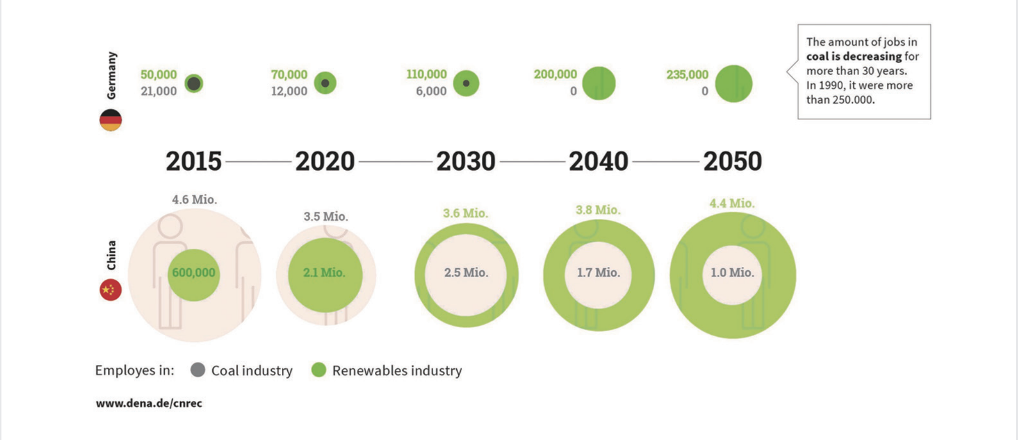
Figure 8: Projection of the Development of Energy Generation Capacities in Germany and China (2015-2050)[44]



Employees in the coal and renewables industry

Furthermore, in both countries the energy transition has effects on the amount of employees in the two sectors. In China, many people are employed in the coal industry, so a quick transition in order to reach climate protection goals is a challenging task. In Germany, the structural change of the coal industry has developed over several decades. In comparison with China, in Germany there are proportionately fewer jobs affected by the transformation. The trends of the scenarios show that there are more new jobs generated in the renewables industry than existing jobs lost in the coal industry, provided that the right political course is set.

Figure 9: Projection of the Development of Employees in the Coal and Renewables Industry in Germany and China (2015-2050)[45]



4. Denmark

Higher Share of RE in Energy and Power Consumption

In 2017, Denmark continued to add renewable capacity to the system, which along with a good wind year lead to a new record in the share of renewables in both energy and power consumption.

32.4 percent of the energy consumption where covered by renewables in 2017. In terms of power generation Denmark set a new world record of covering 43.8 percent of the Danish power consumption by wind power generating 14.8 TWh by onshore and offshore installations in Denmark. Power production from solar power plants has increased again and now contributes 2.3 percent to the total power production. Including the increasing usage of biomass for the power sector the average carbon emission per produced kWh went below 200 gram compared to more than 500 grams in 2005.

With 32.3 percent of the final energy consumption coming from renewable source including biomass in 2017 and with the planned additional renewable capacity to be installed in the next couple of years, Denmark will surpass its obligations to the EU of 30 percent of final energy consumption with good margin by 2020.

After a slight increase in the carbon emission from the energy sector in 2016 the emission again went down in 2017 with a decrease of more than 5 percent. Since 1990 the carbon emission related to energy has reduced by 33 percent despite that the final energy consumption has only been reduced by 1 percent in the same period. The transition toward renewable energy sources and improved efficiency in the energy sector including combined heat and power generation are the key factors behind this development.

Transition in Close Cooperation between Public and Private Sector

Several long-term plans and strategies have been setting ambitious goals for the development in the energy sector in Denmark. There has been broad political consensus about both the goals and the implementation of the most important initiatives. The involvement and stimulation of both the private sector and academia has also been very important for the changes in the Danish energy sector. It set the basis both for the development of new technologies like renewable energy and energy efficiency, and for the transformation of energy systems and planning including exploiting synergies like combined heat and power generation, utilization of exceed heat from the industry, etc. The private sector has provided important stepping-stones for policy makers to reach and even surpass energy targets and ambitions.

Denmark started this journey without having all the solutions and answers. Both the public and private sector have been able to mobilise funding for the development of new energy solutions in close cooperation with universities and other part of Danish academia. However, as an open economy in international competition all solutions have to pass the test of offering economically viable energy services to companies and consumers going forward. A strong focus has been on maturing and reducing costs of new energy technologies and systems to serve the Danish society with both economically and environmentally sustainable products and solutions.

Holistic Long-term Energy Planning

For a sector characterised by major long-term investments like power plants, grid, etc., it was important to provide visibility on long-term policies and thus business certainty which reduces risk premiums and funding costs. For new and immature energy technologies, Denmark has been offering economic frameworks like feed-in premiums securing the financial viability of the projects. These support mechanisms have been closely monitored to make sure energy consumers would benefit from improvements of the economic efficiency of emerging technologies.

An on-going dialogue between politicians, lawmakers, regulators and key stakeholders in the energy sector including major utilities, technology companies and energy system operators has been key factor in the development of energy policies and regulation in Denmark. The dialogue has ensured good and effective decisions and solutions as well as a high level of investor certainty. Major changes in the energy market have been analysed, discussed and in most cases some level of compensation has been offered for disruption of traditional business models toward a low carbon future of the Danish energy supply.

The transition of the Danish energy system has also included smaller consumers and private households. This was done by using a combination of energy standards, incentives and public campaigns focusing on energy efficiency, common energy solutions like district heating and changes in everyday behaviour to secure a more energy efficient society. One of the biggest efficiency gains has been made in the heating of Danish households with an 80% reduction in energy consumption per square meter since the 1960s. Part of the stimulus of energy efficiency has come from introducing energy taxation for businesses and private energy consumers. Raising the price of energy has improved the business case for investing in energy saving technologies and systems.

Setting and Meeting Ambitious Energy Targets

As a member of the EU since 1973, Denmark actively follows EU targets for the transformation of the energy sector. Denmark has rapidly implemented the market and sector transformation of the energy sector, including international energy trading and unbundling of the power sector. Denmark's "early mover advantage" also meant that the country specific targets in the EU's energy strategy 2020 approved in 2009 were significantly higher than the EU average despite the lack of traditional renewable energy options like large-scale hydro power. Denmark's 2020 target includes a 31 percent GHG reduction compared to 1990 level[46] and as mentioned before getting 30 percent of Denmark's final energy consumption from renewable energy source – both well above the overall EU targets for 2020 that aim at a 20 percent GHG reduction compared to 1990 level and a 20 percent share of renewable energies. Projections made by the Danish Energy Agency show that Denmark will most likely surpass both targets with a GHG reduction of 32 percent in 2016 and renewable energy generation share already at 32 percent in 2017.

New Ambitious Energy Agreement Unanimously Approved

Not surprisingly Denmark is set to have more ambitious targets with respect to the EU energy targets for 2030.[47] Based upon these targets, the political negotiations on a new Danish energy agreement began earlier this year in order to set the course and targets for the period beyond 2020 for the Danish energy sector. High on the agenda was a further transformation away from fossil fuel based energy sources, a further improvement of energy efficiency and the advance of a market based energy sector securing a cost effective transformation and thus competitive energy prices for consumers and enterprises.

Textbox 1: Key Elements in New Danish Energy Agreement

- Focus on ways and means to reach Danish energy target of covering 55 percent of gross final energy consumption by renewable energy sources by 2030
- Further expansion of offshore wind power generation through tender for additional three 800 MW projects to be built before 2030
- Funding for technology neutral renewable energy tenders for additional onshore wind and solar PV capacity and support scheme for biogas
- Support further electrification of Danish energy sector by lower and adjusted electricity taxation
- More market-based energy systems in order to reduce the level of public support including more competitive based and focused support for energy efficiency initiatives, further liberalisation of the heat sector, etc.

In late June 2018 an agreement that includes all of the political parties represented in the Danish parliament was reached aiming for more ambitious targets set by EU and responding to a call for additional effort by the Paris Agreement to secure the 2 degree target. The Danish government is now aiming at a renewable energy target of 55 percent of the gross energy consumption by 2030 responding to the increase of the overall EU renewable energy target by 2030 from 23 to 32 percent. The current "frozen policy scenario"[48] shows that Denmark will be 15 percentage points off this target without new political and regulatory initiatives. The new Danish energy agreement includes a target of adding additional three 800 MW offshore projects by 2030 and funding of EUR 563m for technology neutral renewable energy tenders. At the same time spatial planning for up to 10 GW of offshore wind capacity in Danish waters will be conducted to insure that further offshore wind capacity can be established quickly if so decided.

One part of the new energy agreement is also the explicit target to eliminate coal consumption in the Danish power sector altogether by 2030. Coal accounted for almost 30 percent of Danish power generation in 2016. The increase in wind and solar based power generation along with a further transition toward biomass and biogas power generation is the main element in this transition toward a zero coal based power sector in Denmark.

To support the electrification of the Danish energy supply including the use of more electricity in the heating sector a reduction of taxation of electricity and a revision of other energy related taxes have been proposed. The proposal also includes a reallocation and more specific support for certain energy efficiency measures in the industry and for R&D of green energy solutions.

In the late autumn of 2018 the Danish government presented a climate and clean air act (Together for a greener future) focusing on climate and air pollution from especially the transportation and agriculture sectors. The main headlines of the plans are:

- Phase out the sale of new petrol and diesel cars in 2030
- Zero carbon emissions and air pollution from busses and environmental zones by in cities 2030.
- A climate- and environmentally-efficient agricultural sector, with a strong focus on research.
- Lower emissions from industry and housing including behavioural campaign with climate labelling
- Research efforts to develop carbon capture and storage technologies for use in Denmark's fields and forests

Political negotiations over the plan are still going on but selective initiatives including lower electrical vehicles taxation have been enforced.

Flexibility Key for Renewable Energy Integration

A significant element of the Danish energy transition has not only been introducing new technologies in energy sources, energy generation and energy transformation but also transforming systems and markets to accommodate these technologies both from a technical and economic point of view. A good example of the energy system transformation is how the power sector has been redesigned to accommodate large quantities of fluctuating renewable power generation, particularly wind power. As described in more details in China Renewable Energy Outlook 2017 the key elements in the system transition have been advanced planning and forecasting; improving flexibility of CHP plants; creating an effective and transparent power market; and establishing a strong domestic transmission grid and cross-border interconnectors.

Going forward, with the goal of even more fluctuating power in the Danish energy system, further planning of infrastructure (grid) and market is vital to preserve the high level of system stability and competitive power prices. Further integration and interconnection with neighbouring countries and the EU power system is part of the answer. In addition, the ability to store and use electricity in other sectors like heat through heat converters is being explored. Furthermore, the future electrification of transportation is part of this plan. The Danish energy planning is closely aligned with the EU plans for a more deeply integrated Energy Union.[49]

Transfer to China: Large-scale RE Integration and Market Transformation

China has already introduced many of the technologies Denmark has been using for the transformation of the energy sector. Denmark and China are consequently sharing the challenges in terms of system integration and change in business models for the power sector. Denmark has a lot of good experiences especially regarding how to convert CHP plants from must-run units to important local flexibility resources. Focusing on power plant flexibility in the large coal-fired power plant fleet in China is one way to address the current curtailment issues for fluctuating power sources like wind and solar both from a technical and economic point of view in China. Conversion of coal-fired power plants into waste or biomass is another way to maintain thermal power generation in a cleaner and more sustainable way. It could lead to reducing the carbon footprint and making use of China's biomass potential. Finally, methods and experiences made in Denmark in terms of power sector planning and scenario analysis could be used to facilitate alternative routes for the energy future of China along with more focus on improving overall energy efficiency and reducing the energy intensity of the Chinese economy as done by Denmark in many sectors.

5. United States of America (USA)

Power System Transition: Where the U.S. Stands

The power sector transition in the U.S. is primarily driven by considerations of reliability, cost and resilience. The Trump administration aims to propel America to lead the world in both oil and natural gas production and in reducing energy emissions.[50] In 2018, the U.S. became world's largest crude oil and natural gas producer.[51] At the federal level, 2017 saw the Trump administration modify or reconsider many energy-related policies implemented under the Obama administration, including the U.S. Nationally Determined Contribution (NDC) under COP 21, the Clean Power Plan, and Corporate Average Fuel Economy standards for vehicles. In addition to these actions at the national level, state- and local-level actions must also be considered. This is due to the division of authority between the federal government, which has jurisdiction over interstate commerce, and the states, which have primary jurisdiction over local issues such as customer rates and plant siting. The impacts of federal policy are often mitigated by market factors not regulated by the federal government, such as the price of natural gas relative to the price of coal, reductions in the cost of new technologies such as wind and solar power, and power plant decisions controlled by state authorities.

The U.S. will keep promoting renewable energy development. In January 2019, Daniel Simmons was officially sworn in as the Assistant Secretary for Energy Efficiency and Renewable Energy (EERE) at the Department of Energy.

"Renewables, along with energy storage and energy efficiency, are critical elements of our overall energy and economic strategy, and I am pleased to have Assistant Secretary Simmons on board to continue advancing our country's renewable technologies." Mark W. Menezes, Under Secretary of Energy[52]

When Congress signed the Energy Policy Act in 2005, 51.3% of power generation was supplied by coal.[53] Since then, innovation in fuel extraction techniques such as hydraulic fracturing in combination with horizontal drilling has caused a significant increase in the supply of natural gas, leading to lower prices. Additionally, renewable energy adoption has increased significantly, primarily driven by declines in capital costs for wind and solar power systems, favorable policies, and increased investor confidence in the performance of these technologies. Because of these changes, the share of coal generation in the U.S. power sector dropped to 27.4% in 2018.[54] This change has also been reflected in a recent trend of coal plant retirements—according to AEO 2019, at the end of 2018 U.S. coal generator capacity totaled 240 GW, down from approximately 310 GW in 2008. An additional 101 GW of capacity is projected to retire by 2050.[55] Meanwhile, utility-scale renewables accounted for over 17.0% of total U.S. electricity generation; notably, utility and small-scale solar net generation increased by 24.4%, and total renewable generation increased by 4.5% from 2017 to 2018[5]. The transition has also been reflected in jobs. Solar workforce has grown 159% from 2010 (93,502 workers) to 2018 (over 242,000 workers) in the U.S.[56] Although experienced slightly decline since 2016, the outlook for solar jobs is expected to improve in 2019 because of the state level policy incentive and the backlog of utility-scale projects.[57]

Current Focus Points and Potential

Some key approaches and experiences of the U.S. energy transition are described below, with their implications for the future of the U.S. energy sector and thoughts about their relevance for the Chinese energy transition.

Bottom-up Policy Development

Independent of the federal government, several states and cities have formed a coalition—the U.S. Climate Alliance—to implement the U.S. NDC of economy-wide GHG reductions between 26-28% below 2005 levels by 2025 at the state level. Members of the Alliance include 19 states and the territory of Puerto Rico, representing over 40% of the U.S. population and comprising 31.2% of 2015 U.S. energy-related carbon dioxide emissions.[58 59 b]

A key policy instrument to achieve GHG reduction goals has been the Renewable Portfolio Standard (RPS), versions of which have been enacted by 29 states.[60 c] The Lawrence Berkeley National Laboratory estimates that in 2018, 55% of retail electricity sales were covered by an RPS in U.S. California, Connecticut, Massachusetts, New Jersey, and New York made major revisions to their RPS programs in 2018. For instance, California increased its RPS target to 60% by 2030 and mandated a 100% clean energy target by 2045.[61] Establishing an energy efficiency target is another renewable incentive approach. For example, in 2018, Colorado regulators boosted Xcel's annual energy efficiency target 25% (from 400 GWh to 500 GWh, 2019 to 2023) in order to provide increased benefit to customers and reduce the utility investment costs.[62]

Looking forward, ambitious policies are anticipated to continue to emerge from the state and local level.[63] In the private sector, 49% of large corporations headquartered in the U.S. were actively sourcing renewable energy in 2018.[64] Globally, corporations signing clean energy contracts have more than doubled between 2017 and 2018, to 13.4 GW, of which U.S. corporations accounted for 60%.[65]

[b] Since these data were compiled, an additional state, Wisconsin, has joined, bringing the total number of member states to 20, plus Puerto Rico.

[c] 29 States + Washington DC + 3 territories have a Renewable Portfolio Standard (8 states and 1 territory have renewable portfolio goals).

Market Structures and Prices

Overall there has been movement away from centrally regulated command and control monopoly utilities to competitive markets, but these have taken different forms due to regional circumstance, political commitments, and transmission interconnections. In addition to the numerous regional, multistate markets which operate under the jurisdiction of the Federal Energy Regulatory Commission (FERC), other novel approaches to encourage the optimal dispatch of renewables have appeared.

California's Independent System Operator (CAISO) has operated the Western Energy Imbalance Market (EIM), implementing the near-real-time trading of energy between utilities since 2014; mechanisms like this prevent the curtailment of excessive renewable generation by expanding the market's footprint, mitigate congestion, increase system flexibility, and enhance grid reliability. Eight states and one Canadian province are now part of the EIM, with two utilities having joined in 2018, and five more planning to do so by 2021.[66]

In New York, there have been additional developments in the state's Reforming Energy Vision (NY REV) initiative. Through a series of regulatory changes, NY REV intends to change the role of utilities from selling power at the distribution level to operating a distribution platform for the participation of distributed energy resources (DER). In this vision, the distribution system maintained by the utility becomes a power market for behind-the-meter resources, storage, and microgrids to participate as producers and consumers. The project represents a significant regulatory effort towards a flexible, resilient electric grid.[67]

FERC Policy Update

In 2018, FERC implemented a number of rules to enhance power system reliability, improve regional market transparency, ensure system security, and reduce customer expenditures. Table 2 illustrates the main issues FERC addressed in 2018.

Table 2: EU Energy Targets for 2030 and 2050	
DOCKET	DESCRIPTION
RM18-1-000 AD18-7-000	At the federal level, the U.S. Department of Energy proposed a new tariff structure for RTOs to compensate resources which provide resilience benefits, especially those with onsite fuel such as coal and nuclear plants. This proposal was rejected by FERC in early 2018, but FERC has since initiated a new proceeding and asked grid operators to provide details concerning how they are planning for grid resilience.[68]
RM17-13-000 RM17-12-000	FERC proposed to approve new mandatory Reliability Standards to bolster supply chain risk management protections for the nation's bulk electric system.[69]
RM16-23	FERC issues final rule on electric storage participation in regional markets. This rule helps remove barriers from traditional market design on energy resources by requiring each regional grid operator to revise its tariff to establish a participation model for electric storage resources. This rule will enhance competition and promote greater efficiency in the nation's electric wholesale markets and will help support the resilience of the bulk power system.[70]
RM17-2-000 RM17-8-000	FERC issues final rules to improve regional market transparency and interconnections. RM17-2-000 addresses transparency in terms of uplift payment, operator-initiated commitments and transmission constraint penalty factors in power markets. RM17-8-000 addresses reform of generator interconnection procedures, promote informed interconnection decisions and enhance the interconnection process.[71]
RM18-2-000	FERC directed the North America Electric Reliability Corp to develop modifications to the Critical Infrastructure Protection Reliability Standards to improve mandatory reporting of cyber security incidents.[72]
RM19-5-000 PL19-2-000 AC18-59-000	FERC took future steps on tax reductions for energy customers and provides industry guidance.[73]

Evolution of the Baseload Concept

Increasing penetrations of variable renewable energy have changed the nature of what "baseload" generation means and its contributions to system reliability. Characteristics such as flexibility can be more useful planning concepts for exploring approaches to minimizing power disruptions.[74] With a sufficiently time-resolved understanding of the demand profile and wind and solar forecasts, operators can assess how much flexibly scheduled power from other sources, including combined cycle natural gas, coal or nuclear, demand response (DR), or other assets, is needed. In California, novel approaches to DR are being utilized to reduce the need to turn on thermal plants for peak load. CAISO has introduced a Proxy Demand Resource market, which allows for aggregators of distributed energy resources (DER) to participate in real-time and day-ahead energy markets. Aggregators have seen a high level of adoption through alerting customers in real-time when consumption at their node is high and compensating them for reducing their load.[75] Continuous interaction with customers allows DR to be utilized by smaller loads at a much higher frequency than typical DR resources. These flexible resources are enabled by various mechanisms, including specific products or the ability to bid services into markets such as capacity, demand response, or ramping. [76]

Various DER technologies such as PV paired with storage, combined heat and power systems, and microgrids enhance system resilience during system-wide grid outage events. As the frequency and intensity of outage events evolve, policy makers at all levels are introducing new interconnection processes and standards to facilitate the adoption of resilient technologies in the power system.

The Future of Storage

Significant decreases in the cost of battery storage systems have occurred in recent years and continued cost decreases are anticipated. In the future, variable renewables could increasingly become paired with battery storage to provide additional grid services in a cost-effective manner. Recent FERC orders could significantly alter the landscape for utility-scale battery storage by requiring grid operators to allow the participation of storage in energy, capacity, and ancillary service markets.[77] Additionally, a recent FERC order requires that all newly interconnected generators provide primary frequency response capabilities[78]; this could result in renewable resources susceptible to deviations in their frequency from wind or clouds increasingly being paired with battery storage to stabilize frequency output.

Barriers to Trade

President Trump announced a four-year tariff (Section 201) on imports of certain PV modules to the U.S. beginning in 2018.[79] The tariff begins at 30% and ratchets down by 5% per year until expiring in 2021. The tariff is designed to inspire additional investment in domestic PV manufacturing; some have estimated that it could cause a short-term reduction of 11% in new PV installations in next five years.[80] Solar project cancellation and interconnection delays in 2017 resulted in many projects spilling over into 2018.[81] The U.S. expects 11.1 GWdc of new PV installations in 2018, with virtually flat growth compared to 2017.[82] The uncertainty of the Section 201 tariff caused developers to delay projects, and could be a reason for increasing utility solar procurement in late 2018.[83]

Transfer to China

Beyond the obvious systemic differences, China and the U.S. share a number of common challenges on the path to power sector transformation, each country standing to benefit from the experiences of the other. A deliberate approach to sharing lessons learned can have a beneficial long-term impact on both countries and on the international community. Some notable aspects are described below.

Needs for technology research and development

Advances in technology will further enable greater deployment and broader application of advanced energy technologies. There is still room to achieve higher efficiencies, lower costs, and better environmental sustainability in manufacturing and disposal of these technologies. Such continued advances could accelerate energy sector transitions to a lower-carbon-emitting composition. Examples include PV chemistries not reliant on rare earth minerals, development of new storage technologies capable of meeting specific power sector needs throughout a range of time scales, and advances in new technologies such as marine hydrokinetic generation.

Industry maturation: standards

One hallmark of mature industries is the existence of standardization to reduce transaction costs and increase regulatory certainty. As the renewable energy industry matures, an increasing share of cost reductions may come from the establishment of these standards. Standardizing the communication protocols of components such as controllers could reduce project engineering costs associated with nascent technologies like microgrids. Similarly, establishing standard contracts improves investor confidence and lowers transaction costs associated with financing. Opportunity for international standardization of Renewable Energy Certificate (REC) tracking instruments also exists. As China's own Renewable Portfolio Standard develops, communication with U.S. states that have implemented REC tracking schemes is a valuable avenue to share lessons learned.[83] As the market for RECs grows globally, standardization in database management and accreditation methods will become critical in ensuring the validity of environmental attributes certificates.

Flexible power systems

Perhaps the greatest challenge energy sectors face globally is the effective integration of variable renewable energy at high penetrations. This challenge will be much more prevalent and pervasive as the industry grows and countries achieve their policy goals. Effective integration can be achieved through planning for system flexibility and through power market design. As China looks to fully integrate its wholesale power market by 2040, lessons can be learned from international experience, including U.S. ISO/RTOs and jurisdictions like the Western EIM, which have demonstrated an ability to provide reliability while integrating flexible resources.

References

1. " 习近平：决胜全面建成小康社会 夺取新时代中国特色社会主义伟大胜利 —— 在中国共产党第十九次全国代表大会上的报告 ," The State Council, 27 October 2017, accessed at http://www.gov.cn/zhuanti/2017-10/27/content_5234876.htm.
2. " 中电联发布《2018-2019 年度全国电力供需形势分析预测报告》," China Electricity Council, 29 January 2019, accessed at http://www.cec.org.cn/yaowenkuaidi/2019-01-29/188578.html.
3. " 中电联发布《2018-2019 年度全国电力供需形势分析预测报告》," China Electricity Council, 29 January 2019, accessed at http://www.cec.org.cn/yaowenkuaidi/2019-01-29/188578.html.
4. "2018 年可再生能源并网运行情况介绍 ," National Energy Administration, 28 January 2019, accessed at http://www.nea.gov.cn/2019-01/28/c_137780519.htm?from=groupmessage&isappinstalled=0.
5. "2018 年可再生能源并网运行情况介绍 ," National Energy Administration, 28 January 2019, accessed at http://www.nea.gov.cn/2019-01/28/c_137780519.htm?from=groupmessage&isappinstalled=0.
6. "2018 年 1-11 月全国电力工业统计数据一览表 ", China Electricity Council, 20 December 2018, accessed at http://www.cec.org.cn/d/file/guihuayutongji/tongjxinxi/yuedushuju/2018-12-19/f6961d3c182099d18a77d3aff5c763de.pdf.
7. " 国家能源局：2018 年新能源弃电超 300 亿度 ," China Energy Newspaper, 17 January 2019, accessed at http://news.bjx.com.cn/html/20190117/957343.shtml.
8. "2013 年风电产业继续保持平稳较快发展势头 ," National Energy Administration, 06 March 2014, accessed at http://www.nea.gov.cn/2014-03/06/c_133166473.htm; "2014 年风电产业监测情况 ," National Energy Administration, 12 February 2015, accessed at http://www.nea.gov.cn/2015-02/12/c_133989991.htm; "2015 年风电产业发展情况 ," National Energy Administration, 02 February 2016, accessed at http://www.nea.gov.cn/2016-02/02/c_135066586.htm; "2016 年风电并网运行情况 ," National Energy Administration, 26 January 2017, accessed at http://www.nea.gov.cn/2017-01/26/c_136014615.htm; "2017 年风电并网运行情况 ," National Energy Administration, 01 February 2018, accessed at http://www.nea.gov.cn/2018-02/01/c_136942234.htm; "2018 年可再生能源并网运行情况介绍 ," National Energy Administration, 28 January 2019, accessed at http://www.nea.gov.cn/2019-01/28/c_137780519.htm?from=groupmessage&isappinstalled=0; "2017 中国电力发展报告 ," National Energy Administration, 18 May 2018.
9. " 我国十五能源发展重点专项规划 ," National Development and Reform Commission, 13 August 2001, accessed at https://news.sina.com.cn/c/2001-08-13/327870.html.
10. " 国家能源局综合司征求《关于实行可再生能源电力配额制的通知》意见的函，" National Development and Reform Commission and National Energy Administration, 13 November 2018, accessed at http://www.nea.gov.cn/2018-11/15/c_137607356.htm.
11. " 关于宁夏风电基地 2018 年度风电项目竞争配置评优结果的公示 ," Ningxia Development and Reform Commission, 17 December 2018, accessed at http://www.nxdrc.gov.cn/info/1013/20874.htm.
12. " 关于宁夏风电基地 2018 年度风电项目竞争配置评优结果的公示 ," Ningxia Development and Reform Commission, 17 December 2018, accessed at http://www.nxdrc.gov.cn/info/1013/20874.htm.
13. Shi Jingli, " 电力体制改革形势下可再生能源电价机制研究 ," China Economic Publishing House, March 2017, pp. 166.
14. "Guiding Opinions on Improving Scale Management and Implementing Tendering PV Projects, NRDC Energy [2016] No.1163, " (CHN: 关于完善光伏发电规模管理和竞争方式配置项目指导意见，发改能源 [2016]1163 号), National Development and Reform Commission and National Energy Administration, 30 May 2016, accessed at http://www.ne21.com/news/show-77051.html.
15. " 李创军：我国光伏发电度电成本 10 年下降约 90%," National Energy Administration, 14 April 2018, accessed at https://www.sohu.com/a/228248326_99919252.
16. " 国家发展改革委 国家能源局关于积极推进风电、光伏发电无补贴平价上网有关工作的通知 , 发改能源〔2019〕19 号 ," National Development and Reform Commission and National Energy Administration, 7 January 2019, accessed at http://www.ndrc.gov.cn/zcfb/zcfbtz/201901/t20190109_925398.html.
17. Projects that only receive local subsidies are still considered as subsidy-free pilots. In regions where subsidy free remains impossible, the government will continue to hold wind and solar auctions.
18. Cai Yixuan, "COP24 速递 | 中国碳市场周岁 , 碳价预期如何 ?" Energy Observer, 18 December 2018, accessed at http://wemedia.ifeng.com/93708336/wemedia.shtml.
19. " 国家发展改革委办公厅国家能源局综合司关于开展电

力现货市场建设试点工作的通知，发改办能源〔2017〕1453 号，" National Development and Reform Commission and National Energy Administration, 28 August 2017, accessed at http://www.ndrc.gov.cn/gzdt/201709/t20170905_860117.html.

20. " 电力现货市场试点期限推迟，电力现货市场究竟难在哪里？ " Energy Magazine, 27 November 2018, accessed at http://www.chuandong.com/news/news.aspx?id=224710.
21. " 国家能源局综合司关于健全完善电力现货市场建设试点工作机制的通知，国能综通法改〔2018〕164 号，" National Energy Administration, 8 November 2018, accessed at http://zfxxgk.nea.gov.cn/auto81/201812/t20181217_3499.htm.
22. " 电力现货市场建设试点已有三个启动试运行，" www.bjpsb.com, 28 December 2018, accessed at http://www.bjpsb.com/dqchuli/25978.html.
23. 谭慧娟，" 广东现货市场体系，" 19 November 2018, accessed at http://www.sgcio.com/news/guancha/2018/1119/101614.html.
24. " 国家发展改革委关于印发《可再生能源发展 " 十三五 " 规划》的通知，发改能源〔2016〕2619 号，" National Development and Reform Commission, 10 December 2016, accessed at http://zfxxgk.ndrc.gov.cn/web/iteminfo.jsp?id=394.
25. Jorrit Gosens, "Environmental Protection Tax Law of the People's Republic of China – Policy Summary," GIZ China, 1 February 2018.
26. " 习近平：决胜全面建成小康社会 夺取新时代中国特色社会主义伟大胜利 —— 在中国共产党第十九次全国代表大会上的报告，" The State Council, 27 October 2017, accessed at http://www.gov.cn/zhuanti/2017-10/27/content_5234876.htm.
27. " 国家能源局关于印发 2018 年能源工作指导意见的通知，" National Energy Administration, 9 March 2018, accessed at http://www.gov.cn/xinwen/2018-03/09/content_5272569.htm.
28. "China Renewable Energy Outlook 2018," China National Renewable Energy Centre, December 2018, accessed at http://boostre.cnrec.org.cn/index.php/2018/11/27/creo2018.
29. "China Renewable Energy Outlook 2018," China National Renewable Energy Centre, December 2018, accessed at http://boostre.cnrec.org.cn/index.php/2018/11/27/creo2018.
30. "Funding for climate action", European Commission, 20 February 2019, accessed at https://ec.europa.eu/clima/policies/budget_en.
31. "Database Energy", Eurostat, 20 February 2019, accessed at http://ec.europa.eu/eurostat/web/energy/data/database.
32. According to EU law, it must be distinguished between two different kinds of legal acts: on the one hand, a directive is a legislative act that sets out a goal that all EU countries must achieve. However, it is up to the individual countries to devise their own laws on how to reach these goals. On the other hand, a regulation is a binding legislative act that must be applied in its entirety across the EU. The Winter Package contains proposals for four directives and four regulations.
33. "Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council", European Union, 21 December 2018, accessed at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0001.01.ENG&toc=OJ:L:2018:328:TOC.
34. The following four legislative acts on the design of the electricity market have not been formally agreed and publicised (editorial deadline: 15 March 2019). However, informal agreements have been reached for all four legislative acts. The European Parliament is expected to vote in the plenary session at the end of March 2019, followed by formal adoption by the Council.
35. "Proposal for a Regulation of the European Parliament and of the Council establishing a European Union Agency for the Cooperation of Energy Regulators (recast)", Council of the European Union, 18 December 2018, accessed at https://data.consilium.europa.eu/doc/document/ST-15495-2018-INIT/en/pdf.
36. "Proposal for a Directive of the European Parliament and of the Council on common rules for the internal market in electricity (recast)", Council of the European Union, 11 January 2019, accessed at https://data.consilium.europa.eu/doc/document/ST-5076-2019-INIT/en/pdf.
37. "Proposal for a Regulation of the European Parliament and of the Council on the internal market for electricity (recast)", Council of the European Union, 11 January 2019, accessed at https://data.consilium.europa.eu/doc/document/ST-5070-2019-INIT/en/pdf.
38. "Proposal for a Regulation of the European Parliament and of the Council on risk-preparedness in the electricity sector and repealing Directive 2005/89/EC", Council of the European Union, 29 November 2018, accessed at http://data.consilium.europa.eu/doc/document/ST-14783-2018-INIT/en/pdf.
39. "Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources", European Union, 21 December 2018, accessed at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG&toc=OJ:L:2018:328:TOC.
40. "Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency", 21 December 2018, accessed at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0210.01.ENG&toc=OJ:L:2018:328:TOC.
41. "Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive

2012/27/EU on energy efficiency", 19 June 2018, accessed at https://eur-lex.europa.eu/legal-content/EN/TXT/?toc=OJ%3AL%3A2018%3A156%3ATOC&uri=uriserv%3AOJ.L_.2018.156.01.0075.01.ENG.
42. Agora Energiewende, "Die Energiewende im Stromsektor: Stand der Dinge 2018", accessed at https://www.agora-energiewende.de/veroeffentlichungen/die-energiewende-im-stromsektor-stand-der-dinge-2018/.
43. Kommission Wachstum, Strukturwandel und Beschäftigung, „Abschlussbericht der Kommission Wachstum, Strukturwandel und Beschäftigung", accessed at https://www.kommission-wsb.de/WSB/Redaktion/DE/Downloads/abschlussbericht-kommission-wachstum-strukturwandel-und-beschaeftigung-2019.pdf?__blob=publicationFile&v=5.
44. German Energy Agency (dena), April 2019, accessed at https://www.dena.de/themen-projekte/projekte/cnrec-energiewende-expertise-fuer-china/.
45. German Energy Agency (dena), April 2019, accessed at https://www.dena.de/themen-projekte/projekte/cnrec-energiewende-expertise-fuer-china/.
46. Official Danish GHG targets are compared to 2005 level. In order to increase the coherence of this report data were converted to 1990 level based upon data available for 1990 and 2005.
47. See also chapter 2 on the energy system transformation in the European Union
48. The Danish Energy Agency monitors the expected development of the Danish energy system based on the current energy policy measures in a frozen policy scenario. This scenario is used as a baseline for decisions on new policy measures.
49. See also chapter 2 on the energy system transformation in the European Union
50. "Secretary Perry State of the Union Statement", Department of Energy, 6 February 2019, accessed at https://www.energy.gov/articles/secretary-perry-state-union-statement.
51. "DOE 2018 Notable Achievements", Department of Energy, January 2019, accessed at https://www.energy.gov/sites/prod/files/2019/01/f58/DOE-YearEndAccomplishments2018.pdf.
52. "Daniel Simmons Ceremonially Sworn In as DOE Assistant Secretary for Energy Efficiency and Renewable Energy", Department of Energy, 6 February 2019, accessed at https://www.energy.gov/articles/daniel-simmons-ceremonially-sworn-doe-assistant-secretary-energy-efficiency-and-renewable.
53. Fred Freme, "U.S. Coal Supply and Demand: 2005 Review", U.S. Energy Information Administration, 2005, accessed at https://www.eia.gov/coal/review/pdf/feature05.pdf.
54. "Electric Power Monthly", U.S. Energy Information Administration, 27 February 2019, accessed at https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_1_01.
55. "Annual Energy Outlook 2019 with projections to 2050", U.S. Energy Information Administration, 24 January 2019, accessed at https://www.eia.gov/outlooks/aeo/pdf/aeo2019.pdf.
56. "Solar Jobs Census 2018", Solar Energy Industries Association, 2018, accessed at https://www.seia.org/research-resources/solar-jobs-census-2018.
57. "National Solar Jobs Census", The Solar Foundation, 2018, accessed at https://www.thesolarfoundation.org/national/.
58. "Energy-Related Carbon Dioxide Emissions by State, 2000-2015", U.S. Energy Information Administration, 22 January 2018, accessed at https://www.eia.gov/environment/emissions/state/analysis/.
59. "U.S. Climate Alliance About US", United States Climate Alliance, 2019, accessed at https://www.usclimatealliance.org/about-us/.
60. "Detailed Summary Maps", NC Clean Energy Technology Center, 2019, accessed at http://www.dsireusa.org/resources/detailed-summary-maps/.
61. Galen Barbose, "U.S. Renewable Portfolio Standards 2018 Annual Status Report", Lawrence Berkeley National Laboratory, November 2018, accessed at http://eta-publications.lbl.gov/sites/default/files/2018_annual_rps_summary_report.pdf.
62. "Decision approving, with modifications, non-unanimous comprehensive settlement; and establishing electric energy savings and demand reduction goals for 2019 through 2023, with associated financial incentives". Public Utilities Commission of the State of Colorado, 6 June 2018, accessed at http://www.m.swenergy.org/Data/Sites/1/media/documents/news/co-xcel-dsm-puc-decision-6-6-18.pdf.
63. Glen Andersen, et al. "Here Comes the Sun, A State Policy Handbook for Distributed Solar Energy", National Conference of State Legislatures, July 2017, accessed at http://www.ncsl.org/Portals/1/Documents/energy/SolarEnergyToolkit_31552.pdf.
64. "Corporate Sourcing of Renewable Energy: Market and Industry Trends", International Renewable Energy Agency, May 2018, accessed at https://www.irena.org/publications/2018/May/Corporate-Sourcing-of-Renewable-Energy.
65. "2018 Was a Record Year for Corporate Clean Energy Contracts", Greentech Media, 31 January 2019 accessed at https://www.greentechmedia.com/articles/read/reports-confirm-a-record-year-for-corporate-clean-energy-contracts#gs.N8L4mFLO.
66. "About Western EIM", Western Energy Imbalance Market, 2019, accessed at https://www.westerneim.com/Pages/About/default.aspx.
67. Joshua L. Sturtevant, "New York's reforming the energy vision- opportunities and obstacles on the horizon", Sullivan & Worcester LLP, 16 May 2016, accessed at https://www.lexology.com/library/detail.aspx?g=bbeb89a4-810f-47fc-bae1-c6271e366f99.
68. "FERC Initiates New Proceeding on Grid Resilience, Terminates DOE NOPR Proceeding",

Federal Energy Regulatory Commission, 8 January 2018, accessed at https://www.ferc.gov/media/news-releases/2018/2018-1/01-08-18.asp?csrt=1558937739961636912 1#.XGxkWuhKg2x.

69. "FERC Proposes to Adopt Enhanced Supply Chain Risk Management Reliability Standards", Federal Energy Regulatory Commission, 18 January 2018, accessed at https://www.ferc.gov/media/news-releases/2018/2018-1/01-18-18-E-2.asp?csrt=15589377399616369121#.XGxkluhKg2x.

70. "FERC Issues Final Rule on Electric Storage Participation in Regional Markets" ", Federal Energy Regulatory Commission, 15 February 2018, accessed at https://www.ferc.gov/media/news-releases/2018/2018-1/02-15-18-E-1.asp?csrt=15589377399616369121#.XGxkvuhKg2x.

71. "FERC Issues Final Rules to Improve Regional Market Transparency, Interconnections ", Federal Energy Regulatory Commission, 19 April 2018, accessed at https://www.ferc.gov/media/news-releases/2018/2018-2/04-19-18-E-2.asp?csrt=15589377399616369121#.XGxlG-hKg2x.

72. "FERC Requires Expanded Cyber Security Incident Reporting", Federal Energy Regulatory Commission, 19 July 2018, accessed at https://www.ferc.gov/media/news-releases/2018/2018-3/07-19-18-E-1.asp?csrt=15589377399616369121#.XGxlWuhKg2x.

73. "FERC Acts on Tax Reductions for Energy Customers, Provides Industry Guidance", Federal Energy Regulatory Commission, 15 November 2018, accessed at https://www.ferc.gov/media/news-releases/2018/2018-4/11-15-18-E-1.asp?csrt=15589377399616369121#.XGxlt-hKg2x.

74. J. Cochran, M. Miller and O. Zinaman et al, "Flexibility in 21st Century Power Systems", 21st Century Power Partnership, 2014, accessed at https://www.nrel.gov/docs/fy14osti/61721.pdf.

75. Claudia, "How does OhmConnect make money", ohmconnect, 2019, accessed at https://www.ohmconnect.com/faq/introduction-to-ohmconnect/how-does-ohmconnect-make-money.

76. "Flexible ramping product", California ISO, 2019, accessed at http://www.caiso.com/informed/Pages/StakeholderProcesses/CompletedClosedStakeholderInitiatives/FlexibleRampingProduct.aspx.

77. "Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators", Federal Energy Regulatory Commission, 15 February 2018, accessed at https://www.ferc.gov/whats-new/comm-meet/2018/021518/E-1.pdf.

78. "Essential Reliability Services and the Evolving Bulk-Power System—Primary Frequency Response", Federal Energy Regulatory Commission, 15 February 2018, accessed at https://www.ferc.gov/whats-new/comm-meet/2018/021518/E-2.pdf.

79. "Section 201 Solar Tariffs", Solar Energy Industries Association, 2018, accessed at https://www.seia.org/research-resources/section-201-solar-tariffs.

80. Julia Pyper, "New Tariffs to Curb US Solar Installations by 11% Through 2022", GTM Research, 23 January 2018, accessed at https://www.greentechmedia.com/articles/read/tariffs-to-curb-solar-installations-by-11-through-2022#gs.9pMONcyF.

81. "Solar Market Insight Report 2017 Year in Review", Solar Energy Industries Association, 2018, accessed at https://www.seia.org/research-resources/solar-market-insight-report-2017-year-review.

82. "Solar Market Insight Report 2018 Q4", Solar Energy Industries Association, 2018, accessed at https://www.seia.org/research-resources/solar-market-insight-report-2018-q4.

83. Kate Chrisman, et al. "State of the Market 2017: Corporate Renewable Procurement in China", Business Renewable Center, 2018, accessed at https://www.rmi.org/wp-content/uploads/2018/04/BRC_China_state-of-the-market.pdf.

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