REGULATORY ASSISTANCE PROJECT

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Climate Action is Energy Security: Recent Developments in the Power Sectors of India, China and Europe

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In 2021, roughly 39% of the world's electricity came from non-carbon-emitting resources. One quarter of that was output from wind and solar generation. Together they produced nearly 3,000 terawatt-hours (TWh) of electricity. For the first time, these renewables served more than 10% of global power demand. Hydroelectric and nuclear production accounted for most of the rest of the non-emitting generation, a little more than 25% of the world's electricity.[1]

These are extraordinary and exciting numbers, especially when compared to those of only a decade earlier when wind and solar produced less than 1% of total global electricity. Since 2017, most new capacity has been wind and solar. In 2021, their 364 s (GW), of which 130 GW were in China, accounted for three quarters of new capacity additions. In all, 85% of new capacity last year was carbon free.[2] In China, India, Europe and the US, solar (including small scale, distributed photovoltaics) topped the list of new capacity installed.

The primary drivers of these investments are policy and economics. Today wind and solar are most often the long term, least cost options. This economic advantage comes as a result of more than two decades of regulatory and industrial policy around the

[1] Maia, S. and Demôro, L. (2022.9). *Power Transition Trends in 2022*. Bloomberg NEF, Bloomberg Philanthropies. https://assets.bbhub.io/professional/sites/24/BNEF-Power-Transition-Trends-2022_FINAL.pdf

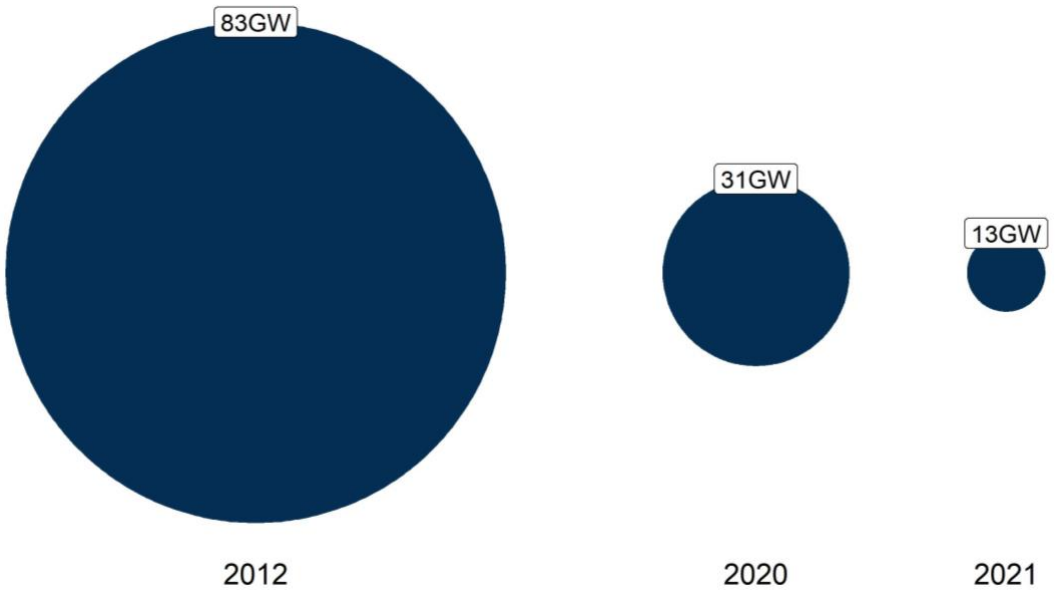
[2] Maia et al., 2022.

world: the creation - by government action - of markets for renewable resources has, as demand has grown, driven costs down and made profitable what before only satisfied niche applications.

But global coal-fired generation totaled a record 9,600 terawatt-hours, up 8.5% from 2022, a dark counterpoint to these happy statistics. Demand for electricity jumped 5.6% in 2021, as the world began to emerge from the Covid-19 pandemic. Global hydro production was below forecasts and natural gas prices rose. China, India and the US were responsible for 72% of that coal-fired power production. It all added up to a 7% jump in global CO_2 emissions last year - with the lion's share coming from countries that have committed to becoming net zero carbon in the next thirty to forty years.[3]

Nevertheless, global investment in new coal capacity is dropping. In 2012, 83 GW of new coal-fired generation came online around the globe. In 2020, 31 GW were added. It fell to 13 GW last year and retirements of coal plants are increasing. In 2021, 21 GW of coal-fired generation in developed countries were shut down - the most ever.[4]

Figure 1. New coal-fired capacity in 2012, 2020 and 2021



Data source: Maia, S. and Demôro, L. (2022.9). *Power transition trends in 2022*

Despite the recent uptick in global coal consumption, it is clear that a decarbonized global power system is within reach. This transition can be achieved at low cost while maintaining high levels of reliability. The challenge for policymakers around the world is to continue to reform power sector policy, regulation and market mechanisms in order to support this clean energy transition. This paper reviews power sector reform in India, China and Europe. Recent action in these regions suggests some promising

[3] Maia et al., 2002.

[4] Maia et al., 2022.

pathways. They are marked, as one would expect, by combinations of policy directives and market reforms suited to their particular circumstances - but among the things they have in common are a strong reliance on planning and a recognition of the value of demand side resources.

India

Reliability of service is a central theme of power sector policy in India today. At its most basic, reliability is a question of access. At the turn of the century, more than a third of India's population did not have access to electricity. This was primarily an urban-rural divide: less than 50% of people in rural India had electricity while more than 85% of urban citizens did.[5] But lack of access wasn't the only problem. Those who did have it nevertheless could not rely on it: repeated outages were a regular feature of daily life. Many businesses - hotels, manufacturers - invested in onsite backup generation. The baritone of diesels was a familiar hum in Indian cities.

Today, only 1% of the population in India doesn't have electricity.[6] While acknowledging that, in some remote areas, electric service is limited to a few hours each day, it is still not hyperbolic to say that this even limited universal service has been an extraordinary accomplishment. With it come advances in standards of living and public health.

It's been fueled by investment in wires, fossil generation and renewables. In 2012, installed capacity totaled 199.8 GW. There were 112 GW of coal-fired generation and less than 10 GW of wind and solar. Today total installed capacity in India is 405.7 GW. Coal still accounts for more than 50% (204 GW) but there are over 40 GW of wind and 59 GW of solar. The country is on track to meet its 2022 target of 175 GW of installed renewables capacity (160 GW in May 2022, of which 46.5 GW is large hydro and 15 GW is small hydro and biomass).[7] Fossil gas generation totals 24.8 GW.

As access has increased, so too has reliability improved - reliability as experienced by end users in the number and duration of outages, which is all that matters. But reliability from the perspective of system planners and operators is more nuanced. It has two dimensions: system security and resource adequacy. System security is the operational dimension, in which a combination of available resources is deployed to match expected demand in real time at the lowest reasonable cost. Resource adequacy is the long term dimension, in which investment is required to maintain, refresh, expand and transform the portfolio of resources so that they will continue to be available as needed to meet future demand at the lowest reasonable cost. Although the two dimensions are distinct, they are intrinsically related: system security cannot be achieved if there are insufficient resources for the task.

Recognizing that a systematic approach to reliability is needed, the Central Electricity Authority of India, a division of the Ministry of Power, began in September of this year by issuing draft guidelines for resource adequacy planning. When finalized, the

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[5] The World Bank. (n.d.). *Access to Electricity (% of population)-India*. https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=IN

[6] The World Bank, n.d.

[7] Government of India, Ministry of Power, Central Electricity Authority. (2020.10). *Growth of Electricity Sector in India from 1947–2020*. https://cea.nic.in/wp-content/uploads/pdm/2020/12/growth_2020.pdf. Invest India. (2022.9). Renewable Energy. https://www.investindia.gov.in/sector/renewable-energy

guidelines will "institutionalize a Resource Adequacy planning framework to be followed by distribution licensees for power procurement and capacity contracting."[8] CEA gives several reasons for its action:

- To prepare for high penetrations of the variable renewable resources that will come online in the next eight years; the government has set a national target of 450 GW of renewables by 2030.
- To address significant surpluses and shortages of capacity that are the consequence of uncoordinated and methodologically inconsistent approaches of the states to resource procurement; to make possible economically more efficient resource portfolios through the sharing of reserves.
- To link resource adequacy to market design; to ensure that market mechanisms will fairly compensate providers of reserves, among other capabilities.
- To improve planning methods, especially load forecasting.
- To establish means for monitoring and enforcing compliance with resource adequacy obligations.[9]

These guidelines should have a significant and positive impact on resource procurement and the achievement of India's aggressive renewables and climate goals. That they were developed as a consequence of a decades long effort to bring electricity to more than a billion people gives them an intriguing signature: India has expressly linked a clean and reliable electricity future to ubiquitous service and social welfare.

China

A renewables "surge" is the theme of China's power sector transition in the past decade, as shown in figures 2 and 3 on the next page. In 2021, with 130 GW of new wind and solar, total wind and solar installed capacity rose to 670 GW, nearly 90 times that in 2012,[10] and it was responsible for 11.7% of the country's electricity production. Total electricity production from renewables (including large hydro) was 29.4%, up from 2% in 2012.[11, 12] And perhaps most exciting is that 2021 marked the first time that the total installed non-fossil energy capacity (47%) exceeded that of coal power (46.7%).

[8] Central Electricity Authority. (2022.9) *Draft Guidelines for Resource Adequacy Planning Framework for India*. 章节 1.2. https://cea.nic.in/wp-content/uploads/irp/2022/09/Draft_RA_Guidelines___23_09_2022_final.pdf

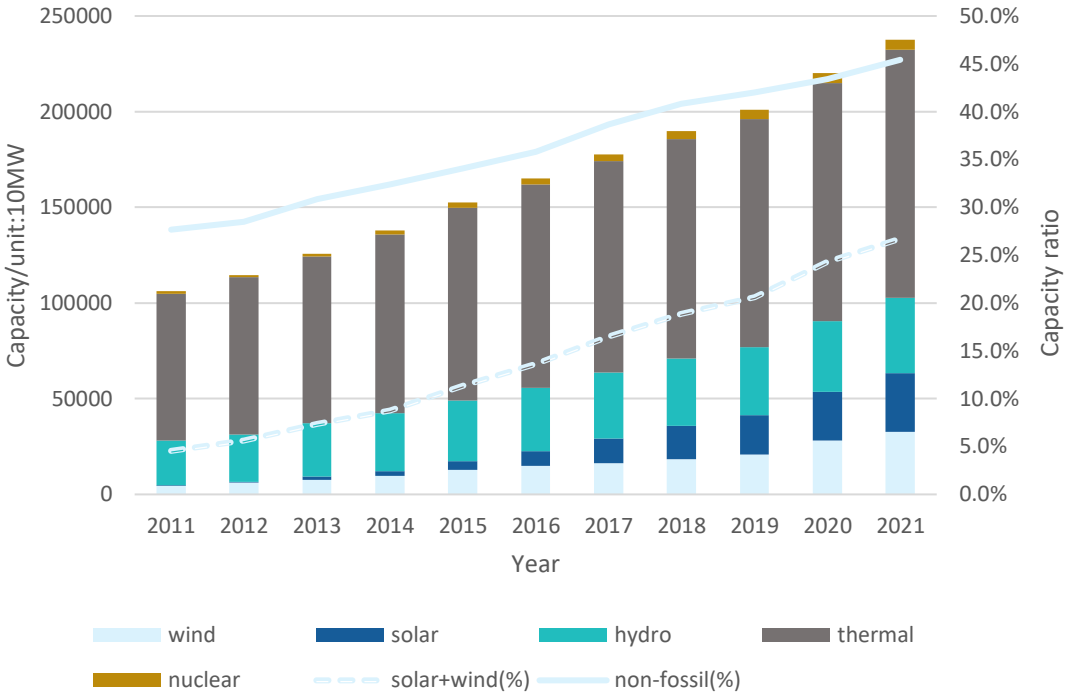
[9] Central Electricity Authority, 2022, para 1.1.

[10] The State Council, The People's Republic of China. (2022.7). *China leads in renewable energy growth*. https://english.www.gov.cn/statecouncil/ministries/202207/12/content_WS62ccd034c6d02e533532d9b4.html#:~:text=The%20country's%20total%20installed%20capacity.to%20the%20National%20Energy%20Administration

[11] S&P Global. (2022.9). *China could exceed renewables generation target of 33% by 2025*. https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/092322-china-could-exceed-renewables-generation-target-of-33-by-2025

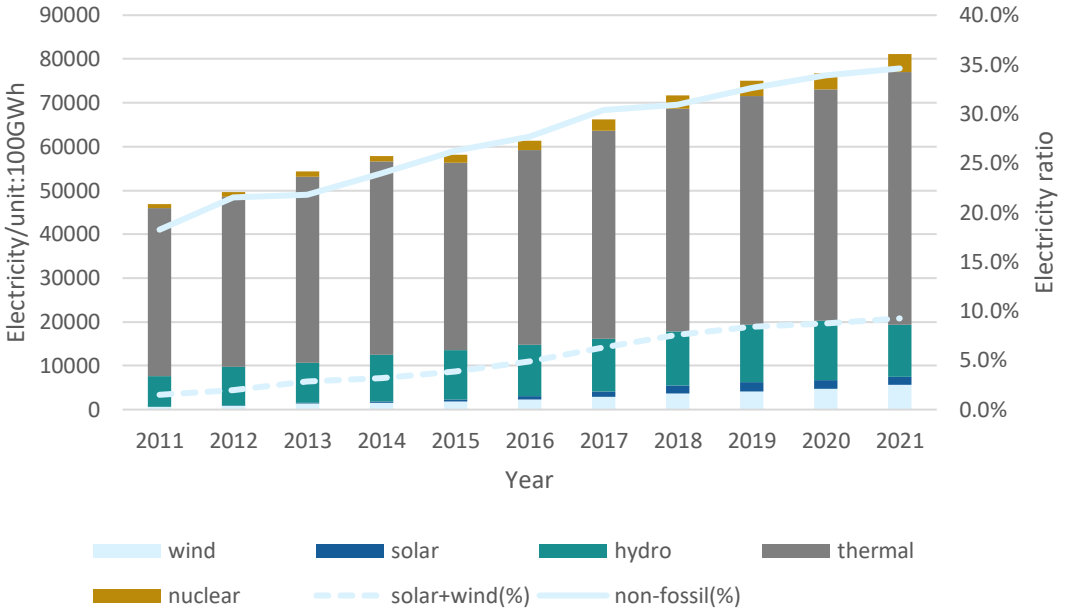
[12] 北极星太阳能光伏网.(2013.1). *2012中国光伏装机1.19GW 大幅低于预期.* https://guangfu.bjx.com.cn/news/20130116/413946.shtml

Figure 2. Installed capacity in China (2011-2021)



Data source: China Electricity Council, National Bureau of Statistics

Figure 3. Electricity generation in China (2011-2021)



Data source: China Electricity Council, NBS National Bureau of Statistics

Close examination of Figures 2 and 3 reveals that there is a transition underway. As large scale development of renewables continues, the role of traditional fossil-fired generation is diminishing:

- Total installed capacity reached 2377 GW in 2021, more than double the number in 2011 (1056 GW).
- The share of non-fossil installed capacity increased from **27.5%** (290 GW) in 2011 to **47%** (1118 GW) in 2021.
- The share of thermal power installed capacity declined sharply from **72.4%** in 2011 to **46.7%** in 2021.
- 2020 was the **first year** in which the share of coal-fired installed capacity (49.0%) amounted to **less than half** of the country's total installed capacity.
- Total power generation increased from 4604 TWh in 2011 to 8112 TWh in 2021.
- The share of coal-fired electricity dropped from **73.9%** in 2012 to **60.0%** in 2021.

Estimates of the amount of investment needed to achieve carbon neutrality over the next 30 years vary widely, from as little as ￥100 trillion to nearly ￥500 trillion (see Table 1 on the next page). In addition, the Chinese government has pledged more ambitious policy goals within the context of the "dual carbon target" (peak carbon emissions before 2030 and carbon neutrality before 2060) and specified in the 14th Five-Year-Plan (renewables generation target at 33% by 2025).

Table 1. Expected investment in China to realize carbon neutrality

	CICC Research Institute[13]	The Goldman Sachs Group[14]	ICCSD[15]	Green Finance Committee, China Society for Finance and Banking[16]	Peking University's Guanghua School of Management[17]
Predicted value (trillion RMB)	139	104 (The report mentions about 16 trillion dollars. We use 6.5 as the exchange rate.)	127 (2 ℃ target) 174 (1.5 ℃ target)	487	Around 200
Predicted period	2021-2060	2021-2060	2020-2050	2021-2050	2021-2060
Covering industrial area	Low carbon energy-related fields, excluding ecological environmental protection	Low carbon energy-related fields, excluding ecological environmental protection	Low carbon energy-related fields, excluding ecological environmental protection	According to the 211 fields in the "Green Industry Catalogue", it includes areas related to low carbon energy systems and ecological environmental protection	Different methods of back-of-the-envelope estimates
Fixed assets and liquidity coverage	Only fixed asset investments are included	Only fixed asset investments are included	Only fixed asset investments are included	Including fixed asset investment and liquidity requirements	

The recent power sector crisis in Sichuan in 2022 led some analysts and stakeholders to suggest there is a tradeoff between power sector decarbonization and power sector reliability. However, as experience elsewhere shows, this does not have to be the case. Rational power sector decarbonization, with its reliance on the flexibility and geographic diversity of loads and production, can actually improve reliability.

Power sector reform – if designed and implemented well – will help to ensure the power system's reliability of power supply as China's level of renewable energy penetration increases. A crucial aspect of this will be to carefully follow through on the government's commitment to "unified" national power markets. This will help the country continue to move away from a province by province approach to power system operations and investment and will help avoid the type of crisis seen in Sichuan, where the province relied heavily on a single local hydro resource.

[13]中金公司研究部,中金研究院. (2021). *碳中和经济学：新约束下的宏观与行业趋势*. 中信出版集团.

[14] 高盛集团. (2021). *中国走向净零碳排放之路：清洁能源技术革新*.

[15] 清华大学气候变化与可持续发展研究院等. (2021). *中国长期低碳发展战略与转型路径研究：综合报告*. 中国环境出版集团.

[16] 马骏.(2021). *碳中和愿景下绿色金融路线图研究报告*. 中国金融出版社.

[17] 刘俏.(2022). "2022清洁能源技术与双碳"科学论坛, 演讲稿.

Recent events and government directives have created new opportunities to develop and implement innovative policies, regulations, and market mechanisms to accelerate power sector reform and the low carbon transition. Among them are the following:

- **The national electricity market guideline.** In January 2022, National Development and Reform Commission (NDRC) and National Energy Administration (NEA) jointly released Document 118, *Guiding opinions on accelerating the construction of a national unified electricity market*. This document outlines the creation of a "national unified electricity market" to improve standardization and consistency in the implementation of electricity markets in China.[18]
- **Development of regional markets is speeding up.** At the end of 2021, State Grid officially issued the *Inter-Provincial Electricity Spot Trading Rules (Trial)* in accordance with the requirements of the *Reply to Inter-Provincial Electricity Spot Trading Rules* issued by the National Development and Reform Commission and the National Energy Administration, which clarified the methods for implementing day-of and day-ahead spot trading across provinces. This should lead to greater utilization of renewable energy[19]. On July 23, 2022, the southern regional power market covering the five provinces of Guangdong, Guangxi, Yunnan, Guizhou, and Hainan started trial operation. It is the clearinghouse for several types of electricity products, which differ in the durations of their commitments: day-of and day-ahead spot trading, week long and monthly contracts, and longer term (half year, annual, etc.) contracts. Experience here should lead to the creation of other regional markets and, eventually, their unification in a national market system.
- **Carry out provincial level spot market pilots.** Provincial spot market pilots, such as Sichuan's, began as early as 2017. Since then, a number of modifications to the pilots have been implemented. Most recently (December 2021), Sichuan began the trial operation of what it calls its "long-period continuous settlement" market.[20] Given the province's unique portfolio of hydro and thermal resources, the pilot attempts to deal with seasonal surpluses and shortages by limiting hydro participation in the market to the "dry" and thermal participation in the "wet" season. As this pilot is not yet a year old, the experience with this approach has yet to be fully evaluated.
- **Market reform and the scaling up of renewables expose the need for transmission planning and investment.** Market mechanisms and renewables integration depend upon a strong and flexible grid. Developments in the China Southern region and in Sichuan, for example, reveal how transmission planning and investment are integral to functioning markets and achievement of the country's long term energy and environmental goals.

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[18] 国家发展改革委，国家能源局. (2022.1). *关于加快建设全国统一电力市场体系的指导意见*. https://www.ndrc.gov.cn/xxgk/zcfb/tz/202201/t20220128_1313653.html

[19] 国家电网有限公司. (2021.11). *省间电力现货交易规则（试行）*. http://www.bj-px.com.cn/html/files/2021-11/24/20211124173432625408406.pdf

[20] 四川省发展和改革委员会. (2021.12). *四川电力现货市场启动长周期连续结算试运行*. http://fgw.sc.gov.cn/sfgw/c106053/2021/12/30/4a5af25588eb40f9b707d197b79c05cd.shtml

Europe

Since late 2021, the European Union has seen increased consumption of coal and lignite in the power sector, driven by unexpectedly scarce natural gas supplies (and correspondingly high natural gas prices). This is despite an increase in CO2 allowance prices (currently around €66/tonne) in the Emissions Trading Scheme (ETS). In the short term the changing relative price of coal and gas is leading to higher consumption of coal. However, in the longer term the cost advantages of wind, solar and clean demand side resources – supported by policy commitment to decarbonization goals – is expected to continue to drive coal out of the system.

Concerned about this and about additional possible interruptions in fossil gas supplies from Russia (which have since come to pass), several EU countries earlier this year announced temporary measures to ensure that their gas storage facilities would be filled as quickly as possible to avoid shortages in the coming winter. Their main tool for doing so is to divert some gas used to generate electricity to storage and replace the gas-fired generation with coal-fired. There will be a slight uptick in EU greenhouse gas emissions this year, but it will be short lived and should not impair the achievement of Europe's long term climate objectives. No EU country has reversed its commitment to phase out coal by 2030 at the latest. [21]

A small amount (13.5 GW) of previously retired or restricted coal-fired power plants have been placed on "standby", to be used only in emergencies. This is a 12% increase in operational EU coal-fired generation capacity, or an increase in 1.5% of total installed generation capacity. Specifically:

- On 8 July, 2022 **Germany** enacted a new energy law, of which one element is the Replacement Power Plant Provision Act. It allows for 8.2 GW of previously retired coal-fired capacity (6.3 GW of hard coal and 1.9 GW of lignite) to be put on standby. The new energy law also includes a higher renewable energy target of 80% by 2030.
- Recently, **the Netherlands** amended legislation that, since the beginning of 2022, had constrained its hard coal plants (4.5 GW) to operate at no more than 35% of their maximum capacity. The amended law allows them to run at 100% until the end of 2023.
- **France** will reopen the 595 MW Emile Huchet 6 coal plant for the coming winter (2022-23).
- **Austria**'s 246 MW Mellach plant will temporarily be taken out of mothballs but will run on coal rather than gas.

These plants will be on standby and be used in emergencies, as "last resorts." The impact on EU CO_2 emissions is estimated to be small. If these plants were to operate at a 65% capacity factor throughout 2023 (the actual percentage is likely to be lower), they will generate 60 TWh (about enough to serve the EU for a week) and produce a

[21] Brown, S (2022.7). *Coal is not making a comeback: Europe plans limited increase*. Ember. https://ember-climate.org/insights/research/coal-is-not-making-a-comeback/

net increase in CO_2 emissions of 30 million tonnes (approximately 1.3% of total EU CO_2 emissions or 4% of power sector emissions in 2021).[22]

Complementing these actions was the EU-wide agreement, on 26 July 2022, on a 15% reduction in winter gas demand.[23]

Unsurprisingly, the current crisis has accelerated European action on its clean energy transition. In May, the European Commission adopted the *REPowerEU* plan, which, among other things, increased the "Fit for 55" targets for energy efficiency from 9% to 13% and for renewables from 40% to 45% by 2030. It will also speed up the electrification of fossil fuel end uses—transportation and building heating, in particular. The plan calls for over €200 billion in new investment in the next five years.[24]

And, more recently, EU energy ministers, through the Council of the European Union, adopted a package of crisis response measures in which end use efficiency, load reductions, and demand flexibility take on increasing in importance. It calls a 10% decrease in demand for electric energy and a 5% drop in peak demand reduction. It's up to each Member State to determine how it will meet these goals; programmatic approaches will vary widely. In addition, certain pricing controls to shield consumers from high prices will be imposed.[25] The measures are temporary. They will go into effect on 1 December 2022 and will expire at various times in 2023. The longest lived will expire on 31 December 2023.

Conclusions

Countries around the world are committed to decarbonizing their power sectors. It has become very clear that paying careful—and unflagging—attention to the details of power sector reform is necessary if those commitments are to be met. Heavy reliance on fossil fuels has been shown again to be the high risk strategy. By any reasonable measure—such as price volatility, supply vulnerability, and environmental impacts—fossil fuels have little to recommend them. There can be no more secure an energy strategy than minimizing reliance on these fuels. Europe's experience reveals the high cost of delayed action. India appears to be heeding that lesson. And China is making great progress with power sector reform – and crucial details of this reform will determine whether fossil fuel resources will be treated rationally in coming years.

Every country, of course, is unique in its history, its institutions, and the particulars of its power sector. But the stories of India, Europe, and China, like other stories untold here, demonstrate that, given the physics of electricity and the demands of the low carbon transition, many of the items on national power sector reform "to do" lists probably look very much alike. Three at the top might be these:

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[22] Brown, 2022.

[23] European Council. (2022.12). *Impact of Russia's invasion of Ukraine on the markets: EU response.* https://www.consilium.europa.eu/en/policies/eu-response-ukraine-invasion/impact-of-russia-s-invasion-of-ukraine-on-the-markets-eu-response/

[24] European Commission. (2022.5). *REPowerEU: a plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition*. https://ec.europa.eu/commission/presscorner/detail/en/IP_22_3131

[25] European Council. (2022.9). *Council agrees on emergency measures to reduce energy prices.* https://www.consilium.europa.eu/en/press/press-releases/2022/09/30/council-agrees-on-emergency-measures-to-reduce-energy-prices/

- Design, implement, and refine market mechanisms to ensure reliability, renewable energy integration, unlock the value of demand side resources (especially flexibility and distributed renewables), and control costs;
- Improve power sector planning to identify grid needs; and
- Provide strong and predictable regulatory oversight of markets and network monopolies, with the power not only to identify market failures but to remedy them.

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