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Long-Term Goal-Setting and Planning for Decarbonising the Indian Power Sector –

Need for a Coordinated Approach

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Long-Term Goal-Setting and Planning for Decarbonising the Indian Power Sector –

Need for a Coordinated Approach

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Abstract

Preparations for the UN Conference on Climate Change (COP26) and the globally-felt urgency to mitigate climate change have highlighted the importance of long-term goals and the associated planning to decrease the emission intensity of the power sector in India. So far, India has done well on the path to fulfilling its NDC commitments. Over the last decade, there have been unprecedented technological and other changes in the energy sector, particularly rapid reductions in the cost of renewable energy (RE) based power. The Government of India has responded to these changes with dramatic enhancements in the targets for RE. However, the road ahead will be challenging, and therefore, a coordinated approach to long-term goal-setting and planning will be required. Currently, there is no overarching target for emission intensity reduction in the power sector. Instead, there is a profusion of targets with one for almost every resource used for generating electricity, reducing considerably the flexibility for distribution companies to select an optimal resource mix. Long-term planning is carried out at two levels. At the central level, the Central Electricity Authority (CEA) develops a National Electricity Plan every five years. At the local level, distribution companies are responsible for resource planning but concerted effort will be required to strengthen the capacity within distribution companies for carrying out effective resource planning.

Based on a review of the current approach and lessons from the experience with long-term goal-setting and planning in the UK and Australia, the paper recommends the following approach for long-term goal-setting and planning so that India can navigate the energy transition economically, speedily, and smoothly: (1) Establish an autonomous and credible agency that will set the target year for complete decarbonisation of the power sector; (2) Break up the period between now and the target date into shorter periods of five years, each with its own interim target for permissible emission intensity in terms of grams of CO_2-eq per kWh of electricity sold, to be applied to all load-serving entities; (3) Assign the responsibility for monitoring the progress of reductions in emissions reduction and recommending mid-course corrections to the independent agency.

Executive Summary

As the 26th United Nations (UN) Conference on Climate Change, also known as the Conference of Parties (COP26), draws closer, the flurry of studies on what India should, or should not, do regarding its international commitments on greenhouse gas (GHG) emissions highlights the importance of both, the process to set long-term goals, and the associated long-term planning to chart a path for the realization of these goals.

So far India is doing well, and is one of the few countries on a path to fulfilling its commitments for its nationally determined contributions (NDC) for 2030. Since 2010, when the Jawaharlal Nehru National Solar Mission (JNNSM) was launched, there have been unprecedented technological and other changes in the energy sector, particularly dramatic reductions in the cost of renewable energy (RE) based power. The Government of India has responded to these changes by equally dramatic enhancements of the targets for RE generation capacity in the resource mix. However, the road ahead on the energy transition is going to become more challenging. Therefore, it is important to develop a coordinated approach to both, goal-setting and the associated long-term planning, that is effective and economically sound, so that the energy transition is as smooth as possible, and is done at the lowest cost.

The focus in this paper is on the electricity sector. Most of the work in India on mitigating emissions has been done in this sector. Examining the long-term goal setting and planning process for the electricity sector should provide lessons and useful insights for other sectors, and for the whole economy. We review how long-term goal-setting and planning are carried out in India at present, identify shortcomings, and recommend changes to make both more effective. Our recommendations are also informed by our review of the experience of two countries with long-term goal-setting and planning—the United Kingdom (UK) and Australia—and the lessons for India from their experience.

As we look at how long-term goals are set in the Indian electricity sector, several problems come to our attention. First, there is no overarching target in terms of emissions intensity for the sector. (Given that India is a developing economy, it is more appropriate to consider GHG emission-intensity targets for the electricity sector rather than absolute emission targets.) The target for the installed capacity of renewable energy (RE) plants is the closest proxy. Second, there is a profusion of separate targets for almost every resource used to generate electricity. Such an approach reduces the flexibility of distribution companies to select resources to meet their loads, resulting in a non-optimal resource mix, and a higher cost of electricity. The reduced flexibility could also stymie the development and deployment of newer technologies such as battery storage and small modular nuclear reactors. Third, there is insufficient attention to other development goals—domestic manufacturing, import dependence, and employment—when targets are announced. Even when these other goals are considered, ad-hoc measures are taken instead of a well thought out strategy. Fourth, many of the targets are pronouncements but often without an official policy document providing details of the target and outlining the rationale or deliberations behind its selection.

With a greater reliance on markets and privatisation, the nature of long-term planning in the electricity sector has changed, and is now carried out at both the national and local levels. Centralized planning is carried out by the Central Electricity Authority (CEA), and local-level planning is carried out by distribution companies. The CEA brings out the National Electricity Plan (NEP), which should ideally serve as a guide for investments in generation and storage, and should also ensure the adequacy of the transmission system to carry the required loads reliably. India is presently reaching the end of the third NEP (2017–2022). It is important to point out that the establishment of electricity markets, both at the wholesale and retail level, will not obviate the need for planning. Instead, it will make it more challenging. Planning at the central level will be required to ensure adequacy of the transmission system, and at the local level for the distribution company to ensure adequacy of its network and to serve its remaining customers.

Four steps would greatly improve the NEP. First, it should be an integrated plan, instead of having two parts as is the case now—the transmission part of the plan is developed after the generation part has been finalized. Second, it should consider a much wider range of alternate plausible futures, and address uncertainty in a more comprehensive manner. Third, it should include consultation with a much wider set of stakeholders. Fourth, given the rapid pace of change in the sector and the resulting uncertainty, it should be reviewed in the middle of each five-year period.

There are also serious shortcomings in long-term planning by distribution companies. Resource planning is not a part of the lexicon of the Indian power sector, and is poorly understood by distribution companies and regulators. At best, the focus is on sufficient generating capacity to meet peak loads—without much consideration of long-term system costs, an optimal resource mix, or risk management. A concerted effort will be required: (a) to increase awareness about the value of resource planning; (b) to develop a regulatory framework for resource planning; and, (c) to train staff of distribution companies and regulatory commissions on the practices of resource planning.

Once there is sufficient expertise to carry out effective resource planning in distribution companies, it would be best for each state to have an emissions-intensity target for the electricity sector, derived from the emissions-intensity target for the national economy. One option for such a target could be in terms of grams of CO_2-eq emissions per kilowatt hour (kWh) sold.[1] State targets could be ratcheted down over time, to reduce the sector's emissions-intensity.

Each distribution company would need to develop and implement resource plans to meet the emissions-intensity target for its state. A difficult question is how to divide the national emissions-intensity target between states? There are some options we list in the paper, but the choice from those options requires a separate discussion.

Until recently, planning in the electricity sector did not include building resilience into physical infrastructure, because it was felt that the power sector had well-established engineering rules and processes to cover that aspect. With the increasing number and severity of extreme weather events, not just in India, but across the world, the unthinkable has become the new normal. Planning for such events is important not just to prevent damage to the physical infrastructure, but also to factor-in vagaries in supply, as generation from renewable energy (RE)—wind, solar, and hydro—is directly linked to weather and climate. We cannot afford any longer to label these extreme weather events as unforeseeable; we must prepare for them in our planning processes. Planning, for making the power system more resilient, will not be easy because building-in resilience adds costs. Therefore, to mitigate costs and to find the optimal type and level of resilience that should be built in, long-term planning will require detailed and accurate information about the type and severity of climate risk that an area is likely to face.

We recommend the following approach for the setting of long-term goals and associated planning, as India navigates its transition to clean energy in the electricity sector.

- **An autonomous and credible agency and a long-term target.** We suggest that an autonomous and technically well-respected agency be assigned the responsibility for determining targets for emission intensity or net emissions. This agency could be either a new agency or created from an existing one, such as the CEA, with an expanded mandate to cover climate change issues for all sectors. The same agency should set the target year for complete decarbonisation of the electricity sector. The target year should be based on modelling and analysis of multiple

[1] In addition to carbon dioxide (CO_2), there are other GHGs, and their global warming potential is higher than CO_2. In order to be able to compare the emissions of all the GHGs on a uniform basis for their global warming potential, the measure CO_2-eq has been developed. One tonne of CO_2-eq of any of the GHGs has the same global warming potential as one tonne of CO_2.

plausible futures to set an ambitious but achievable target. Consultation with a wide-ranging set of stakeholders, and transparency about the assumptions and rationale for the selected target, should be an integral part of the process.

- **Shorter-term planning periods with targets.** The period between now and the target date for complete decarbonisation of the electricity sector, should be divided into shorter periods of five years each; each with its own interim targets. These interim targets should be set for the maximum permissible emission-intensity of electricity sold, and stated in terms of grams of CO_2-eq per kWh of electricity sold. The interim targets, possibly differentiated by state, should apply to all load-serving entities (LSEs).

- **Five-Yearly National Electricity Plan (NEP) with mid-term review.** At the start of each five-year planning period, CEA should develop a NEP that represents the optimal path to reach the target of complete decarbonization. The NEP should identify the required augmentation and upgradation of the transmission grid to ensure transmission adequacy and reliability of the power system. The NEP should be an adaptive plan with signposts and decision-points, and should ideally also serve as a guide for investments in generation and storage.

- **Effective resource planning by distribution companies.** Currently the main LSEs are distribution companies, but if and when retail competition occurs at a significant level, retail suppliers would also be LSEs. Targets for emission intensity instead of amounts of specific resources (RE, hydro, etc.) would provide flexibility to distribution companies to procure the optimal resource mix for their specific mix of consumers and load profile. However, in order to take advantage of this flexibility, the distribution companies will need to carry out effective long-term resource planning. As mentioned earlier, power procurement and resource-planning practices of distribution companies have very serious shortcomings as of now. A very significant effort will be needed to enhance the resource planning capabilities of the staff of distribution companies.

- **Effective monitoring by the independent agency.** Monitoring the progress of reductions in emission intensity will be critical to India's success in decarbonising its electricity sector. The independent agency (discussed in the first point above) should be tasked with: (a) monitoring annual progress; and, (b) suggesting corrective actions at the end of the five-year periods.

Long-Term Goal-Setting and Planning for Decarbonising the Indian Power Sector –

Need for a Coordinated Approach

1. Introduction

The 26th UN Conference on Climate Change, also known as the Conference of Parties (COP26), will be held in Glasgow in early November 2021. As the conference draws closer, the issue of goal-setting in the energy sector is getting increased attention. Countries are being asked to enhance their emission-reduction targets. With many countries announcing net zero targets, there is pressure on India to enhance its existing commitments for emission reductions. If India announces any new targets, those targets will determine to a large extent, the path that India's energy sector takes for the next few decades. Irrespective of the stand that India takes at COP26, the recent flurry of studies on what India should, or should not, do regarding its trajectory of greenhouse gas (GHG) emissions, highlights the importance of examining how targets for the energy sector are set in India.

With the rapid increase of renewable energy (RE) in its energy mix, India is moving to fulfil its commitments made in its NDC in Paris and has much to celebrate and be proud of. The Climate Change Performance Index (CCPI) is an annual ranking of 57 countries that together account for more than 90% of the world's GHG emissions. The CCPI for 2021 rated India's performance as "high" and ranked it seventh out of 57 (Burck et al., 2021).[2]

There have been unprecedented technological and other changes in the energy sector since 2010 when the Jawaharlal Nehru National Solar Mission (JNNSM) was launched. Globally, the cost of electricity from solar PV plants in 2020 has dropped to about 15% of what it was in 2010 (IRENA, 2021). In addition, there is a greater understanding of how to integrate RE into the power system and consequently more confidence in adding increasing amounts of RE to the generation mix. Successive governments in India have responded to these changes by enhancing the targets for RE generation capacity in the resource mix. However, it may be time to rethink how targets are set in the electricity sector. The urgency to reduce GHG emissions requires that India develop a long-term strategy to make dramatic reductions in the emissions intensity of the power sector. Uncertainty in the power sector is likely to grow and any approach for setting long-term goals must incorporate strategies to respond to the various sources of uncertainty. Furthermore, as the energy sector's emission intensity decreases, further reductions are likely to become increasingly difficult. Therefore, given the enormous challenges that lie ahead as India transforms its energy system, it is important to examine the target-setting and associated planning process to see if they can be made more efficient. This would result in lower expenses, less confusion, and overall better outcomes.

Our focus in this paper is on the electricity sector, because most of the work on climate change mitigation in India has been done in the electricity sector. The electricity sector is also the easiest one to decarbonise, and many countries have started their climate change mitigation efforts in this sector. We hope that the work described in this paper will provide useful lessons regarding both setting goals for the long-term, and planning for decarbonising other sectors and the whole economy.

There has been a change in the nature of long-term planning since the early 1990s, thanks to greater reliance on markets and privatisation. This holds true for the electricity sector as well. Prior to the 1990s

[2] The developers of the CCPI said that no country's performance warranted a rating of "very high," and therefore, the first three ranks of the overall table are blank. With those three blanks in the table, India ranks tenth.

India followed planned economic development and the energy sector's trajectory developed based on five-year plans.[3] In the first few post-Independence decades, targets were appropriate for various energy resources. For example, electricity requirement was calculated based on the projected economic growth rate, and targets for coal procurement for electricity generation would be set accordingly. Planning for the electricity sector nationwide, during this era, was done by the Central Electricity Authority (CEA).

With the passage of the Electricity Act (EAct) of 2003, generation, except from hydroelectric plants and nuclear plants,[4] was delicensed, and it was expected that planning would become more decentralised and be done by distribution companies. While setting broad overarching targets would still be appropriate, setting targets for each resource used for electricity generation would become unnecessary and inappropriate.

As we scan the targets being set for the electricity sector, we find that, contrary to expectations, overarching targets have been neglected. Instead, multiple, overlapping, and often inconsistent targets are now being set in the electricity sector.

In this paper, we start with an examination of what constitutes good goal-setting and long-term planning. Against this ideal process, we look at how goal-setting is carried out in the Indian electricity sector and what concerns emerge. We follow that with a look at the status of long-term planning in India; at the central level by CEA and at the local level by distribution companies. Then, in an effort to suggest improvements to the goal-setting and long-term planning processes, we look at two international examples of goal-setting and long-term planning for mitigating climate change and transitioning to clean energy, to cull lessons for India. We end with our recommendations.

2. Characteristics of Good Goal-Setting and Long-Term Planning

Concrete goals can and have been valuable in the progress of a nation, or in a sector of its economy. Such goals can be aspirational, and thus motivate the citizenry to work towards them. This, in turn, helps the nation marshal the resources necessary to meet these goals.

Broad consultation in goal-setting and implementation, greatly enhances cooperation and coordination between various groups and stakeholders. Because a goal must motivate people, it must be seen to be important by stakeholders. This works best if the goal is at the macro-level and is linked to an important socio-economic issue. Micro-level goals often do not carry much weight with citizens. Furthermore, micro-level details are best left to those who will be taking action to meet the macro-level goals, allowing them the necessary flexibility. Taking an example from Tongia (2016), in a war, the commander gives the top-level command, "Capture that hill", but does not say how it should be done or what weapons to use; those decisions are best left to the field officers who will be implementing the order.

In the power sector, an example of a good macro-level goal is the Government of India's (GoI's) recent initiative, Sahaj Bijli Har Ghar Yojana (Saubhagya),[5] launched in September 2017 to provide access to electricity for all households in the country by December 2018. Good examples of macro-level goals to reduce emissions are the pledges by several countries to reach net zero emissions. Here we are not commenting on how good the target is from a global perspective, or on the likelihood of the target being met, but merely about the performance indicators (net emissions, electricity access, etc.) being of socio-economic importance in the respective country and being one behind which the citizens are likely to rally.

[3] The last plan was the Twelfth Five Year Plan (2012-17).

[4] Nuclear Power Corporation of India Limited (NPCIL) continues to be responsible for design, construction, commissioning, and operation of all nuclear power plants in India (NPCIL, 2021).

[5] Translated in English, 'A scheme to provide electricity to each and every household.'

Good goal setting needs to be accompanied by good long-term planning; first, to enable the setting of ambitious but achievable goals, and second, to ensure high likelihood of the goal being achieved. There has been an evolution in thinking about long-term planning in the power sector. Earlier, long-term planning in the Indian power sector was deterministic; with some sensitivity analysis added, to see how the results of a planning model would change if there were changes (often small), in key variables. Among the most significant changes we will see in the power sector in the coming decades is a much higher level of uncertainty. This increased uncertainty will stem from three main sources:

- **New technologies.** There are several new technologies that are already being developed and others on the horizon that are likely to bring dramatic changes in the sector. Examples of these technologies are: energy storage technologies including batteries; small modular (nuclear) reactors (SMRs); generation and use of green hydrogen; and behind-the-meter technologies to make demand flexible.

- **RE generation.** Vagaries of the weather will affect RE generation. Until now, weather has mostly affected the demand for electricity. However, with a large contribution of energy by RE, supply will also be affected. Therefore, due to the effect on both demand and supply of electricity, the impact of weather could be much greater overall. An example of the potentially pernicious impact of weather would be hot, humid, cloudy, and windless days when demand for electricity is likely to be high, but generation from solar and wind would be low.

- **Climate change.** We are already experiencing the impacts of climate change with a far greater number of extreme weather events in India. Just this year (2021), India was hit with two cyclones, Tauktae and Yaas, one on its west coast and the other on the east coast (Gupta, 2021). Heavy rains in many parts of the country have triggered floods, landslides, and brought many cities to a grinding halt (Jadhav & Kumar, 2021; Kumar, 2021). In Delhi, every month since August 2020 has recorded an extreme weather event—extreme rainfall, or historical coldest day, or historical hottest day, or coldest or hottest monthly average temperature (Gandhiok, 2021).

  Other parts of the world have not been spared either. Western Canada and parts of the US saw record high temperatures, as high as 49.6 degrees Celsius (deg. C), followed by wild fires, while Texas had a freeze with record low temperatures in February. Germany had floods that killed more than 180 people, and New South Wales (Australia) also had record heavy floods in March. (Gupta, 2021). In early September 2021, the states of New York and New Jersey saw heavy rains that overwhelmed cities and resulted in flooding that left 43 people dead. Statements, after the storm, by New York officials, including the Governor of New York, contain important lessons for planning for such disasters. First, "that the unthinkable was quickly becoming the norm," and second, that therefore, we can no longer label these extreme events as "unforeseeable" or unexpected, but must prepare for them in our planning processes (Newman, 2021).

  These extreme weather events are likely to lead to loss of life and damage to infrastructure including the power system. Therefore, long-term planning must include adequate measures to make the entire power system resilient enough to face these events. Furthermore, because historical weather patterns are unlikely to be very useful for predicting future weather patterns, these changes in climate and the increased frequency of extreme weather events will greatly exacerbate the difficulty in predicting RE-generation discussed earlier.

Because of the much higher level of uncertainty in the future, several changes will be required to the planning processes in the electricity sector. First, deterministic planning will have to be replaced by the development and analysis of plausible alternate scenarios accompanied by stochastic (probabilistic) approaches to planning. Second, very long planning horizons, say 20-50 years, will need to be broken up into shorter periods so that new knowledge about emerging technologies can be incorporated into plans. Third, plans will be need to be monitored so that the course can be corrected to respond to both new knowledge and any unforeseen problems in implementation that may occur. Fourth, to the extent possible, instead of chunky generation capacity additions, additions would need to be modular to minimize the risk of stranded assets. Fortunately, RE technologies allow such modularity and rapid installation of new generating capacity. SMRs, as and when they become commercially viable, would also be well suited to such modularity.

It is sometimes thought that the establishment of electricity markets, at the wholesale and retail level, will obviate the need for planning. That is unlikely to happen; instead, planning will become more important and challenging. Planning at the central level will be required to ensure adequacy of the transmission system, and at the local level for the distribution company to ensure adequacy of its network and to serve its remaining customers.

3. Concerns about Goal-Setting in the Indian Electricity Sector

As discussed in the introduction, targets in the power sector have been successively enhanced as a response to rapid changes over the last decade in costs, technologies, and knowledge. However, now with the urgent requirement to dramatically reduce the nation's GHG emission intensity and the associated challenges, a well thought out proactive approach to goal-setting is required. The first step in developing such an approach is to understand the shortcomings of the current approach to goal-setting.

Before we examine carefully the targets for each resource later in this section, we examine the process of target-setting in the Indian power sector. We see the following shortcomings:

- **Lack of an overarching target for reduction of emission intensity.** First, there is no overarching target in the power sector stated directly in terms of reduction of GHG emission intensity, although the underlying motivation behind the targets for various resources could be reduction of emissions intensity, protecting the local environment, and ensuring energy security. Second, the focus usually remains only on the supply side, ignoring demand-side measures and behavioural changes that may be more cost-effective, have lower environmental impacts, and address significant socio-economic issues. We recognise that the target for RE is a bit different, because it is more closely related to the broader issues of reducing the intensity of GHG emissions, and enhancing energy security. We discuss this in more detail later in this section.

- **Profusion of targets with little consideration for optimal resource-mix.** As we will describe in the following sections on specific resources for generation, there are separate targets of one kind or another, not just for RE, but for almost every resource used to generate electricity. Ideally, each distribution company should select resources based on its load profile, existing resources in its supply portfolio, and costs of new resources. As discussed in more detail in Section 4.2, the selection should be based on minimizing long-term total system costs. Having separate targets for each resource severely constrains a distribution company's flexibility in selection and optimization of its resource mix. Silo-based targets lead to a scramble for the lowest cost options within each silo, instead of a portfolio of options which result in the lowest overall system cost, increasing costs ultimately paid by end-consumers of distribution companies. Such targets may have been appropriate in a command-and-control economy, but seem out of place today with the push towards markets and competition. Furthermore, there are several new technologies that could be game-changers in the sector, such as: energy storage (particularly using batteries); emerging technologies such as green hydrogen and nuclear SMRs; and flexible demand. By reducing a distribution company's flexibility in choosing the best resource mix, multiple targets may stymie the development and deployment of these new technologies. There are other problems too—the application of uniform (albeit profuse) targets across the country ignores regional and state-wise heterogeneity and in some cases can lead to sub-optimal solutions. Last but not the least, there is little or no rationale given for the targets; they are often inconsistent with one another, and many of these are developed with limited consultation.

- **Insufficient prior discussion of costs.** Another problem with the (numerous) targets in the Indian power sector is that before the targets are announced, there is almost no discussion of the costs that will be involved. Sometimes, there is discussion of costs *after* the targets are announced and when implementation begins. At this point efforts are made to reduce costs through mechanisms such as competitive bidding. It is ironic that while there is a lot of concern about retail tariffs for electricity and making electricity affordable, little attention seems to be paid *before* the announcement of a target, to the costs of generation which account for 70%–80% of the cost for electricity that is ultimately paid by consumers.

- **Insufficient attention to other development goals.** Choices in the energy sector have impacts on several other factors such as domestic manufacturing, import dependence, and employment. However, when targets are announced for the energy sector, there is often insufficient attention paid to these other impacts. Sometimes, these other development goals are discussed, but the efforts made to pursue them are anaemic.

- **Lack of an official policy document outlining the rationale for a target.** Interestingly, many targets are pronouncements but, often without an official policy document providing details of the target and outlining the rationale or deliberations behind its selection. This lack of a clearly stated rationale is cause for concern, particularly when it is known that the level of the target can have a significant effect on overall costs that will be paid by consumers, and the effort that will be required to reach it.

- **Almost no discussion of criteria to split national targets between states.** For some targets, it may be appropriate to have a uniform target for all states, while for other targets, other characteristics—such as the resource-endowment in a state, its income levels, or its existing resource-mix for electricity generation—may need to be considered when dividing a national target among states. However, there is almost no discussion on devising optimal, state-wise criteria, when it comes to splitting national targets between the states.

In order to illustrate some of these problems with the setting of targets, we now look in more detail at the process and at the targets, with regard to specific resources used to generate electricity.

3.1 Renewable Energy (RE)

The most well-known target is to have 175 GW of generating capacity from RE by 2022, with 100 GW coming from solar energy, 60 GW from wind energy, and the remaining 15 GW from other RE, including biomass and micro-hydro. The 100 GW of solar capacity is further divided into 60 GW from grid-connected installations and 40 GW from rooftop solar (RTS) installations. The target of 175 GW of RE has now been enhanced to 450 GW by 2030 (*India Today*, 2019).[6]

The NDC submitted by India for the Paris Agreement had two significant pledges related to energy use. The first was to ensure that non-fossil fuel-based resources in the electricity resource-mix formed at least 40% of the installed generation capacity by 2030. The second was to decrease the emission intensity of GDP by 33% to 35%, by 2030 relative to its level in 2005. India is well on its way to fulfilling both these pledges (Climate Action Tracker, 2021a; Koshy, 2020). This success, and particularly the rapid addition of RE to the generation mix, is to be celebrated. However, it will still be useful to examine how the targets were set and how the process can be improved. This will help India to continue to progress in reducing the intensity of its emissions in the most efficient and economic manner.

[6] In his speech, Prime Minister Modi said that the target was being extended to 450 GW, but did not specify the date by which this target would be met. However, most news reports on this issue say the target year is 2030 and most people in the energy sector make the same assumption.

Both the pledges in the NDC are at an aggregate-level, and being linked to GHG emissions they do partly fulfil the need to be linked to a socio-economic issue. While we are not suggesting any changes to the commitments in the NDC, with regard to developing and implementing domestic policies, it may be better to state these targets differently. Ideally, it would have been better to set reduced emission-intensity as the main target, subsuming the non-fossil fuel-based generation target. That would have ensured consistency between the two pledges. But that may not be possible at this stage. In any case, reducing emission intensity should be recognised as a "higher level" goal, compared to just the installation of non-fossil fuel generation capacity.

It is worth noting that even for non-fossil-fuel based generation, most of the attention has been on RE. This may be because the target to reduce the intensity of emissions may be more easily attainable, especially given a 2005 base, while the RE target is more ambitious. Furthermore, setting a target such as 450 GW of RE can be valuable as a signalling device. In any case, the government should regularly monitor the progress in reducing emission-intensity, as is done with the progress of the amount of RE capacity that has been added.

Even for the RE target alone, the articulation could be improved for the purposes of developing domestic policies. First, instead of a target in terms of generation capacity (MW or GW), it would be better to state the target in terms of share of energy (gigawatt-hours [GWh] or terawatt-hours [TWh]) because it is usage, not capacity, that determines emissions. This is important because for RE, given the limited time of the day or year when it can generate, the share of generation capacity can seem large, even though its share of energy generated could be considerably smaller. For example, as of May 2020, the share of RE of installed capacity was about 24% while its share of energy generated was only about 12% (Standing Committee on Energy, 2021). Further, it is important to note that from a societal perspective, focusing only on RE as a proxy for clean energy, can lead to neglect of energy efficiency, demand response, and other new generation technologies that could emerge in the future. All these can be important alternative approaches for providing clean and affordable electricity. Therefore, while RE is a very important source of clean energy, addition of RE capacity should not be the goal in itself, instead the goal should be to have clean and affordable electricity and overall sustainability.

Table 1 shows the RE targets in GW that have been set starting with the Jawaharlal Nehru National Solar Mission (JNNSM) in 2010, up to the most recent announcement by Prime Minister Modi in 2019. For the 2019 target there is no official breakdown given by RE source (solar, wind, etc.). However, in a memo, the Ministry of New and Renewable Energy (MNRE) states that the target for solar for 2030 is 280 GW and is based on work done by CEA on determining an optimal mix of resources for electricity in 2030 and given in their report on the subject (CEA, 2020). Based on that memo and comments by some authorities, we have taken the numbers for the other RE sources (wind, biomass, and small hydro) also from the report by CEA. The total for all RE sources, based on the CEA report, adds up to 435 GW—a little short of 450 GW as announced by the PM.

In addition to this small discrepancy in the total, there are other problems due to the lack of an official document giving the target for RE for 2030. The PM's speech refers to 450 GW of RE by 2030, but the pledge in India's NDC says by 2030, at least 40% of the total electricity generation capacity should be from non-fossil fuel-based sources (not RE alone). These differences can lead to confusion.

Table 1: RE Targets and Achievements (GW)

Type of RE by Source	Targets for 2022 From JNNSM Set in 2010	Targets for 2022 Revised in 2015-16 Budget Set in 2015	Targets for 2030 PM Speech Set in 2019*	Cumulative Achievements as of August 31, 2021
Solar	22	100	280	46
Grid Connected	20	60	NA	39
Roof-Top/Off-Grid	2	40	NA	7
Wind	NA	60	140	40
Biomass	NA	10	10	10
Small Hydro Power	NA	5	5	5
TOTAL RE	NA	175	450	100

**The PM's speech talked only about the total of 450 GW of RE. MNRE says that the target for solar of 280 GW is based on the optimal mix in 2030 given by CEA in its report. Therefore, we have taken the numbers for wind, biomass, and small hydro from the CEA report. Because of this mix of information sources, the total does not add up to 450 GW. It is possible that other RE sources may make up the difference (about 15 GW).*

Source: Ministry of Finance (MoF), 2015; CEA, 2020; and India Today, 2019; MNRE, 2010 & 2021b.

Given the huge role that the RE targets play in determining the course of the power sector, it would have been very helpful if the rationale and analysis had been provided as successive targets were enhanced. For example, when the target of 20 GW of solar energy by 2022 (set in 2010) was enhanced to 100 GW, there was no analysis given to support the change, nor much discussion on how the target was going to be met.

It was slightly different when the target of 450 GW of RE was announced, because as we discussed earlier, the higher target may have been based on the analysis carried out by CEA. However, there is no official policy document detailing the rationale for the target, the roadmap for achieving it, or a break-up of the target by RE source (solar, wind, biomass, etc.). The ratio of wind and solar generation capacity affects the costs for grid integration significantly, given the vastly different output profiles by time of day (ToD) and season. Tongia (2021) finds that adding wind can sometimes have greater system benefits than solar despite wind having a higher cost on a per kWh basis. It is fortunate that India is likely to meet the target for creating 40% electricity generation capacity from non-fossil fuels by 2030, as the Minister for Power stated recently. The high targets for RE have played a role in that expected success, but so has the reduction in RE prices globally, making RE an economically attractive option for electricity generation.

3.1.1 Rooftop Solar (RTS)

While the expected success in meeting overall RE targets by 2030 is to be celebrated, the experience with the target set for rooftop solar has been very different. As mentioned before, when the earlier target of 100 GW by 2022 was announced, it was said that 60 GW was to come from grid-connected solar and 40 GW from rooftop solar (RTS), but no rationale was provided for this split of the target. The 60:40 split is proving to be difficult to achieve. Even though both grid-connected solar and RTS are unlikely to meet their respective targets for 2022, RTS is far behind, as seen in Table 1. A little reflection would have revealed that RTS would likely face challenges on three fronts. First, given the density of Indian cities and smaller houses, the contribution of RTS on a per-household basis would be considerably lower than seen in richer countries. Second, because of lower income levels, most residential consumers would be more resistant to RTS which requires a high initial investment. Third, because of the large amount of cross-subsidy in electricity retail tariffs, commercial and industrial users, as well as cross-subsidizing customers, would disproportionately prefer RTS, affecting utility finances and average tariffs, further complicating the implementation of RTS. Letting market forces decide the split between grid-connected solar and RTS would have been a superior approach.

3.1.2 Renewable Purchase Obligations (RPOs)

The EAct (2003) mandates the State Electricity Regulatory Commissions (SERCs) to promote RE by specifying a percentage of the total electricity consumption that each distribution company is required to purchase from RE sources. Operationalising these mandates, the National Tariff Policy (NTP) of 2006 advised SERCs to set a minimum percentage of energy from RE sources to be purchased by distribution companies, leaving the level of the Renewable Portfolio Obligation (RPO) to the discretion of the SERC. This RPO was to be made applicable latest by April 1, 2006. Arguing that because RE power was more expensive than conventional generation, the procurement of RE was to be done at preferential tariffs also to be determined by the SERC. Subsequently, the National Action Plan on Climate Change (NAPCC), released in 2008, was more specific about the levels of the RPO, and suggested that the RPO be set at 5% for 2009–10 and be increased by 1% each year for ten years (GoI, 2008). The NAPCC also recommended that procurement of RE power should be done using competitive bidding.

The Jawaharlal Nehru National Solar Mission (JNNSM), a part of NAPCC, was launched in 2010 with a goal of reaching 20 GW of grid-connected solar by 2022 in three phases: 1–2 GW in Phase 1 (2010–13); 4–10 GW in Phase 2 (2013–17); and 20 GW in Phase 3 (2017–22). The JNNSM suggested that there be a separate RPO for solar energy, starting with 0.25% in Phase 1 and increasing to 3% by 2022—because at that time wind was less expensive than solar. While the JNNSM recommended a uniform RPO for all states, it recognised that the states differed in the potential for solar-based RE, and therefore, recommended a renewable energy certificate (REC) that could be traded between solar-rich states and solar-poor states. While the NAPCC document had recommended using competitive bidding for procurement of RE, the JNNSM endorsed the use of feed-in tariffs (FiTs) to remove price barriers from hampering adoption of solar-based RE. In January 2011, the NTP was amended to implement the recommendations of JNNSM, including the recommendation that distribution companies procure RE at preferential tariffs. In 2015, even before COP21 was held in Paris, the target for solar was increased, (100 GW by 2022), and the NTP was also modified in 2016 requiring that the solar RPO would be set so that, by 2022, it reached 8% of total consumption of electricity excluding hydropower. The revised NTP recommended that procurement of RE be done using competitive bidding to keep the tariff low. Table 2 shows the current RPO. (We discuss the hydropower RPO later in the section on hydropower.)

The RPO for 2019–20 required that the share of RE in each state should be 17.50%, consisting of 7.25% from solar, and 10.25% from non-solar sources. However, nationwide an RE share of only 10.77% was achieved in 2019-20 (Standing Committee Energy, 2021). The achievement on fulfilling the RPO varies greatly across states, with six states (Andhra Pradesh, Himachal Pradesh, Karnataka, Rajasthan, Sikkim, and Tamil Nadu) having exceeded the RPO. Karnataka stands out with RE contributing 2.5 times that required by the RPO. Seven states have achieved between 55%–100% of the RPO, while the rest have achieved less than 55%.

Table 2: Renewable Purchase Obligations of Distribution Companies

(All RPO quantities are given as a percentage of total electricity consumption, excluding contribution from large hydro projects)

<table>
<tr><th rowspan="2">Year</th><th rowspan="2">Solar (%)</th><th colspan="3">Non-Solar</th><th rowspan="2">Total RPO (%)</th></tr>
<tr><th>Hydro (%)</th><th>Other Non-Solar (%)</th><th>Total Non-Solar (%)</th></tr>
<tr><td>2019-20</td><td>7.25</td><td></td><td>10.25</td><td>10.25</td><td>17.50</td></tr>
<tr><td>2020-21</td><td>8.75</td><td></td><td>10.25</td><td>10.25</td><td>19.00</td></tr>
<tr><td>2021-22</td><td>10.50</td><td>0.18</td><td>10.50</td><td>10.68</td><td>21.18</td></tr>
<tr><td>2022-23</td><td rowspan="8">To Be Specified Later</td><td>0.35</td><td rowspan="8">To Be Specified Later</td><td rowspan="8">To Be Specified Later</td><td rowspan="8">To Be Specified Later</td></tr>
<tr><td>2023-24</td><td>0.66</td></tr>
<tr><td>2024-25</td><td>1.08</td></tr>
<tr><td>2025-26</td><td>1.48</td></tr>
<tr><td>2026-27</td><td>1.80</td></tr>
<tr><td>2027-28</td><td>2.15</td></tr>
<tr><td>2028-29</td><td>2.51</td></tr>
<tr><td>2029-30</td><td>2.82</td></tr>
</table>

Note: The hydro purchase obligation is for electricity from Large Hydro Projects (LHP) commissioned after March 8, 2019.

Source: (MoP, 2021a)

There are three positive features of the RPO scheme. First, the RPO has been set in terms of percentage of energy supplied and not generation capacity even though the national target for RE has been set in terms of generation capacity (450 GW by 2030). Second, even though the RPO recommended by MoP is uniform for all states,[7] the scheme recognizes that some states are RE-rich and provides, through RECs, a mechanism for RE-poor states to buy RE credits from the RE-rich states. Third, the RPO scheme has adapted to changed circumstances—changes in national targets, and the need to separate solar RPO from non-solar RPO when JNNSM was launched.

As Prayas Energy Group (2021) points out, when JNNSM was launched, solar prices were very high, so a separate obligation for solar was required. Now that solar is the least expensive generation resource, it may be better for solar and non-solar to be merged, so that distribution companies have the freedom to have the best resource-mix for their load. Therefore, several states have requested MoP for solar and non-solar RPOs to be merged (Prayas Energy Group, 2021). One shortcoming in the scheme that was removed in 2016, was the recommendation to have both an RPO and Feed-in Tariffs (FiTs)—RPOs represent a quantity requirement and FiTs are a price specification. Specifying both is unnecessary and could lead to higher prices (Prayas Energy Group, 2017). Since 2016, when the NTP was revised, procurement of RE is being done through competitive bidding, leading to lower prices.

Purchase obligations are usually imposed to support the development and adoption of nascent technologies. The prices of RE have been dropping recently and it is now competitive with conventional generation technologies such as coal-fired generation; plus, the need for RPOs for RE is also

[7] Currently the RPOs developed by MoP are not binding on the states, and as per EAct (2003), the SERCs retain the freedom to set their own RPOs. Therefore, even though the RPOs developed by the Ministry of Power (MoP) are uniform across the states, the actual RPOs established by the respective SERCs do vary from state to state. However, MoP is exploring avenues to make the RPOs developed by it mandatory; for example, through new rules still in the draft stage (MoP, 2021b)

disappearing. Moreover, RE-based power can now be bought and sold in electricity markets providing another avenue for developers of RE power to sell electricity from their plants. India Energy Exchange (IEX) has introduced market products for the sale and purchase of green power such as the Green Term Ahead Market (GTAM) and the Green Day-Ahead Market (GDAM) both of which are now operational. These green markets will provide opportunities to developers or owners of green power to sell their power and even be merchant plants. Rather than imposing RPOs, it is generally better to encourage distribution companies to use good resource-planning practices to develop long-term plans that minimise both long-term total system costs and the environmental impacts of electricity. Effective resource planning provides distribution companies the flexibility to select the mix of resources that are optimal for each of them.

3.1.3 Domestic Manufacturing of Equipment for Solar-Based RE Power Plants

When JNNSM was launched in 2010, most of the raw materials and components for solar PV plants were imported. The JNNSM envisioned transforming India into a leader of low-cost high-quality manufacturing of solar components and material. It included several initiatives to realise this vision, including:

- **Research and development.** As part of the strategy, JNNSM said that a Solar Research Council would be set up to oversee strategy. In addition, a National Centre of Excellence and a network of other Centres of Excellence were to be established that would implement the plans formulated by the Solar Research Council. There would be pilot projects to promote technology development and enable cost reduction. In addition, it indicated that an "ambitious human resource development programme" would be established including specialised courses in solar energy at premier academic institutions.

- **Financing and incentives.** Several "SEZ like incentives" were to be provided, including removal of import duty on capital equipment and raw material, Special Incentive Packages (SIPs), and low interest loans. There were also provisions for including technology transfer requirements into procurement contracts from foreign sources.

Unfortunately, in spite of all these provisions that were included in JNNSM, domestic manufacturing of solar equipment has not taken off. MNRE estimates that in order to meet the target of 450 GW of RE by 2030, of which 280 GW is expected to be from solar, solar capacity additions of 25 GW will be required every year until 2030 (MNRE, 2021a). Table 3 shows the current manufacturing capacity for solar PV components in India. It can be seen that the domestic manufacturing capacity is considerably lower than required to meet the expected demand, and under these circumstances, one would have expected that the domestic manufacturers would be working at full capacity. But Gulia and Garg (2021) report that the capacity utilisation is only 40%–45%. It is odd that a significant fraction of the domestic manufacturing capacity is idle. One reason for this anomaly is that domestically manufactured modules are more expensive than imports, and therefore, most solar project developers in India prefer to import solar modules, mostly from China. In 2018–19, India imported $2,160 million worth of solar cells and modules, 81% of which came from China (Standing Committee on Energy, 2021).

Table 3: Solar Manufacturing Capacity in India

Component	Annual Manufacturing Capacity (GW/year)
Polysilicon/Ingots/Wafers	No manufacturing in India
Solar PV Cells	3
Solar PV modules	10-15
Solar Inverters	5

Source: Standing Committee on Energy, 2021.

The Government gives the following reasons for the non-competitiveness of domestically manufactured solar equipment (Standing Committee on Energy, 2021):

- No manufacturing in the upstream part of the value chain (polysilicon ingots and wafers). Manufacturing in these stages is both capital- and energy-intensive.
- Economies of scale not realised due to lack of integrated manufacturing and modern technology.
- High cost of land, electricity, and capital, coupled with lack of a skilled workforce.

In response to a question about steps that have been taken by MNRE, the ministry said the following steps were taken to boost manufacturing of solar equipment in India (Standing Committee on Energy, 2021):

- Public procurement for solar cells and modules that fulfilled domestic content requirements (DCR).
- Tenders for procurement of solar power linked with setting-up solar manufacturing capacity.
- Plans to establish RE manufacturing hubs near ports.
- Imposition of basic customs duty (BCD) on imported solar PV cells and modules.
- Creation of RE Investment Promotion and Facilitation Board (REIPFB) to help prospective investors interested in manufacturing for the RE sector in India.
- Development of an Approved List of Solar PV Models and Manufacturers (ALMM) to ensure quality of products.

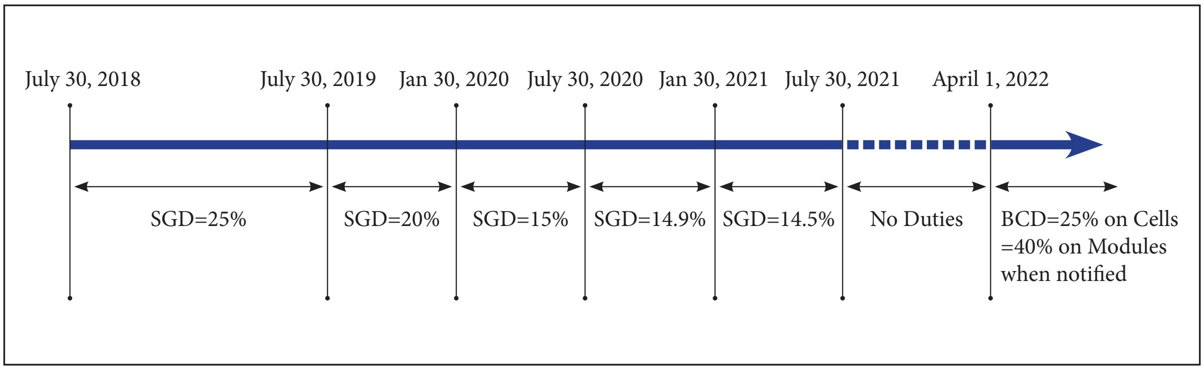
The Government has also launched a production-linked incentive (PLI) scheme for high efficiency solar PV modules and solicited bids. The response was "overwhelming", being subscribed four times over (JMK, 2021). Many of the steps for boosting manufacture of solar equipment, including the PLI scheme, have been taken recently and it is too early to assess their success. However, there is some information available on one of these steps, the imposition of duties. On July 30, 2018, the Government imposed a safeguard duty (SGD) on solar cells and modules from China and Malaysia for two years, reasoning that domestic manufacturers of solar cells and modules were not able to compete with imports on price (MoF, 2018). The duty was to be 25% for the first year, 20% for the following six months, and then 15% for another six months. At the end of the two-year period, the Government imposed the safeguard duty for another year, at 14.9% for the first six months and 14.5% for the following six months, (and added Vietnam to the source countries). Thus, some level of safeguard duty was applied for a total of three years, ending July 29, 2021.

On March 9, 2021, while the SGD was still in force, MNRE issued a memorandum on basic customs duty (BCD) on solar photovoltaic (PV) cells and modules/panels. It mentioned that India was heavily dependent on imports; that there were instances of "certain countries dumping solar cells and modules to kill the nascent domestic industry" requiring the imposition of SGDs; and that the Covid-19 pandemic had led to disruption of imports of solar cells and modules, which had affected additions of solar capacity in India (MNRE, 2021a).

Arguing that with "huge solar targets and that electricity is a strategic sector of the economy," India needed to develop its own manufacturing capacity and reduce dependence on imports and thus avoid future disruptions, MNRE made a proposal to impose basic customs duty (BCD) starting April 1, 2022 of 25% on solar cells and 40% on solar modules (MNRE, 2021a). While the MoF agreed to the proposal at that time, it has not yet been notified. If the notification is delayed beyond April 1, 2022, then the imposition of BCD may be further delayed. Figure 1 shows the timeline of the various types and levels of duties that have been applied to imported solar cells and modules.

It is important to note that the proposal to impose BCD was without the grandfathering of projects that had already been bid out (MNRE, 2021a). It seems that this eight-month duty-free gap was provided so that already bid-out projects could import the required modules, ruling out the need for grandfathering of projects. This eight-month window has made developers rejoice, because it will provide them time to import low-cost modules (*Business Standard*, 2021b). On the other hand, domestic manufacturers see this as a difficult time because there will be very few sales during this period.

Figure 1: Timeline of Duties on Solar Cells and Modules



Note: SGD = Safeguard Duty, and BCD = Basic Customs Duty.

Source: Inergystat, 2021; MoF, 2018; MNRE, 2021a.

Assessing the impacts of the duty regime started in 2018, it is reported that the SGD produced no increase in domestic manufacturing of solar cells and modules because it was thought to be inadequate to incentivise increased manufacture (Chandrasekharan, 2020; Saur Energy, 2021). Furthermore, this see-sawing of duties on imports that the sector saw over the last three years was seen to be very disruptive for a sector that relies heavily on imports, and it also increased the cost of solar power.

On the issue of imposition of basic customer duty, solar power-plant developers have a different view from manufacturers of solar cells and modules. Developers argue that the cost of modules will increase after BCD is imposed, raising prices of solar power for consumers. It will also slow progress toward the goal of 175 GW of RE by 2022. Developers also argue that downstream activities (project development, construction, and operation of solar power-plants) generate more than 80% of the employment from solar power, compared to less than 20% from manufacturing; and downstream activities generate 87% of the value addition, compared to 13% from manufacture of modules and inverters (Saran & Rustagi, 2018). Developers agree that domestic manufacturing should be encouraged; however, they say this should have been done by giving direct subsidies to domestic manufacturers to enhance their capacities (Saur Energy, 2021). On the other hand, domestic manufacturers contend that BCD is necessary to allow them to compete with imports.

3.1.3.1 Analysis and Summary on Domestic Manufacturing of Solar Equipment

From the launch of JNNSM in 2010, the government realised that domestic manufacture of solar equipment was important, and even included several provisions to facilitate it. However, not enough detailed attention was paid to India's strengths and weaknesses in this area. Therefore, the aim to be a major player in solar equipment manufacture, wasn't given enough support either and was, ultimately, not realised. Moreover, trade protection measures like SDG and BCD were applied in an ad-hoc manner.

In contrast to India's actions on promoting domestic manufacturing, China put its "whole governmental system behind manufacturing," (TERI, 2019), and as a result is today the world leader in manufacture of solar equipment having captured 70%–100% of the market for the various segments—polysilicon, wafers, solar cells, and solar modules (Saur Energy, 2021). But this is water under the bridge, and the government should now deliberate along with all relevant stakeholders and develop a well-thought-out strategy to develop competitive domestic manufacturing of solar equipment for the coming decades. Moreover, the experience with these thwarted efforts to promote domestic manufacturing of solar equipment should be a lesson, so that the country can do better with domestic manufacturing of other new technologies, such as batteries and hydrogen production.

3.2 Hydropower

According to the GoI, even though India has a large hydropower potential of about 145 GW, only about 45 GW of it has been realised and the rate of new additions of hydropower capacity has been slow. In order to remedy this situation, the GoI Cabinet approved the following measures on March 7, 2019 to promote hydropower (PIB, 2019b).

- Large Hydropower Projects (LHPs) (greater than 25 MW) were to be declared as RE projects. Earlier only Small Hydropower Projects (SHPs) (less than 25 MW) were treated as RE projects.
- Within the Non-Solar RPO, a new category called Hydro Purchase Obligation (HPO) would be added, and the HPO would represent an obligation to purchase power from new LHPs commissioned after these measures were notified.
- Tariff rationalisation by allowing some back-loading of tariff for hydropower.
- Budgetary support for flood moderation components and "enabling infrastructure" such as roads and bridges.

Explaining the need for these measures to promote hydropower, GoI said that because most of the hydropower potential existed in the "higher reaches" of the Himalayas and the north-east, hydropower would lead to greater overall socio-economic development and increase employment in those locations. Second, hydropower could provide very significant benefits in balancing the grid, particularly as the contribution from intermittent RE sources increased. The third reason given by GoI for promoting hydropower was that it also provided water security and helped in moderation of floods. It argued that distribution companies were reluctant to sign PPAs for hydropower because of the higher tariffs. Therefore, allowing tariff rationalisation, providing budgetary support for flood-moderation components, and enabling infrastructure would help reduce the tariff for hydropower—as the tariff is ultimately paid by the consumer.

In addition to these reasons explicitly given by GoI, there are other reasons that are said to be behind the decision to require HPOs. Factors inherent in the development and construction of hydro plants—such as unexpected geological features at the site and the need for clearances—create uncertainties in estimating costs, as well as in estimating time to complete projects. Given these uncertainties, hydro plant developers find it difficult to participate in competitive bidding and to sign PPAs with states or distribution companies (Bhaskar, 2013). But without a PPA, developers are often unable to get financing. The result is limited private-sector participation in hydro-plant development. Another reason given for

HPOs to promote hydropower development is that, because wholesale electricity markets in India are not fully developed, the non-energy benefits of hydropower—fast ramping, reactive power and voltage support—are not valued. By focusing only on the cost of electricity from hydro plants in Rupees per kWh, they are effectively undervalued.

A day after the approval of the measures to promote hydropower by the Cabinet, on March 8, 2019 MoP issued a memorandum reiterating the measures, and on January 29, 2021 issued an order modifying the trajectory for RPOs, by adding HPOs to be fulfilled by distribution companies (MoP, 2021a). The HPO trajectory in the order has been designed to add 30 GW of new hydro capacity by 2029–30.

In addition to the reasons given in Section 3.1.2 to forgo purchase obligations of any kind, there are other reasons why setting HPOs would not be appropriate. First, because hydropower is a mature technology, no support is required to promote its use, to accelerate movement along the learning curve for the technology. Second, the amount of hydro that would be needed will depend on several factors, different for each distribution company; the cost of hydro relative to other available technologies; requirement for rapid ramping and flexibility; load pattern; and the resource mix.

Setting a uniform HPO as a percentage of total electrical energy required by a distribution company would lead to non-optimal resource selection and higher costs. In addition, there is far greater uncertainty in the time and cost of constructing a hydroelectric plant compared to other types of generating units. For example, the Subansiri Lower hydroelectric project of 2,000 MW, located on the border of Assam and Arunachal Pradesh, was originally supposed to be operational around 2009–11, but is now expected to be operational in 2023–24, a delay of 13 years at a cost more than three times the original estimate (CEA, 2021a). Therefore, depending on the type of contract, there could be much greater risk of cost-escalation for a distribution company, when contracting for power from a hydro plant that is under construction.

An even more important reason to be cautious, not just about HPOs, but even further hydropower development itself, is the growing recognition of the environmental impacts of hydropower and its potential to greatly increase the destruction due to natural disasters (Prayas Energy Group, 2021). Shrestha et al. (2021) mention the environmental impacts of hydropower on water flows and quality, and "the health of aquatic and terrestrial ecosystems." Construction of large hydropower projects with storage reservoirs also leads to displacement of people. In addition, the interplay of hydropower projects and natural hazards in the fragile ecosystem of the Hindu Kush-Himalaya region can greatly magnify the impacts of events (Shrestha et al., 2021). The flash flood triggered by a rockslide in Chamoli in early 2021 is one example of the destruction of life and property that can occur. The flood swept away the under-construction Tapovan Vishnugad Hydropower Project and damaged the Rishi Ganga Hydropower Project; 70 persons lost their lives and another 134 persons have been reported missing (Shrestha et al. 2021).

There are well-recognised uncertainties in the construction of hydropower plants which create difficulties for private developers in securing financing. But it would be unfair to pass on the risk of hydropower development to distribution companies through mandatory HPOs. In case the central government has compelling reasons for encouraging further hydropower development (in spite of the hazards identified earlier), then it would be more appropriate for the central government to bear the risk, at least financially. It could sign a PPA with a private hydropower developer as an intermediary, as is done by Solar Energy Corporation of India (SECI) Ltd in the case of solar RE projects. On the non-energy benefits of hydropower not being recognised, we note that CERC is working on markets for ancillary services. Once those markets are in place, hydropower plant owners would be rewarded for the non-energy benefits of their plants. This is a better approach than imposing mandatory HPOs, which would be difficult to undo once the markets for ancillary services are operational.

Another unusual characteristic about the HPO is that it does not refer to the total amount of hydro energy in the resource mix, instead it refers to the amount of hydro energy from new hydropower plants (those commissioned after March 2019), and ignores the amount of hydropower the distribution company may already have in its mix. This is unlike the RPO—which is the total RE energy (solar and non-solar)—irrespective of its vintage. Therefore, the HPO seems to be a mechanism designed to ensure distribution companies' uptake electricity from the new hydropower plants. But, as discussed earlier, it would not be appropriate for the Centre to coerce distribution companies to buy this power. Distribution companies should have the freedom to procure appropriate resources to meet the needs of their customers.

3.3 Natural Gas

When announcing the target for the contribution of natural gas to the country's energy basket, the Minister for Petroleum and Natural Gas said that the use of natural gas should be increased from the then share of 6.5%, because gas is a clean fuel and various feedstocks can be converted to natural gas (PTI, 2016). Noting that the world average share of natural gas was 23.5%, he said India would plan for a 15% share by 2030 (*Business Standard*, 2021a).

Natural gas is a relatively clean fossil fuel and plays an important role in several industries other than the power sector, including as a feedstock. In the power sector, gas plants not only have lower GHG emissions per kWh, compared with coal plants, but also can provide greater flexibility in responding to changes in load—a characteristic that will become increasingly important as more RE is added to the generation mix. However, the generation cost of gas plants is much higher than for coal plants in the Indian context, given high costs of natural gas (which is often imported). The use of natural gas in a country's mix depends on the availability of inexpensive natural gas within the country. Thus, gas contributes a large fraction of the electricity generated in the US and UK, because these countries have large and accessible reserves of natural gas. The global average cannot guide India's targets. Instead, India's use of natural gas should be based on the optimal resource mix that minimises costs and environmental impacts.

Natural gas is often promoted as a transition fuel to substitute for coal, until we move to an all-electric world. However, before building additional infrastructure such as pipelines to facilitate the use of gas, it is important to determine for how long, and in what quantities, natural gas is likely to serve as a transition fuel. The duration of such a transition period would depend on the level and pace of development of alternatives to natural gas. For example, in the electricity sector, battery storage and pumped hydro plants could serve as alternatives to gas for providing flexibility in generation. Electric vehicles can displace gas (and, of course, liquid fuels) in transportation. If alternatives to natural gas are expected to be commercially viable in a short period, then any infrastructure—such as gas pipelines to facilitate use of gas—could become stranded assets and a financial liability for the owners. Therefore, comprehensive analysis based on development of alternative scenarios should precede any setting of targets or construction of new infrastructure for natural gas or any other resource. While the use of gas in power generation is likely to be limited, its use in other industries is likely to be considerably more. Even for those other industries or sectors, gas policy should be based on "collaborative and integrated decision making" (Mehta, 2021).

3.4 Coal and Coal Plants

For coal, there was a goal of producing 1 billion tonnes per annum (Btpa) by 2020, at one point from just public sector mining companies, but that has now been extended to 2023–24 (PIB, 2019a). The government should not need to set production targets for Coal India Ltd. How much coal to produce should be a business decision of the coal companies, based on the demand of their customers, predominantly electricity generators. Therefore, instead of the government, Coal India Ltd should set its production targets based on its estimation of the needs of the electric power industry, the steel industry and the other industries that it serves. In its estimates of these needs for coal, Coal India Ltd must pay attention to changes happening in these other industries—such as the power industry—and modify its estimates accordingly. The government will, of course, need projections of total coal production to inform its plans for railways and electricity transmission. The coal companies (Coal India Ltd and its subsidiaries, and Singareni Collieries Company Ltd) could set their own targets and provide them to the government for this purpose.

With increasing attention to environmental impacts, the role of coal-based power plants is being re-examined. Rapid addition of new coal-based generation capacity over the period 2011–16 has led to excess generation capacity. Currently, there is more than enough firm generation capacity to meet the peak demand. In addition, there is 56,650 MW of coal-based capacity in the pipeline, of which 32,285 MW is expected to be commissioned in the next few years, and 24,365 MW where construction has been put on hold (CEA, 2021b). Suggestions are being made that older, and often more inefficient, coal plants should be retired. There are two other issues regarding coal plants that are drawing attention—the need for environmental control systems (ECS) to reduce their emissions of oxides of sulphur and nitrogen (SOx and NOx); and the need to make coal plants more flexible in their operation to support intermittent and variable RE. But two of these issues—retirement, installation of ECS—are being addressed through simple, uniform rules. There are recommendations that all coal plants older than 25 years should be retired, and that the requirement of ECS should be based on vintage and size of the plant.

However, as Singh and Tongia (2020) show, rather than these simple, uniform rules it may be better to use a strategic approach. First, given that the need for coal capacity is expected to decline, new coal plants should be added only after careful analysis and only where absolutely needed. Because coal plants usually have an operational life of 40 years or even longer, even though life for accounting purposes is often taken to be 25 years, new capacity could end up being stranded before the end of its useful life. Second, Singh and Tongia (2020) show that the three issues—retirement, installation of ECS, and flexibilisation—are interlinked, and that a long-term system-wide analysis to address these issues is likely to be less expensive and could lead to significantly better environmental outcomes. Older coal plants may be less efficient than newer ones, but they may have some advantages for distribution companies to have them in their resource portfolio. Because of their low fixed costs, they can operate at lower PLFs without major economic impact. In addition, older subcritical coal plants are more suited for flexible operation than new supercritical plants. On the issue of installing ECS, Singh and Tongia (2020) show that instead of a uniform requirement of ECS, a phased approach may yield better outcomes—if higher priority is given to areas with high load factors, high pollution levels, and larger population exposure to pollution.

4. Long-Term Planning in the Indian Electricity Sector[8]

With India's emphasis on planned economic development until recently, the electricity sector also followed a five-year plan-based development trajectory. The Electricity Supply Act of 1948 established the CEA and assigned it the responsibility of planning the electrical development in the country. In a period of about two decades following Independence, aided by CEA's planning, the State Electricity Boards (SEBs) performed well, adding new generating plants, expanding the grid to rural areas, while earning a return on their investment. (Singh & Swain, 2018)

Around 1970, the scenario changed. Initially, subsidised electricity was seen as necessary for the green revolution. Later, electrification became a tool for electoral gains, and rural elites started demanding subsidised power both in their homes and on the farms. Non-paying and low-paying load of the SEBs grew, resulting in under-recoveries of revenue, making it difficult for the SEBs to invest in new generation-capacity. The quality of service deteriorated with frequent power outages, which reduced the

[8] This section draws significantly from, and builds upon, the author's earlier joint work: Singh, D., & Swain, A. (2018, July). Fixated on Megawatts: Urgent Need to Improve Power Procurement and Resource Planning by Distribution Companies in India. Centre for Energy, Environment & Resources, New Delhi.

revenues of the SEBs even further, resulting in a vicious cycle of poor service quality and poor financial health of the SEBs. (Singh & Swain, 2018)

This downward slide of the SEBs was aided, if not caused, by political interference in the planning and management of the sector. Political interference, in turn, was facilitated by an amendment to the Electricity Supply Act in 1956 that required SEBs to take "directions on questions of policy" from their respective State governments. In case a SEB refused or failed to follow the directives, the State government could replace the chairman and members of the SEB. This amendment reduced the SEB's autonomy, and allowed electoral considerations to influence setting of tariffs, grid expansion, plant location, and appointments. (Swain, 2006)

With the SEBs unable to make the required investment in new capacity due their fragile financial health, the government tried to increase generation capacity through the involvement of the private sector, consistent with the broader economic reforms in 1991. However, that was not very successful because of the limited capacity of the SEBs to pay for the power.

With the passage of the EAct in 2003, generation was delicensed, SEBs were unbundled, and SERCs established. Electricity supply was again an electoral issue in many states, but now it was because of the sector's poor performance, shortages, and frequent outages. Consequently, there was a rapid increase in generation capacity over the period 2011–16, resulting in excess capacity in many states.

It is understandable that given the history of power shortages in the country, the focus has been on the supply side, and there has been a scramble to add generating capacity of almost any kind. Unfortunately, this expansion of capacity has been accompanied by a decline of good planning and a neglect of uncertainty and risk-management. The "mindless pursuit of megawatts" by states with little appreciation of effective resource planning has led to excess generation capacity in the states. (Singh & Swain, 2018)

The EAct (2003) assigns the responsibility for short-term and "perspective" (long-term) planning to the CEA, which is also supposed to "coordinate the activities of the planning agencies for the optimal utilisation of resources" to serve the interests of the national economy, and to provide reliable and affordable electricity for all consumers (Section 73(a) of EAct 2003).

With unbundling of SEBs required by the EAct, distribution companies became responsible for procuring power, and therefore, the responsibility of planning their power procurement also shifted to them. There is good reason for distribution companies to plan their own power procurement. First, distribution companies are responsible for procuring power to serve their customers and ensure adequacy of supply. Second, as they file petitions for revision of tariffs to their respective SERCs, they are also responsible for procuring power at the lowest cost. Third, they are the ones that know the characteristics of their loads best—the consumer mix and load profiles.

Thus, we see that currently in India, there is planning at both the centralised level by CEA and at the local /decentralised level by distribution companies. In the following two sections (4.1 and 4.2), we look at how this is carried out. After reviewing international experience later in the paper, in the section on conclusions and recommendations, we discuss how best to coordinate and synergise these two levels of planning. Section 4.3 looks at a relatively new topic in planning, but one that will increase in importance in the future—planning for resilience of the physical infrastructure of the power system.

4.1 Centralised Planning by CEA

The EAct mandates the CEA to prepare, once every five years, a National Electricity Plan (NEP) that is in accordance with the National Electricity Policy.[9] It should be noted that before notifying the NEP, the CEA must obtain the approval of the central government, and must revise the plan incorporating any directions given by the government when approving the plan (Section 3(4) of EAct). This provision illustrates that the final NEP is the result of coordination between the CEA and the central government. It also highlights the importance of rigorous analysis by the CEA so that it can convincingly explain the pros and cons of changes that the central government may want to make in the NEP.

The National Electricity Policy[10] elaborates on what the responsibilities for planning entail for CEA (MoP, 2005). It says that the NEP "can be used by prospective generating companies, transmission utilities and transmission/distribution licensees as reference document." It requires that the NEP have a five-year duration, but also provide a perspective for the next 15 years. The components of NEP should include:

- Short- and long-term demand forecast by region.
- Suggested locations for additions of generation and transmission based on economic, technical, environmental, and social considerations.
- Technologies available for efficient generation, transmission, and distribution.
- Choice of fuels based on economic, technical and environmental considerations.

In order to fulfil the mandates in the EAct and the National Electricity Policy regarding planning, CEA produces two major documents. The first is the Electric Power Survey (EPS)—which gives a long-term forecast of demand for electricity for each state, and for the country as a whole. The second is the NEP. The most recent NEP had two parts: one for generation (NEP-Gen) released in January 2018; and the second for transmission (NEP-Trans) released in January 2019.[11] The two parts were developed sequentially. Once NEP-Gen had been finalised, NEP-Trans was developed and made public. We look at the development of EPS, NEP-Gen, and NEP-Trans in the following three sub-sections.

4.1.1 Electric Power Survey

Every five years, CEA puts out the EPS which contains a year-by-year demand forecast for the following ten years and a forecast for the 15th and 20th year from the release of the EPS (Singh & Swain, 2018).

For its forecast, the EPS uses a Partial End-Use Method—a combination of end-use based analysis and trend analysis. The composite forecast for a state is based on a forecast for each of the consumer categories in the state. This category-wise forecast, in turn, is carried out by estimating the specific consumption (consumption per consumer) multiplied by the number of consumers (Singh & Swain, 2018). The specific consumption for each consumer category is based on information from the distribution companies in the respective state. Then the specific consumption for the starting year is used to estimate the specific consumption for the following years using trend analysis, taking into account the impact of various schemes that are likely to have an impact on consumption—such as loss reduction efforts, energy efficiency programmes, and distributed energy resources such as solar roof-top (Singh &

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9 The National Electricity Policy was notified on February 12, 2005. In February2021, MoP announced plans to set up a committee to draft a new National Electricity Policy.

10 Both the National Electricity Policy and the National Electricity Plan can be abbreviated as NEP. In order to avoid confusion, we use the abbreviation NEP to refer to the National Electricity Plan only. Wherever the National Electricity Policy is referred to, we use its full form.

11 NEP-Gen and NEP-Trans is our nomenclature. CEA refers to NEP-Gen as Part I of the NEP, and NEP-Trans as Part II of the NEP.

Swain, 2018). As can be seen from this description, because much of the information comes from the states, the forecasting method relies on consultations between the CEA and the distribution companies in the states.

The EPS forecasts are important because they form the basis of many decisions in the electricity sector. Many distribution companies, often encouraged by the respective SERCs, use them to plan their power procurement (Singh & Swain, 2018). Given the importance of the EPS for the power sector, it is worthwhile to see how its projections over the years have compared with the actual growth in demand. Prayas Energy Group (2017) reports that there has been consistent overestimation of demand often by 30% to 40%. This very high level of consistent overestimation has had serious implications for the sector, particularly for distribution companies which have ended up with large amounts of excess capacity in their resource portfolio. The CEA has recognized this systematic overestimation, and is trying to remedy the situation in the development of future forecasts (Singh & Swain, 2018).

4.1.2 National Electricity Plan–Generation (NEP-Gen)

A draft of the most recent NEP-Gen was issued in December 2016, and the Final NEP-Gen was issued in January 2018. NEP-Gen was developed using a capacity-expansion model called Electric Generation Expansion Analysis System (EGEAS).[12] For using the model, the user inputs the following data:

- Hourly load for each year.
- Information about existing resources such as capacity, heat rate (an indicator of efficiency), fuel prices, etc.
- Information about new resources that are available, including capital costs, heat rate, fuel prices, etc.

The model simulates the operation of the power system over the planning horizon. It adds new resources when necessary to meet the load. New resources/technologies are selected to minimise the total system cost over the planning horizon.

The Draft NEP found that no new coal capacity would be required until 2021–22. It estimated that about 44 GW would be required during 2022–27 but that would be fulfilled by the approximately 50 GW of coal capacity that was under construction. Therefore, the Draft NEP concluded that in the base case, no additional coal capacity would be required beyond what was already in the pipeline. The conclusions in the Final NEP regarding new coal capacity were quite different. The Final NEP considered retirement of 22,716 MW over 2017–22, and 25, 572 MW over 2022–27. With these assumptions, the final NEP found that new coal capacity would be required (6,445 MW over 2017–22, and 46,420 MW over 2022–27) beyond what was already in the pipeline.

The reason given for the retirements was that these plants were over 25 years in age, and had therefore outlived their usefulness. As pointed out by Singh & Tongia (2020), and in Section 3.4 of this paper on coal and coal plants, while the life for a coal plant for accounting purposes is usually 25 years, the actual useful life of a coal plant is about 40 years. Furthermore, strategic decision-making on retirement of coal plants is better than blanket rules that specify one age threshold beyond which all plants should be retired.

Consideration of uncertainty by CEA was inadequate in both the Draft and Final NEP. Only a narrow range of futures were considered and "[t]here was no consideration of wide-ranging scenarios" (Singh & Swain, 2018). The Draft NEP included sensitivity cases to examine the impact of changes in load, RE capacity, or hydro availability. The Final NEP paid even less attention to uncertainty with only a single

[12] In place of EGEAS, CEA now uses a newer model ORDENA for its studies.

alternate scenario where load growth was increased from 6.18% to 7.18%. As an example of important uncertainties that should have been considered but were not, Singh and Swain (2018) noted there was no consideration of the impact of changes if RE with storage became less expensive than electricity from coal. Under such circumstances, there would be considerable incentive for load, particularly from the commercial and industrial categories, to migrate away from the distribution company.

4.1.3 National Electricity Plan–Transmission (NEP-Trans)

Transmission planning generally, and the development of NEP-Trans more specifically, is necessary to meet three requirements (CEA, 2019):

- Transmission augmentation, to evacuate power from new-generation capacity additions;
- Transmission augmentation, to service increases in demand for electricity by customers;
- Transmission system strengthening, to maintain reliability after changes due to the above two causes.

While the transmission system in the entire country operates as one single national grid, it consists of five regions: Northern, Western, Southern, Eastern, and North-Eastern. In addition, there are interconnections with Bangladesh and Nepal over which import and export of power takes place.

The CEA's transmission planning optimises investments in the transmission system, by taking into account load growth and additions to generation capacity. Its planning is aided by numerous system studies and analyses to understand demand growth in different regions, diversity in daily and seasonal load-patterns among regions, and the resulting load-flows over the transmission system. (CEA, 2019)

Optimal development of the transmission system requires coordination of the planning of the Inter-State Transmission System (ISTS) and the intra-state transmission network (CEA, 2019). The ISTS should be able to deliver the power required by the state and maintain reliability. Similarly, the intra-state transmission network should be able to transmit power from the ISTS and the in-state generating plants, to the load centres in the state. This coordination is achieved through Regional Standing Committees on Transmission which have representatives of CEA, Central Transmission Utility (CTU), State Transmission Utilities (STUs) of the states in the region, Regional Power Committees of the respective region, and representatives of Central Public Sector Generating Companies in the respective region (CEA, 2019). Power System Operation Corporation (POSOCO), and other stakeholders, provide operational feedback to the Regional Standing Committees.

While the process for transmission planning in developing NEP-Trans is very thorough, there is one significant shortcoming. Uncertainty and managing risk are not taken into account. NEP-Gen did consider uncertainty (however inadequately), but it seems that it was felt that transmission could be planned in a deterministic way for generation additions and demand growth in the base case of NEP-Gen. We recognise that including uncertainty is more difficult for transmission, as transmission assets last longer; in addition, augmentation of transmission involves far more steps–such as land acquisition for right-of-way in all areas, and states likely to be covered in the path of the transmission line. Therefore, it may not be easy to change a decision regarding a new line, and therefore, the authors of NEP-Trans may have felt there should be no ambiguity in the addition of a transmission line, and the possibility of changing decisions regarding transmission lines should not be entertained.

In spite of the difficulties in including uncertainties in transmission planning, there can be significant benefits to integrating generation and transmission planning, and developing a combined robust plan to incorporate uncertainties in the analyses and minimise risk. Another reason to carry out integrated planning (generation and transmission together) is that augmenting transmission can sometimes be an alternative to adding generation-capacity. In the last section of this paper on conclusions and recommendations, we suggest a way in which such integrated planning can be achieved.

4.2 Resource Planning by Distribution Companies

After discussing CEA's centralised planning in the previous section, we now look at more local or decentralised planning by distribution companies. As discussed earlier, planning by distribution companies is important because they are ultimately responsible for minimising costs for their customers, plus they understand their load the best—the consumer mix and the load profile.

As discussed in the introduction to Section 4, until the early 2000s shortages of power and generation capacity were a major concern for most utilities. However, after the passage of the EAct in 2003, there was a surge in the construction of power plants and many distribution companies ended up with excess capacity in their resource portfolios. The build-up of excess capacity indicates serious shortcomings in the power procurement practices of distribution companies. The challenge of effective power procurement is only going to get bigger in the future. Greater amounts of RE in the resource mix will require that distribution companies address the impact of RE on the grid, and the purchase or provision of higher amounts of ancillary services. In addition, all the sources of uncertainty identified in Section 2 of this paper will greatly magnify the challenges for effective power procurement.

In this section, we review the status of long-term planning of power procurement by distribution companies. But before that, we introduce the concept of resource planning, which encompasses power procurement, but is broader in its scope.

Resource planning is the process used by a distribution company to meet the electricity requirements of its customers. Resource plans have a long-term horizon, usually 10–20 years. The result of a resource planning exercise is an action plan that contains a list of all the actions that the respective distribution company should undertake, such as capacity additions, retirements (if any) of capacity, power purchases, and initiation of energy-efficiency programmes (Singh & Swain, 2018). While resource planning includes power procurement, it is a broader exercise because it minimises long-term system costs while also minimising risk and meeting environmental and policy goals. Singh & Swain (2018) carried out a detailed study to understand the resource-planning practices of distribution companies in three states, in order to develop recommendations for improving resource planning by distribution companies throughout India. We draw on their conclusions in this section.

They found that "resource planning is not part of the lexicon of the [Indian] power sector", and that it was poorly understood by distribution companies and regulators. They found that, at best, distribution companies focused on having sufficient capacity to meet peak demand, without much consideration of long-term system costs and risk management. Decisions about capacity additions or power procurement were bundled with tariff filings that had time horizons of one to three years. Furthermore, capacity additions are scrutinized on a case-by-case basis (one addition at a time), rather than in a holistic manner with an analysis of long-term system costs.

Furthermore, they found considerable interference by state governments in planning and procurement of power. They also found that in the case of some of the public-sector distribution companies, responsibilities for resource-planning type activities were spread across different divisions resulting in "diffused responsibility and diluted accountability."

One of the most neglected aspects of long-term planning is the recognition of uncertainty and the management of the associated risk. Section 2 of this paper explained that the future will see a much higher level of uncertainty and that effective long-term planning will require a shift from deterministic methods to stochastic methods.

Software tools for modelling and analysis are available to develop alternate plausible scenarios, and carry out sensitivity and probabilistic analysis. These techniques are being used by the more forward-looking utilities in the advanced countries. A newer and lesser-known technique, is the use of options analysis or optionality. In a nutshell, options analysis does not treat decisions such as capacity additions, as a one-time event. Instead, it breaks decisions into stages and recommends moving to a successive stage when better information is available, that is, when the uncertainty is greatly reduced.

Each of the four broad techniques (scenario analysis, sensitivity analysis, probabilistic analysis, and options analysis) discussed above, its own advantages and disadvantages, but best practice does not require selecting one technique over the others. Singh & Swain (2018) show how these techniques can be woven into a logical progression, based on the work of Borison (2014), so that the advantages of all four techniques is harnessed to allow the creation of far more robust plans. The suggested sequence is outlined here:

- Scenario analysis to generate plausible alternate plausible futures, and identify uncertainties.
- Sensitivity analysis to identify the most important drivers of change in costs or environmental impacts; these then become the variables to focus on in the subsequent steps.
- Probabilistic analysis to identify alternatives that perform better, balancing value and risk.
- Option analysis to determine the best adaptive management plan for the preferred alternative plan.

Clearly, effective resource planning will be crucial for creating a power system that is cost-effective and produces the minimal environmental impacts. Singh & Swain (2018) recommend the following steps to promote resource planning:

- Increase awareness about the importance and value of resource planning.
- Mandate regulators to require resource planning by distribution companies.
- Develop a regulatory framework for resource planning.
- Train the staff of distribution companies and regulatory commissions on the practices of resource planning.

4.3 Making the Power Sector Resilient to Extreme Weather

Until recently, long-term planning in the power sector was mostly about the optimal resource-mix and augmenting transmission—issues we have discussed so far in this section. Earlier efforts at planning usually involved very little discussion on physical infrastructure, on the assumption that designing infrastructure was a routine engineering task for which there were well-established rules and procedures. But given the changes we are already seeing in the climate, and even more drastic changes expected in the future, issues related to the physical infrastructure can no longer be ignored in planning.

As mentioned earlier, all parts of the world are experiencing more severe and a greater number of extreme weather events. What was earlier unthinkable in terms of weather has become the new normal. Furthermore, we can longer think of such extreme weather events as "unforeseeable" or "unexpected." Like most other infrastructure the power sector is vulnerable to damage from these weather events, and the planning process must include measures to make the power sector infrastructure resilient in the face of these extreme weather events.

Examples of the impact of extreme weather events on the power sector infrastructure, abound. For example, in September 2021, East Midnapore district in West Bengal was battered by almost continuous rain for ten days (Phadikar, 2021). In two blocks of the district, most of the substations were submerged and those that were not submerged were turned off for safety. There were also some fatalities due to electrocution. Over one lakh people were without power for several days, leading to a blockade by protesting block residents.

This vulnerability of the power sector to weather extremes is not limited to India, but is seen across the world. In the US, most of the state of Louisiana, including New Orleans, was without power for days due to damage by Hurricane Ida (Eavis & Penn, 2021). The reason for the prolonged outage was that poles and towers of Entergy, the biggest utility in the state, had not been built to withstand a major hurricane. In California, electric utilities had to shut off power to "tens of thousands of customers" to prevent the electrical equipment "setting off wildfires and to reduce energy demand during heat waves" (Eavis & Penn, 2018). The freeze in February, 2021 in Texas caused a grid failure leading to loss of electricity and heat for days for millions of people (Eavis & Penn, 2018).

Given the extent of damage to the power system from weather events that we are already seeing in India and the rest of the world, in the following subsections we look at how long-term planning can incorporate measures to enhance resilience of the system to extreme weather events.

4.3.1 Approaches to Resilience of Physical Infrastructure to Extreme Weather

There are a few approaches that can be taken to make physical infrastructure in the power sector less vulnerable to extreme weather events.

4.3.1.1 Resilient Equipment

The most obvious way to reduce vulnerability of physical infrastructure is to use equipment that is more resilient. For example, in order to protect against storms (cyclones, hurricanes etc.)—as in the case of Louisiana—the utility could put up electric poles and towers that could handle higher wind speeds. Another possibility would be to replace overhead transmission and distribution lines by underground lines. The cost would be much higher, and could also be more difficult to access the lines following an outage. For an area that risks getting flooded, substations could be built on a raised platform.

One of the shortcomings of this approach to resilience is that it will increase costs. Furthermore, a decision will have to be made about the level of additional resilience to be added. For example, in the case of Louisiana, what wind speeds should the new poles and towers be able to withstand? Suppose the poles and towers are upgraded to withstand 150 mph winds (the wind speeds that Hurricane Ida brought), but the next storm brings wind speeds of 170 mph? Of course, the utility could overbuild and ensure the structures can withstand higher wind speeds, but that would further add to the cost. Therefore, it is important to know what level of weather events a particular area could experience in the future.

4.3.1.2 Redundancy of Equipment and Systems

Traditionally utilities have used redundancy of equipment, systems, and pathways to plan for contingencies such as the breakdown of equipment. For example, in densely populated areas of cities or for critical loads, utilities are likely to use a meshed network for distribution, rather than a radial network. A meshed network provides multiple paths for electricity supply to customers, so, if one path experiences a failure or breakdown, electricity can still be provided to customers through an alternate path. This is not possible with a radial distribution network that has only a single path for delivery of electricity.

As Blumsack (2021) points out, such redundancy will not be of much use in many extreme weather events, and utilities need to rethink their approach to resilience. In the case of storms or floods, entire areas are affected, and therefore, the spare equipment will also be under water during a flood or vulnerable to damage in a storm with high wind speeds. However, redundancy could help in cases of extreme high temperatures, cases of which we are likely to see in India.

4.3.1.3 Need to Shift Focus from Resilience of Equipment to Resilience of Services

Blumsack (2021) recommends that utilities, while planning for disasters, should shift the focus from ensuring resilience of equipment to resilience of services for customers. He suggests that instead of focusing only on restoring power supply as quickly as possible, utilities also focus on providing lifeline systems using solar panels, batteries, and generators.

4.3.2 Recommendations for Ensuring Resilience

Given that measures to enhance resilience of power supply are likely to significantly increase the cost of electricity, it is important to optimise additional investment for resilience in a targeted manner. For each transmission or distribution company, it will be necessary to: (1) understand the kind of risk (extreme temperature, or flooding, or storms) and its severity that is likely to be faced in the future; and (2) the areas that are likely to be vulnerable, with as much precision as is possible. For high-temperature events redundancy may help; for floods, raising the height of power equipment (substations, etc.) may help; and for storms with high wind speeds, either more resilient towers and poles, or laying distribution lines underground may help.

5. International Examples of Goal-Setting and Long-Term Planning in the Energy Sector

We now look at two international examples of goal-setting and long-term planning in the energy sector, from the UK and Australia. We are not suggesting that India emulate these countries, because the circumstances in India are clearly very different. However, these examples illustrate the advantages of a holistic approach to goal-setting and planning. They also highlight the various issues that must be considered in the legislative and regulatory frameworks, to increase the likelihood of success in meeting goals related to the energy transition. Therefore, the international experience discussed here may provide lessons for India as it navigates its own energy transition.

5.1 United Kingdom

5.1.1 The Climate Change Act

In 2008, the UK passed the Climate Change Act that required that the net economy-wide GHG emissions of the country by 2050 be 80% lower than the levels in 1990. In 2019 the Act was amended to set the 2050 target at 100% lower than the 1990 levels, so as to be consistent with the UK's pledge to have net-zero emissions by 2050 in the Paris Agreement (UK-PGA, 2008). In addition to setting an ambitious long-term target, the Act is comprehensive and also pays attention to implementation processes that greatly increase the likelihood of success in addressing climate-change issues. Therefore, it is often seen as a model for other countries as they set up a framework to address climate change and manage the energy transition.

We recognise that the Climate Change Act applies to the UK's entire economy and not just to its electricity sector, yet, we think the UK experience holds important lessons for goal-setting and long-term planning in the electricity sector for two reasons. First, their process for goal-setting was to divide the long-term goal into a sequence of shorter-term goals and planning periods. This, coupled with their institutional framework, and monitoring mechanism, all have lessons for the Indian electricity sector. Second, the electricity sector in the UK has been the biggest source of emission reductions, contributing almost half of the emissions reductions so far. Therefore, the strategies and processes used by the UK electricity sector would, by themselves, hold important lessons for this paper.

The passage of the Climate Change Act was the culmination of a build-up of political momentum in favour of strong action by UK on climate change, marked by an unusual set of circumstances of cross-party consensus and cooperation with civil society organisations. Before 2005, while the UK did have a national climate change programme, it consisted of goals and aims that were not binding. In 2005, there was a campaign called "The Big Ask"—initiated by Friends of the Earth, an environmental organization—to have legislation that would legally bind the UK to carbon-emission reduction targets (ClientEarth, 2009). In April 2005, Friends of the Earth drafted a bill requiring 3% reductions year-on-year, leading to an 80% reduction by 2050 which was sent to Parliament by a group of three MPs, one from each of the major parties (ClientEarth, 2009; Friends of the Earth, 2017).

With the support of local groups, Friends of the Earth then built-up grassroots support for a Climate Change Law, holding more than 100 public meetings, involving local people and local MPs. In July 2005, at the G8 Summit in Gleneagles hosted by UK, PM Tony Blair put climate change on the international agenda (Bayne, 2005). In September 2006, the Conservative Party, in the opposition at the time, added its support for the campaign for a Climate Change Bill. Providing additional impetus was the publication of two "high-profile reports" in the following two years—*The Economics of Climate Change: The Stern Review,* in 2006; and the *Fourth Assessment Report (AR4)* brought out by the Intergovernmental Panel on Climate Change (IPCC) in 2007. Both reports warned of the risks of climate change and the need for urgent action (ClientEarth, 2009). All this political pressure and activity led to the Climate Change Act becoming law in November 2008.

The Act requires that the UK Government prepare carbon budgets for every five-year period and that the carbon budget be prepared 12 years before the start of the respective period. The government is also required to ensure that carbon emissions in any five-year-period do not exceed the carbon budget for that period. The Act mandated that the government had to report the level of GHG emissions to the Parliament every year, and at the end of each five-year budgetary period, if the carbon budget has not been met, it must explain to Parliament why that has happened.

The Act also established a Climate Change Committee (CCC), originally known as the Committee on Climate Change, which advises the government on the level of the carbon budgets for each five-year period. While providing advice on carbon budgets, the CCC is required to take into account many issues such as the scientific knowledge on climate change, technology relevant to climate change, economic and fiscal issues, and many others. Every year, the CCC is required to file a report with the Parliament on three issues: (1) the progress made in meeting the carbon budget and the 2050 target; (2) additional progress that is required; and (3) whether the carbon budget and the 2050 target are likely to be met.

In addition to reduction of carbon emissions, the Act also addresses adaptation to the impacts of climate change. At least once every five years, the UK government is to report to Parliament on the risks the country faces from the impacts of climate change. The government is also required to report to the Parliament on its plan of action to address these risks "as soon as is reasonably practicable", once the report is tabled in which the risks have been identified. According to the Act, the CCC is also required to advise the government on adaptation to climate change, in writing and at least six months before the government is to file its report to Parliament. In addition, in its annual progress report, the CCC is required to include its assessment of the progress on adaptation.

5.1.2 Functioning of the UK's CCC

The CCC has eight members and the Adaptation Sub-Committee (ASC) has five, in addition to the Chair of the CCC who heads it. The most striking feature of both the CCC and the ASC is the level and range of expertise of the members—the current Chair, Lord Deben, served as Secretary of State for Environment (1993–97), and the members' expertise covers natural environment, behaviour, climate science, economics, food/agriculture, and technology/engineering (Averchenkova et al., 2018). The CCC is supported by a secretariat of about 35 members (CCC, 2021).

The expertise within the CCC is combined with "constant and intensive dialogue with stakeholders and government counterparts", resulting in recommendations that are ambitious, based on rigorous analysis and also likely to be feasible in practice (Averchenkova et al., 2018). As an example of the functioning of the CCC, we examine, in a little more detail, at how the UK's Sixth Carbon Budget was developed.

5.1.2.1 Development of the Sixth Carbon Budget

The UK's Sixth Carbon Budget covers the period 2033–37. In keeping with the requirement that a carbon budget be set 12 years before it becomes operational, the CCC sent its recommendations to the government in December 2020.

As preparation for its advice to the Parliament, the CCC launched a "Call for Evidence" (CfE) to get inputs from interested parties. The CfE listed questions in five areas: climate science and international circumstances; the path to the 2050 target; delivering (meeting) carbon budgets; issues related to Wales, Scotland, and Northern Ireland; and sector-specific questions. Next, the CCC engaged with other experts, commissioned studies, worked with consultants and organised roundtables, in its efforts to enrich its analyses and strengthen its recommendations (CCC, 2020a).

The UK's CCA gives its government freedom to decide on how to meet the carbon budgets. For the Sixth Carbon Budget, the CCC presented a "Balanced Net Zero Pathway" and recommendations based on it. This was supposed to be "illustrative" of what "a broadly sensible path based on moderate assumptions would look like". The CCC also developed three available, exploratory scenarios, to show the range of pathways to net zero. These exploratory scenarios could be useful to guide the government to handle uncertainty, and to show how slow progress in one area could be offset by more rapid progress in another area. The analysis, and the recommended carbon budgets were developed sector by sector, yielding sector-wise pathways to net zero (CCC, 2020a).

In addition to the Carbon Budget, the CCC also presented two accompanying reports to the UK Government. One was the *Methodology Report*, which explains the approach used for each sector and the associated evidence and data (CCC, 2020b). The level of detail in *the Methodology Report* is a testament to the rigour in the CCC's analyses, and the level of transparency that is maintained. The second report was titled *Policies for the Sixth Carbon Budget and Net Zero*. The *Policies* report contained the recommended overall policy initiatives. In addition, it laid out the policy changes required for each sector. Although the UK's Sixth Carbon Budget does not come into effect until 2033, the *Policies* report has identified policy changes required now if the Sixth Carbon Budget is to be met by 2037, the last year of that budget (CCC, 2020c).

5.1.2.2 CCC's Influence without Statutory Power

The role of the CCC is advisory and the responsibility for the final decisions on target emission-levels in the carbon budgets, and the policies to achieve them, lies solely with the government. However, according to the CCA, the government must take the CCC's advice into account, and if it deviates from the targets proposed by the CCC, it must explain why it has done so.

Fankhauser (2018) describes the CCC as "one of the most intriguing features" of the UK's governance of climate change. Even though it does not have any statutory powers to change the government's decisions, the CCC is very influential. It enjoys great respect and credibility, and its statutory advice is generally followed, although there have been a few exceptions. Based on an analysis of UK parliamentary debates, Fankhauser (2018) found that members of parliament cited the CCC as their main source of independent information, and this mainly when they pushed for greater ambition. The impact of the CCC's work is also found in bills dealing with subjects beyond climate, such as, infrastructure, oil and gas, water, housing and planning, and civil aviation. (Fankhauser, 2018)

The UK's CCA does provide a legal route to confront the government on policy decisions that are inconsistent with the obligations of the Act (CCC, 2020d). Thus, even without formal powers to change the government's approach or decisions, the CCC is able to wield considerable influence by relying, "…on the political embarrassment that its assessments may cause [the government] and the threat of a judicial review brought by environmental pressure groups if it fails to meet its statutory obligations under the Climate Change Act." (Averchenkova et al., 2018)

5.1.3 UK's Approach to Emission Reductions

In its approach to reduction of GHG emissions, the UK has not used economy-wide carbon taxes; instead, it has relied on a sectoral approach. Sector-specific planning and targets have been implemented using a combination of standards, incentives and market mechanisms. Some of the policies currently in place include (Black, 2021; Dray, 2021):

- **Emissions Trading Scheme (ETS) for energy-Intensive sectors**. The EU emissions trading scheme, started in 2005, was included in the UK's CCA (Fankhauser et al., 2018). After Brexit, the UK established a UK-only ETS which is similar to the EU-ETS and applies to the same industries. Each unit receives GHG emission permits, and the trading of the permits leads to a price for GHG emissions.
- **Fuel duty on fuel used by automobiles.**
- **Ban on new petrol, diesel, or hybrid cars from 2035.** (BBC, 2020)
- **Energy company obligation for energy efficiency**. Large energy companies are required to improve the efficiency of homes. The costs for the energy efficiency improvements are passed through to consumers.
- **Climate Change Levy (CCL).** All businesses, except those consuming small amounts of energy, are required to pay a CCL for every unit of energy consumed (UK Government, 2021).

In addition, as discussed in more detail in Section 5.1.4.1, the power sector uses a mix of instruments to lower emissions: auctions for RE; floor price for GHG emissions from the power sector to support low carbon alternatives; a capacity market to ensure reliability of the power system; and emission limits on new power plants to prevent addition of new unabated coal plants.

5.1.4 Impacts of the UK Climate Change Act

For the first two carbon budget periods, the emission reductions have been greater than required, by 1% during the first period (2008–2012) and by 14% during the second period (2013–2017) (Priestley, 2019). There has been a decoupling of economic growth from carbon emissions in the UK. From 1990 to 2018, its GDP grew by 75% but GHG emissions declined by 43% (UK Government, 2020). Of course, it would be unfair to expect India to duplicate this track record because the UK had access to inexpensive gas, and its transition to gas, in the power sector, started in the 1990s. Moreover, the UK started from a high base of emissions.

It is interesting to note that 90% of its emission reductions have come from just three areas (Evans, 2021).

1. Electricity supply: 40%
2. Cleaner industry: 40%
    a. Emission controls on manufacturing and waste industry: 25%
    b. More efficient industrial processes and shifting away from carbon-intensive manufacturing: 15%
3. Lower methane emissions from coal mines (because less coal being mined), and lower level of leaks from gas distribution pipelines: 10%

There has been almost no reduction in the emissions from transport, which is the largest contributor to UK's emissions, contributing 28% of the total (Evans, 2021; UK Government, 2020). Similarly, there have been limited reductions in emissions from another large contributor, the buildings sector which contributes 19% of the total emissions (Evans,2021; UK Government, 2020).

5.1.4.1 Changes in the Power Sector

The UK's success in the first two five-year periods has been greatly helped by transformational changes in the power sector, and therefore we look at the changes in its power sector in more detail (Fankhauser et al., 2018). We also hope that this short review of the changes will illustrate some of the reasons for the early success of the UK's CCA.

In its first progress report, the CCC stated that the then existing power markets were designed for efficient dispatch of fossil-fuel plants and would not encourage investment in low-carbon technologies that had high capital costs (CCC, 2009). It suggested changes in the design of the power market. Shortly thereafter, based on its own study started in 2009, the UK regulator, Ofgem, also concluded that changes in the market were needed to ensure reliable supply of electricity to customers in the UK (Ofgem, 2010). Responding to these concerns, the UK's Department of Energy and Climate Change (DECC) issued a White Paper in 2011 describing the proposed Electricity Market Reform (EMR) which was enacted as a law, as part of the Energy Act, 2013.

The EMR has four key policies that support rapid decarbonisation and ensure reliability (Grubb & Newberry, 2017):

- Contracts for differences for RE, based on fixed-price 15-year contracts, to provide certainty to RE power-plant developers
- Floor price for carbon, with gradual escalation to support low-carbon technologies
- Capacity market/mechanism to ensure reliability
- Emissions performance standard for new power-plants in g(CO_2)/kWh, to stop new unabated coal plants

We see that there were three ingredients that led to the successful and significant changes in the power sector:

1. Early recognition of the problem in the design of the electricity markets by the CCC
2. Coordination and cooperation between key players—CCC, Ofgem, and the government (DECC)
3. A responsive DECC that put out a white paper describing proposed changes, and got them enacted into law.

5.1.5 Analysis and Lessons for India

The most striking feature of the UK Climate Change Act is its comprehensiveness, not only on the issue of target setting, but also in the processes and institutions that are required to implement it. Fankhauser et al. (2018), of the Grantham Research Institute for Climate Change and the Environment, carried out a detailed study to assess the UK's experience with its Climate Change Act. Their work was based on interviews with a variety of stakeholders: civil servants, special advisors, government ministers and shadow ministers, members of parliament, and industry representatives.

The information from these interviews was supplemented by insights from relevant literature, the authors' own experience (one of the authors had been a member of the CCC), and informal conversations with experts. Through this assessment, they developed a good list of those features of the CCA that hold important lessons for other countries developing a framework for dealing with climate change. The features Fankhauser et al. (2018) identified are:

- **A comprehensive statutory framework**. With an economy-wide long-term target, the Act clearly defines the direction of travel for the economy and the desired end-point. It also clearly defines responsibilities.

- **Mid-course targets.** The five-yearly carbon budgets break-up the big task into smaller tasks. While the direction of travel is clear, flexibility is provided in selecting a path to reach the long-term goal.

- **Attention to adaptation**. While retaining a focus on the long-term target, the Act does not ignore the risks that will be faced due to the impacts of climate change, and requires plans and programmes to deal with them.

- **Independent advisory body**. One of the most important features of the UK framework for climate change is the CCC, set up to establish "the long-term credibility of climate action and safeguard against political mood swings" (Fankhauser et al., 2018). The CCC has people with a broad range of skills, and its recommendations are based on detailed engineering and economic modelling. As per Fankhauser et al. (2018), the CCC is very well respected by all stakeholders and "has established itself as an authoritative custodian of analytical honesty and rigour."

- **It is worth noting that within less than a year after the Act was passed, the CCC issued its progress report, in which it recommended changes to the electricity markets.** It is those changes, enacted in 2013, that have resulted in a transformation of the power sector and that transformation, in turn, contributed to the UK's success in meeting its carbon budgets. Even the initial target for 2050 of GHG emission reduction by 80% was recommended by the CCC, operating at the time in shadow form. The target was based on modelling and information from the *Fourth Assessment Report* by the IPCC, and was calculated to be a fair share of the UK's responsibility to mitigate climate change (Fankhauser et al., 2018).

- **Monitoring of progress and accountability**. Regular reporting and monitoring of progress is an important feature of the Act that makes it very effective. Every year, the government must report the emission levels to the parliament and if at the end of a five-year carbon budget period it fails to meet the target, it is required to explain why that happened. Furthermore, every year, the CCC is required to provide an assessment of the progress made on reducing emissions.

An additional factor contributing to the success of the Act is the political consensus behind it that has been maintained (Fankhauser et al., 2018). But there are concerns about the future. The government projects that carbon emissions in the third five-year period (2018–22) would be below the budget by 3%, but shortfalls of 6% and 10% are expected in emission reductions in the subsequent two five-year periods (Priestley, 2019). This may be because the earlier actions were "low hanging fruit" and now in the targeted parts of the economy, it may be more difficult to reduce emissions (Fankhauser, et al., 2018). These concerns about future difficulties do not take away from the many valuable features of the UK's CCA.

The UK's experience with the CCA highlights the importance of the following features of the emission reduction framework that would be of great value as India navigates the energy transition. Many of these features, listed below, are either weak or absent in the current framework in India.

- A long-term economy-wide target that defines the overall mission, based on wide consultation. Political consensus is crucial for the success in both setting and implementation of the target.
- Division of the long-term period into shorter, more manageable periods (five years), each with its sub-target. This allows flexibility in implementation, and allows actions to be responsive to changes in circumstances, evolution of technology, and advances in knowledge.
- A well-respected, independent advisory body with a high degree of expertise, particularly in modelling. India has historically struggled to have independent, skilled, financially robust, and empowered independent bodies, more so ones with permanence and institutional memory.
- Regular monitoring, preferably annually, and a strong accountability mechanism.

5.2 Australia

The story regarding climate change is very different in Australia. Its Paris targets of emission-reductions—26–28% from 2005 levels, by 2030—are considered insufficient (Climate Action Tracker, 2021b). The Climate Change Performance Index (CCPI), discussed in the introduction of this paper, ranked Australia eighth from the bottom for 2021 (Burck et al., 2021). However, there is a bright spot in this otherwise disappointing performance: the rapid growth of RE in Australia's power sector, driven by ambitious goals for 2030 set by its states—for example, South Australia is targeting 100% RE by 2030 (Climate Action Tracker, 2021b; McGreevy & Baum, 2021).

We include the experience of Australia here, mostly because its handling of large amounts of RE contains lessons for India, as it too pursues ambitious goals for addition of RE to the generation mix. In addition, unlike the UK, Australia is a large country in terms of area and has a federal structure, similar in some respects to India. The Australian experience with coordination between states and the federal government may hold some lessons for India in handling such coordination, in particular on coordinating long-term planning at the federal and local levels.

The rapid growth in RE in Australia has brought its own challenges. For some years, as greater amounts of RE were being added to the grid, many conventional generation plants were coming to the end of their useful life. This made it more difficult for its National Electricity Market (NEM)[13] to maintain the reliability of the grid. These concerns about reliability came to the fore during the state-wide blackout in South Australia in September 2016 (Finkel et al., 2017). As a result, the Coalition of Australian Governments (COAG)[14] ordered an independent review (the Finkel Review). One of the recommendations of the Finkel Review was to develop an NEM-wide integrated plan—to guide future investment in generation and transmission— to result in better system planning with the Australian Energy Market Operator (AEMO).[15] (Finkel et al., 2017) The Review also stated that as part of its international consultations, it found that Australia lagged behind other countries in developing a national strategy to ensure that the electricity and gas sectors navigated the energy transition "effectively and efficiently". In March 2020, the COAG Energy Council approved a rule requiring AEMO to publish an Integrated System Plan (ISP) at least once every two years.[16]

A review of the 2020 ISP reveals the following characteristics of the plan and the planning process (AEMO, 2020):

- The ISP is a coordinated plan for the entire NEM region and has been developed to serve as a roadmap to guide the energy transition in Australia. It represents the optimum path through the transition, with a planning horizon up to 2040.
- The planning process recognises the economic and technological uncertainties, and uses scenarios to select the "least regret" path. The ISP is presented as a dynamic roadmap, with "signposts and decision points" to help navigate when circumstances change.

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[13] The NEM covers five southern and eastern Australian states—South Australia, New South Wales, Victoria, Queensland, Tasmania—and the Australian Capital Territory (ACT). Western Australia has its own electricity market, the Western Electricity Market (WEM).

[14] Until recently, COAG was the main intergovernmental forum in Australia with the prime minister as Chair, and the premiers and chief ministers of the states and territories, and the president of the Australian Local Government Association (ALGA) as members. On May 29, 2020, the COAG was replaced by the National Federation Reform Council (NFRC), with the National Cabinet at the centre of NFRC. Members of the National Cabinet are the prime minister, and the premiers and chief ministers of the states and the territories. The NFRC focuses on priority national issues that require coordination between the Commonwealth and the states.

[15] The AEMO is responsible for promoting, 'efficient investment in, and efficient operation of' gas and electricity systems. This covers the following areas: maintaining secure electricity and gas systems; managing electricity and gas markets; and design of the future energy system in Australia (AEMO website).

[16] In May 2020, the COAG Energy Council was abolished along with COAG. The COAG Energy Council was replaced by the Energy National Cabinet Reform Committee (ENCRC), and the Energy Ministers' Meeting (EMM).

- It identifies the least cost investments that will be needed, including grid augmentations, generation, and storage. Actionable transmission projects in the ISP are carried out by the transmission owners according to the appropriate regulations. However, there is no regulatory mandate for generation and storage additions in the ISP. Instead, the ISP provides "a signal to inform the decisions of private developers." Therefore, the ISP includes needed market and regulatory reforms, to ensure that the market design will deliver the least-cost outcomes.
- In developing the optimal path, AEMO has considered affordability, reliability and environmental impacts. This is particularly important for the Indian context, where these considerations can represent a challenging trilemma.
- Last, but not least, AEMO has used wide-ranging consultations with stakeholders in developing the ISP. It held two rounds of consultations with industry representatives, academics and consumer groups, one before and another after the release of the Draft ISP.

From the Australian experience, there are lessons for India too as it seeks to transform its power sector with greater reliance on clean energy sources. Rather than relying on piecemeal reforms and targets for each kind of generation resource, it would be much more advisable to have a nationwide system-planning process to understand the changes that are happening; and to identify the market and regulatory reforms that are needed to help the country move through the transition smoothly.

The NEP in India developed by CEA tries to perform the same function that AEMO's ISP does—guide the development of the power sector along an optimal path, minimising costs and ensuring reliability. However, there are several significant differences. First, and perhaps the most important, is that AEMO's ISP is a "whole-of-system plan" that optimises generation and transmission together, unlike the NEP where NEP-Trans is developed after NEP-Gen has been finalised. This could lead to significant sub-optimality. Second, the Australian planning process recognizes the great level of uncertainty in the sector and addresses the uncertainty, for example, by developing an ISP at least every two years. In addition, the ISP is a dynamic plan with signposts and decision points to respond to changes in the sectoral environment. In contrast, the development of the NEP pays limited attention to uncertainty and the Plan is issued only once every five years, making it a much more static plan. Last but not least, in Australia there is extensive consultation with a wide range of stakeholders, which results in exploration of a wide variety of plausible futures and adds to the robustness of the results. While there are consultations for the NEP, these need to cover a much wider range of stakeholders.

6. Conclusions and Recommendations

With the rapid introduction of RE in its resource mix, India has done well on reducing its emission intensity and is one of the few countries that is well on its way to fulfil its pledges for 2030 in its NDC. However, the road ahead on this energy transition is long and rocky, and therefore, this is the right time to see if we can set our energy-use targets for the years ahead in a way that ensures that the transition is economically efficient, effective, and smooth. We are not suggesting changes to the existing pledges in India's NDC, but rethinking targets for use within the country to improve policies and their implementation, and for emission reduction commitments beyond 2030.

Because targets for the electricity sector cannot be completely separated from targets for the energy sector nor from the targets for the entire economy, we first present recommendations for the broader process for setting targets or goals for the transition to cleaner energy, and then follow-up with recommendations more specifically for long-term goal-setting and planning for the electricity sector.

The discussion in this paper, particularly on the international experience, highlights the following areas for improvement in the overall process of goal-setting:

- **Need for long-term goals**. Instead of setting goals for the next five to ten years and enhancing them periodically as we have done so far, it would be better to set a long-term goal. Once we know what the destination is, we can better chart a path to that destination. It would be best if the goal is set for a macro-level outcome, say emissions intensity or net emissions, instead of a single resource, even if it is an environmentally desirable resource such as RE.

- **Shorter-term planning periods with targets.** It would be good to break up the period for the long-term goal (say 30 years from now) into shorter periods of five years, and set interim targets for the end of each five-year period too. Five years, as UK has used, seems like a reasonable "Goldilocks" ideal—not so long that the target date seems too far away (thus reducing the incentive to act), nor too short (because then it would be difficult to get much done). These successive five-year plans should provide sector-wise targets. Importantly, the planning for each period should be done many years in advance, like the UK does.

- **Autonomous and credible agency.** We suggest that an autonomous and well-respected agency, like the CCC in UK, be set up to determine the target (emission intensity or net emissions) in the final year and its trajectory until then. There are two options for establishing such an agency—either establish a new agency or expand the mandate and functions of an existing agency. A new agency would generally be preferred because there would be no legacy issues and the mandate and functions for the new agency could be tailored exactly to the requirements. On the other hand, establishing a new agency can take several years, and the urgency of tackling climate change may not allow such a luxury. One candidate existing agency is CEA. It already carries out national level planning for the electricity sector, and has a large staff and the necessary infrastructure. If it is selected, then legislation will be required to change its mandate from covering only electricity to covering climate change issues for all sectors. The current organisation could become one wing of the expanded agency. The agency, whether a new one or an expansion of an existing agency, should have the following characteristics:

    - <u>Composition and Expertise.</u> The agency should be steered by a council of about ten members, including a chairperson, supported by well-qualified staff. The members should be recognized experts in their fields and together the council should have a varied mix of expertise covering at least the following areas: environmental science, including climate science; economic modelling, forecasting and analysis; energy production and supply; finance and investment; technology development and diffusion; and social impacts of policy (Adapted from UK-PGA, 2008). It would help if the members also come from diverse professional backgrounds and with experience in areas such as government, business, civil society, and academia.

    - <u>Functions.</u> The agency would be expected to carry out the following functions (Adapted from CCC, 2021):

        - Conduct independent analysis, including modelling, relying upon up-to-date knowledge of climate change science, economics, and technological developments.

        - Engage with a wide-range of stakeholders (individuals and organizations) and thereby enrich its analysis.

        - Based on its analyses and stakeholder consultation, provide independent advice to the government on setting and meeting both long-term and interim (five-year) targets for emission intensity that are ambitious but also achievable.

        - Monitor the progress towards the long-term and interim targets, and annually report and suggest mid-course corrections.

- **Incorporation of other development goals in long-term and shorter-term periodic plans.** Other development goals such as promotion of domestic manufacturing, reduction of import dependence, employment, and training should be part of the plans. These plans must also include effective implementation and monitoring measures.

- **Dissemination of details of plans and targets, along with the rationale, through official documents.** As we have seen, details about targets and policies are sometimes available only through media reports. It is important that all details of plans, targets, and the rationale behind them, be widely disseminated through official documents. It will lead to greater understanding of the plans and to ownership by all stakeholders. In addition, stakeholders will be able to refer to the documents to know the details of the plans and targets.

We now turn our attention to the electricity sector which is the focus of this paper.

It is important that the approach used in India for setting and implementation of targets pays attention to, not only environmental impacts, but also the affordability of electricity, and reliability of the power system. One way of attaining this balance is to set environmental or emission targets that each load-serving entity (LSE) must meet. The target should be stated in a way that provides flexibility to the LSEs in achieving it. Currently the main LSEs are distribution companies, but if and when retail competition occurs at a significant level, retail suppliers would also be LSEs.

Ensuring affordability of electricity from regulated LSEs (distribution companies) will need regulation that ensures that power procurement by these entities is based on minimisation of long-term total costs. For competitive retail suppliers, such regulation should not be needed, because market discipline is expected to ensure that they will minimise costs and thus supply affordable electricity to their customers.

In order to ensure reliability of the power system, and to provide guidance for investment in transmission, generation and storage, there should be national-level planning similar to that carried out by AEMO in developing an Integrated System Plan (ISP). The CEA already develops an NEP every five years, and that planning process can serve this purpose with the following three changes. First, instead of developing the transmission plan after the generation plan, it would be better to carry out a "whole-of-system" plan, where generation and transmission are planned together. Second, the NEP must incorporate uncertainties and management of risk to a much greater extent than it currently does, as detailed in Section 4.1. Given the nature and extent of uncertainties in the sector, there should be a mid-term review of the NEP during each five-year period. This would provide an opportunity to incorporate changes in technologies, costs, climate, and economic growth, and also resolve any problems in implementation. In addition, the NEP should be presented as an adaptive plan with signposts and decision points as with the ISP. Third, NEP development should have much wider stakeholder consultation, particularly in the development of alternate plausible scenarios to be considered.

Given that India is a developing economy, it may be better to set GHG emission-intensity targets for the electricity sector, rather than absolute emission targets. There are two options for an emission-intensity target. One option could be to set the target in terms of grams of CO_2-eq per kWh sold.[17] The second option would be to set it in terms of the percentage of annual electricity sold from zero-emission sources. The g(CO_2-eq)/kWh target, which would be applied as an annual average for an LSE, would allow much greater flexibility to the LSE in terms of the resources it could use for the electricity it sells, and yet meet the target. For example, it could decide to use some gas-based generation, which has carbon emissions but which are lower than for coal plants. The second option—of percentage of energy from non-fossil resources—has the advantage that it would be more easily aligned with the

[17] In addition to carbon dioxide (CO_2), there are other GHGs, and their global warming potential is higher than CO_2. In order to be able to compare the emissions of all the GHGs on a uniform basis for their global warming potential, the measure CO_2-eq has been developed. One tonne of CO_2-eq of any of the GHGs has the same global warming potential as one tonne of CO_2.

pledge on non-fossil generation capacity, made in the Paris Agreement by India. It would be easier to monitor the performance of the power sector to see the movement towards the target in the Paris Agreement. However, given India is well on track to meeting its Paris obligations, it can think of being more ambitious, and in that case, the first option is better.

One major challenge in applying either of these options for the emissions target, is developing state-wise targets. There is great diversity in the resource mix of the states. For example, Himachal Pradesh uses mostly hydropower for generation and has very low carbon emissions, while Chhattisgarh, with its heavy reliance on coal-based generation, is likely to have very high carbon emissions. One approach would be to have uniform targets for all the states and have a cap-and-trade mechanism. However, this would be very difficult to implement. It would be easier to have different state-wise targets, based on the current resource mix in each state, with a mechanism to ratchet down the emission target over time. This is an initial suggestion, as developing state-wise targets requires a much longer and more detailed discussion.

As mentioned earlier, it is crucial that LSEs meet the emission-intensity targets at the minimum long-term costs to safeguard affordability of electricity service. Effective resource planning can be a great help in that pursuit. It can also serve as the mechanism to respond to the guidance and signals contained in the NEP for appropriate procurement of generation and storage resources. A good resource plan minimizes long-term costs, while minimising risks and complying with environmental and policy goals. Unfortunately, resource planning is poorly understood by most distribution companies in India. Therefore, as stated in Section 4.2, several steps are required to promote resource planning:[18]

- Increase awareness about the importance and value of resource planning
- Mandate regulators to require resource planning by distribution companies
- Develop a regulatory framework for resource planning
- Train the staff of distribution companies and regulatory commissions on the practices of resource planning.

In summary, target-setting in the energy sector, and more specifically in the electricity sector, can be made more effective by paying attention to the following two principles:

- It is best to set broad, aspirational, yet achievable targets in a consultative manner, so that all stakeholders buy-in. Micro-level details are best left to those who will work on reaching the targets.
- Long-term targets should be broken up into interim targets, allowing for monitoring of progress and mid-course correction. Periodic monitoring, even during these interim periods, is essential for success.

[18] For more information on these steps and resource planning in India, please see Singh and Swain (2018).

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