

Community Paper

Energy Policy Lighthouses

The Little Green Book

In collaboration with the Global Future Council on Energy 2019-2020

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Introduction

By many measures, the world is still in the early stages of a deep and [profound transformation](#) in energy, and industrial and agricultural processes. The aim of that transition is to achieve new policy goals for modern societies – among them, deep cuts in carbon dioxide and other warming gases. Success will require a reduction in emissions from current levels – more than 50 billion tons of carbon dioxide equivalents today, rising at nearly 2% per year in recent years – to essentially zero over the next few decades, while delivering the energy the world needs at affordable costs. This transformation will not be easy, for mobilizing meaningful economic change is rarely a simple process that proceeds without opposition. It is [hard to pin down how quickly it may be occurring already](#). However, with smart policy strategies and profound technological change, the [process can run faster](#), at lower cost and with more benefits to society.

This community paper focuses on the role of policy in these processes of transformation. The experience, so far, is that the societies making the most progress on deep decarbonization have all relied heavily on policy initiatives – to set ambitious goals, to create incentives for innovation and development and deployment of new technologies, to encourage scaling of superior solutions, to encourage new kinds of firms and markets, and to send clear signals about the need for change. With growing attention on the need for energy transformation, there has been increasing interest in the lessons from [many diverse policy experiences](#). The key insight from this effort is that there are many good practices that can be replicated while new more innovative policies can be developed to drive deep decarbonization.

This “little green book” offers a sample of sound policy experiences – policy lighthouses that can guide countries and markets towards new destinations. Like lighthouses, these examples are reliably visible from a distance even when little else – few other models of good policy design – are evident on the horizon. In compiling this list, we have benefitted from experiences around the world that are reflected in the network of the World Economic Forum’s Global Future Council on Energy. Our list focuses on policies that meet the following criteria:

- **Implementable:** The policies have been adopted and put into practice, which means that they have been tested for their political viability and effectiveness.
- **Accountable:** They have measurable impacts and costs, which means that the approach is sufficiently transparent and accountable.
- **Impactful:** The policies make a substantial contribution to sustainable development, including reductions in emissions.

- **Scalable:** They are scalable – so that efforts in the locales in which these policies have been developed and tested can be applied, perhaps with modification, to other settings elsewhere.

These criteria may differ from context to context; as a result, rather than attempt to quantify the fitness of the examples provided herein to these criteria, we’ve relied on the collective judgement of the World Economic Forum Global Future Council on Energy. This “little green book” offers examples, and a framework for filling out the examples and insights. Future work from our team within the World Economic Forum’s Global Future Council will expand the list, refine the criteria and offer more detailed assessment that allows for comparisons.

[Many of the building blocks already exist](#), as do lessons about policy efforts that have been less successful. Translating good practices from one jurisdiction to others – learning and adjusting along the way – is not only possible but necessary if the whole world is to undergo rapid and deep decarbonization.

We use a simple system for categorizing the policies as shown in Figure 1. The columns represent three major goals of policy. It follows the system of classification from an [Energy Transitions Commission report](#), and is anchored in the substantial academic literature on technological transition. In the first row are policies aimed at innovation – that is, producing public goods of new knowledge. Often these policies focus on key niches where societies and consumers are willing to adopt new technologies and ideas (and bear the risk that those technologies will be costly and immature). In the second row we present policies aimed at broader diffusion of successful innovation – creating larger markets and driving down costs while improving performance as firms, consumers and policy-makers gain experience. Finally, there are policies aimed at reconfiguration of whole markets – policies that enable everyone to use new technologies and ensure that the benefits of those technologies (e.g. lower emissions) are ubiquitous.

The rows show different stages of development in technologies and solutions – from early-stage emergence of new ideas through diffusion and then eventual reconfiguration of whole societies to use a new technology or practice. The columns show the method by which the policy achieves change – from direct intervention (e.g. technology standards) to adjustment of market forces (e.g. pollution taxes that force firms to internalize an externality into their production decisions) to altering “norms” about what is good behaviour. Many policies don’t fit neatly into a single category – for example, policies aimed at diffusion of a technology also often play a role in reconfiguration. And

policies aimed at direct intervention or adjustment of market forces also often alter the norms that govern what people and firms think are good and bad behaviour

The columns of Figure 1 represent the types of policy instruments deployed. On the left are direct interventions – for example, technology standards. In the middle are market adjustments such as subsidies or tax reforms that alter the incentives that operate on firms and consumers but don't pick "winners". On the right are social norms – that is, rules and expectations for appropriate behaviour.

In our first sample of policy lighthouses presented in this little green book we offer examples of each of the nine cells created by three policy goals and three types of policy instruments. We provide/include an extra example in the row for the eventual complete decarbonization of the global economy: reconfiguration of societies and markets. Looking across these examples, they broadly cover the major elements of a whole portfolio of needed policy strategies – from those that redirect entire economies to those that work at the early stages of innovation to broader diffusion of new technologies and then reconfiguration of whole markets.

Even though it is impossible to offer any single summary of key lessons for such a diverse set of policies and countries, we take stock of a few that emerge from this early effort:

- While we sought examples that were transparent and well-evaluated, in practice it has been hard to understand the real costs, impacts and scalability of policies. Future iterations of this policy lighthouse green book need to focus not just on filling out the examples, but also on how we can know that certain policies actually work – and how they can be scaled and transferred to new contexts.
- All of these lighthouse cases were designed with an eye to political feasibility and durability. In addition to good policy practices – for example, attention to ensuring

that benefits exceed costs – political sensibility requires ensuring that policies have supporting coalitions and that supporters grow more powerful with policy success.

- Effective policies aimed at promoting the deployment of technologies pay close attention to the cost of financing. Such policies lower risk for favoured technologies and, as a result, enable financiers to channel capital. As a general rule, the transformations needed for deep decarbonization will involve a big shift for energy and industrial systems that are capital-intensive. At one extreme – in the electric power sector, for example – the cost profile of the lowest-emission generators is comprised nearly entirely of capital costs and involves very little operational cost. Financial success with these kinds of technologies requires minimizing how capital markets and other suppliers perceive risk and lengthening the time horizon over which investors will find the technology useful. As we assembled this first list, we developed a much larger list of candidates and then winnowed it. In that process, it became clear that by far the most experience that the world has of policy interventions aimed at energy transition is with policies aimed at diffusion of known technologies and policy instruments that rely on direct intervention, such as technology standards. By contrast, the standard wisdom on good policy design tends to emphasize the need for a diverse portfolio that covers all major goals of transition – innovation, diffusion and reconfiguration – along with interventions that rely on markets instead of picking winners. The real world is quite different from that accepted wisdom.
- Finally, it is important to note that very little policy effort is focused on rewiring social norms, even though, in many areas, both behavioural science and practical experience suggest that this is a powerful mechanism for change. Most policies are based on the idea that policy-makers know which technologies and practices are best, rather than the idea that society itself will drive change.

Figure 1. A system for categorizing policies.

Type of policy instrument				
	Direct intervention	Market adjustment	Adjustment of social norms	
Stage of development	Early-stage innovation	China's Top Energy-Consuming Enterprises programme	Federal/government innovation programmes in the US	Prize-based challenges
	Diffusion of new technologies and practices	Mandatory appliance energy efficiency standards	Shifting from feed-in tariffs to competitive bidding – electricity auctions for renewables in Brazil and India. Renewable auctions in South Africa	UK Climate Change Act
	Reconfiguration of societies and markets	CO2 emission performance standards for new passenger cars in Europe	Carbon tax in Canada and Sweden Western Energy Imbalance Market (EIM). Enhancing coordination of electricity production in the western United States	Cooking fuel access in India – "Give up subsidy" campaign. Direct Benefit Transfer for LPG (DBTL), Give-It-Up Campaign, and Pradhan Mantri Ujjwala Yojana (PMUY)

Early-stage innovation

Direct intervention

China's Top Energy-Consuming Enterprises programme

The Top Energy-Consuming Enterprises programme has made an important contribution to China's significant energy efficiency improvements over the past decade, in particular in industry. The programme was created to encourage technological upgrades in large companies, with the overall goal of reducing energy consumption and thus greenhouse-gas (GHG) emissions. The current programme is a successor to the scheme first included in the 11th Five Year Plan (2006–2010), covering the 1,000 biggest energy-consuming companies. The scheme was extended to the 10,000 biggest players for the 12th Five Year Plan (2011–2015). Now nearly 70% of final energy use by industry is covered by mandatory energy-efficiency targets implemented via the programme.

The current target set by the 13th Five Year Plan (2016–2020) aims to improve energy intensity by 15% and cap total energy consumption at 5 gigatons coal equivalent (Gtce). To achieve these goals, the 30,000 most energy-intensive companies are subject to a raft of mandatory measures, including energy consumption targets, audits and reporting, standards and conservation measures. The energy-saving target in the 11th Five Year Plan was exceeded by 50%. Without these efficiency gains, the country would have used 12% more energy in 2017, compared with a 6% reduction in India and 5% in Brazil.

Success, scalability and challenges

There have been several factors behind the programme's success: Energy efficiency has long been a priority for government. In the early 1980s, consumption quotas were set for state-owned companies (the main energy consumers at the time) and incorporated into their performance assessment system. Efficiency standards were subsequently imposed on all companies and more recently market mechanisms have been put in place. As a result, by the time that the 11th Five-Year Plan implemented the first programme, companies had experience of, and set up robust systems for, energy management. Energy efficiency has also been at the centre of China's broader policies on market liberalization and economic development, as well as its efforts to reduce GHG emissions.

Generous subsidies were also introduced, including an energy efficiency fund to support participants in the Top programme. As a result, China accounted for the largest share (37%) of investment in industrial energy efficiency in 2018.

The country's top-down governance approach has also contributed to the Top programme's success. The central government implemented an extensive monitoring and control mechanism comprising energy efficiency teams in each provincial and city administration. In some regions, companies that failed to meet energy-saving standards had to pay higher power prices. In addition, China's efficiency efforts have been bolstered by the economy's shift away from energy-intensive industry towards higher-value-added sectors such as chemicals and machinery.

Other countries could indeed impose mandatory energy-efficiency targets on industry. The more companies covered, the higher the cost and effort to implement the required tracking and control systems. It would therefore be simpler to begin with the biggest energy consumers and gradually extend the scope in the same way as the Top programme. It may be more difficult for other countries to emulate this policy's success without a top-down political and governance system similar to that of China. The volume of subsidies and monitoring set-up would also be expensive, with multiple stages of audits and inspections by different bodies. Another question would be whether the government would need to protect some industrial sectors exposed to global competition, due to the risk of carbon leakage. Also, command-and-control regulations may result in perverse incentives. An example was reported to have occurred at the end of the 11th Five Year plan period, when local governments resorted to blackouts in order to meet their energy intensity targets.

Useful links:

- Grantham Research Institute on Climate Change and the Environment, "13th Five-Year plan". <https://bit.ly/2NBwbpl>

Market adjustment

Federal and government innovation programmes in the US

In 2005, leaders from both parties in Congress asked the National Academies to identify the most urgent challenges the US faces in maintaining leadership in key areas of science and technology, as well as specific steps policy-makers could take to help the US compete, prosper and stay secure in the 21st century. In its report for Congress, the National Academies called for decisive action, warning policy-makers that US advantages in science and technology – which made the country a world leader for decades – had already begun to erode. The report recommended that Congress establish an Advanced Research Projects Agency within the US Department of Energy (ARPA-E) modelled on the successful Defense

Advanced Research Projects Agency (DARPA), which was credited with such innovations as GPS, the stealth fighter and computer networking.¹

ARPA-E was authorized by the American COMPETES Act, passed by Congress in 2007 and signed into law by President George W. Bush. In 2009, ARPA-E received its first appropriations of \$400 million, which funded the agency's first projects. Projects are developed in labs, universities and other research organizations across the country, and displayed at the annual ARPA-E Innovation Summit, generally hosted in February or March in Washington, DC. The agency aims to support breakthrough innovation in science and technology specifically related to energy use.

Success, scalability and challenges

With 57 programmes related to everything from carbon capture to wave energy, the agency has provided approximately \$2 billion in R&D funding for more than 800 potentially transformational energy technology projects. Since being created in 2007, ARPA-E has had the following outcomes: 76 new companies have formed; 131 have partnered with another government agency; and 145 teams have together raised more than \$2.9 billion in private-sector follow-on funding to continue to advance their technology towards the market. Moreover, as of March 2019, ARPA-E projects have helped advance scientific understanding and technological innovation through 2,489 peer-reviewed journal articles and 346 patents issued by the US Patent and Trademark Office. These indicators demonstrate that ARPA-E's approach to selecting, funding and actively managing early-stage energy R&D continues to pay off, advancing the state of the art in energy science and engineering and defining new opportunities for commercialization of advanced energy technologies.²

The programme has demonstrated effectiveness through the outcomes achieved, and is clearly replicable as it was originally designed on the DARPA programme model. Scalability is also possible, and depends to a large extent on the funding available, along with collaboration with existing innovation ecosystems, including research universities, labs, incubators, accelerators, investors, corporate partners and more. Many of the innovations emerging from ARPA-E originate in federal labs and go on to be supported at later stages of development by incubators and accelerators in the Incubateenergy Network, a project also funded by the Department of Energy and run in partnership with the Electric Power Research Institute (EPRI) and the National Renewable Energy Lab (NREL).

When designing federal innovation programmes such as ARPA-E, it is important to consider the entire ecosystem of stakeholders that need to be engaged to make the effort successful, including labs, research universities, incubators, accelerators, investors, corporate partners and more. Failing to engage stakeholders across the entire value chain of the innovative technologies being developed can lead to significant barriers in implementing and scaling successful solutions. Making the transition from laboratory prototype

to larger-scale development and commercialization can be particularly challenging.

Useful links:

- Advanced Research Projects Agency – Energy.
<https://arpa-e.energy.gov/>

Adjustment of social norms

Prize-based challenges

Prize-based challenges can work as effective change models when thoughtfully applied. In areas where markets have failed and innovation has stalled, and where there is global interest and a manageable project development cycle, prizes can be a successful approach to solving problems. These highly focused policies often complement programmes centred on more general innovation, such as universities, labs, government and corporate research, incubators and accelerators. Several challenges have been used recently to focus on technologies, including carbon sequestration, with programmes like the Carbon XPRIZE. Here we focus on how the logic of prizes developed through earlier experiences is being applied to a new set challenge – air conditioning – with the Global Cooling Prize.

The Global Cooling Prize was launched in November 2018 by a global coalition led by the Department of Science and Technology of the Government of India; the Rocky Mountain Institute (RMI) – a leading global research institute; and Mission Innovation – a global initiative of 24 countries and the European Union to accelerate global clean energy innovation. The initiative is also supported by Conservation X Labs, the Alliance for an Energy Efficient Economy (AEEE) and CEPT University, plus a coalition of more than 20 leading international non-profit organizations, including the World Economic Forum. The competition is designed to incentivize the development of a residential cooling solution that will have at least five times (5X) less climate impact than the standard residential/room air-conditioner (RAC) units in the market today.

Population growth, urbanization and rising income levels, compounded by a warming planet, are driving unprecedented growth in demand for comfort cooling globally from 1.2 billion RACs in the world today to a projected 4.5 billion by 2050. Innovation and new technologies in the cooling industry are especially crucial for India. For the next three decades, three RACs will be sold in markets around the globe every second. Under the business-as-usual scenario, a recent report by the International Labour Organization (ILO) suggests, productivity losses to the global economy from heat stress could reach \$2.4 trillion a year – equivalent to 80 million full-time jobs. Lost productivity from extreme heat in India alone could exceed \$450 billion by 2030. Although a mere 7% of households in India own ACs today, demand for comfort cooling is expected to drive the total stock to more than 1 billion by 2050 – a 40-fold growth from 2016. The Global Cooling Prize could prevent up to 100 gigatons (GT) of

CO₂-equivalent emissions by 2050, and put the world on a pathway to mitigate up to 0.5°C of global warming by 2100, all while enhancing living standards for people in developing countries around the globe.

Success, scalability and challenges

Since the prize was launched, more than 2,100 participant registrations from around the globe have been submitted by innovators, start-ups, research institutes, universities and key industry manufacturers in more than 95 countries. Of the registered entities, 445 teams submitted preliminary ideas and 139 teams from 31 countries followed through with a full detailed technical application to the prize. The eight finalists have been awarded \$200,000 each to develop and ship their prototypes to India for testing in the summer of 2020. The winner of the Global Cooling Prize will be announced in November 2020 and awarded more than \$1 million in prize money.

The finalist teams are led by some of the world's largest air-conditioner manufacturers, including Gree Electric Appliances, Daikin AirConditioning India and Godrej and Boyce; they also include start-ups and corporations: S&S Design Startup Solution, Transaera, M2 Thermal Solutions, Kraton and Barocal. The teams come from India, China, Japan, the US and the UK and showcase a wide diversity of innovative residential cooling technology innovations, including smart hybrid vapour compression cooling, evaporative cooling and solid-state cooling technology designs.³

Today, there are a handful of additional technological areas in which a prize could be the best next step for innovation, and lead to dramatic improvements in efficiency and/or clean energy uptake. These areas include, but are not limited to: cement, clean cooking, clean steel, hydrogen, long-term storage and plastics. When designing challenges such as the Global Cooling Prize, it is important to consider the entire ecosystem of stakeholders that need to be engaged to make the effort successful, including governments, large corporate partners, funders, technical experts and more. Failing to engage stakeholders across the entire value chain of the technology being developed can lead to significant barriers in implementing and scaling successful solutions.

Useful links:

– Global Cooling Prize. <https://globalcoolingprize.org>

Diffusion of new technologies and practices

Direct intervention

Mandatory appliance energy efficiency standards

Mandatory appliance energy efficiency standards, commonly known as minimum energy performance standards (MEPS), set the efficiency levels that energy-consuming appliances and products must meet to be sold in a given country. By setting the requirements for energy performance defined by specific efficiency metrics, MEPS essentially set a floor for the lowest efficiency products on the market and ban products that do not meet the minimum level. This can provide a level playing field in competitive markets by removing the worst-performing products without diminishing consumer choice. As a mandatory regulatory policy, they also help address market barriers to efficient equipment purchases such as imperfect information and split incentives. Additionally, they can directly reduce the electricity demand and electricity costs of households while providing the same or a better level of energy service.

Taking a broader view, MEPS can be an effective way to reduce product energy consumption and energy-related emissions, particularly in countries/regions with large markets, as they apply to all new products entering the market. They can reduce peak electricity load for energy-consuming devices, such as air conditioners, that tend to use electricity during peak hours and improve grid reliability. The standard's stringency level can be raised iteratively over a short period of time, or raised significantly over a longer period of time, to provide manufacturers with a transition time to meet higher efficiency requirements, reducing manufacture resistance. Some subnational regions such as the state of California in the US have set MEPS with more stringent requirements or for products not covered by national MEPS.

Success, scalability and challenges

MEPS have been implemented in major markets globally since the 1970s and are currently in use in more than 80 countries. Countries typically develop their own standards, but there are growing efforts to harmonize MEPS efficiency requirements and/or test procedures regionally or globally. Australia, as one example, has implemented a performance standard for refrigerators since 1999. The programme was introduced to prevent manufacturers from selling outdated or energy-inefficient refrigerators. It set very aggressive targets, which initially were so stringent that no commercial products at the time were compliant. The resulting manufacturer response, coupled with a parallel consumer energy rating labelling programme, led to a reduction in refrigerator energy consumption of more than 60%. The programme has been replicated with other appliances, including washing machines, air conditioners and lighting.

MEPS can be replicated based on similar programmes that already exist in other countries or regions, taking into consideration region-specific operating conditions and usage behaviour. Setting up MEPS is also highly cost-effective for governments: The cost of the avoided energy use could be a small portion of the cost of supplying the same amount of energy. And it also does not necessarily increase the cost for manufacturers. They can be highly effective in reducing future energy consumption and scale up to cover entire national markets, especially for countries undergoing rapid growth in product sales. In China, for instance, MEPS for room air conditioners since 2000 can save electricity equivalent to twice the output of the Three Gorges Dam annually by 2030.

In the Middle East, the Saudi Energy Efficiency Program (SEEP) was launched in 2012 as a government programme coordinating with more than 30 governmental entities and state-owned companies. The programme launched more than 80 different initiatives to improve energy efficiency in the transport, utility, building and industrial sectors, representing more than 90% of domestic energy consumption.

In the transport sector, the Kingdom introduced fuel economy standards for passenger vehicles along with standards for tyres. In the building sector, it introduced energy-efficiency standards, with testing, inspection and certification programmes to enforce standards on air conditioners, refrigerators, washing machines, lighting, thermal-insulating materials and electric motors. In the utility and industrial sectors, the programme launched a number of initiatives aimed at reducing demand in these sectors.

There are two key drivers behind the success of the energy-efficiency programme: The first is the broad coordination between the different governmental entities and private-sector players at the level of planning, delivery and execution of the policies. The second key driver is the focus on policies that achieve mutual benefits for consumers, the private sector, the economy and the environment.

Since the programme was launched, the Kingdom has managed to improve energy efficiency for the building, transport and industrial sectors. For example, following the introduction of passenger vehicle fuel economy standards, the fuel efficiency of new vehicles improved by 11.2% between 2016 and 2018. In the building sector, 26 energy-efficiency standards and regulations were introduced, including MEPS for appliances, white goods and insulation. This has resulted in a 57% improvement in the minimum energy performance standard of split ACs since 2012. One of the key success factors ensuring consumer take-up for this programme was the implementation of an incentive scheme to promote the purchase of high-efficiency AC units.

To unlock the full potential of energy efficiency in building, Tarshid, the National Energy Services Company, was established to retrofit government facilities and to develop a thriving ESCO sector in the Kingdom. For industry, the implementation of an energy-efficiency framework for industrial plants has led to a 1.7% reduction in energy intensity in steel production, 2% for cement and 2.8% for petrochemical plants.

A few barriers to watch out for include the time and effort needed to conduct techno-economic analysis to set and regularly update MEPS at an appropriate efficiency metric to affect the market and stay up-to-date with market improvements in efficiency. Compliance, monitoring and transparent verification mechanisms may be needed to ensure MEPS are fully implemented. They may also become outdated quickly if market transformation occurs faster than anticipated as a result of other complementary programmes, such as energy labelling or financial incentives for more efficient product purchases.

Useful links:

- US Appliance Standards Awareness Project. <https://appliance-standards.org/national>
- International Energy Agency. 2015, “Achievements of Appliance Energy Efficiency Standards and Labelling Programs: A Global Assessment”. <https://www.iea-4e.org/projects/eest-achievements-reports>
- Zhou, N., et al. 2012, “International Review of Framework for Standards and Labeling Setting and Development”. IENL Technical Report. <https://bit.ly/36PDSj8>

Market adjustment

Shifting from feed-in tariffs to competitive bidding – electricity auctions for renewables in Brazil and India; renewable auctions in South Africa

Policy and market developments over the years have enhanced the viability of solar and wind generation as a process of market diffusion of rapidly declining tariffs through the competitive bidding process. From 2005, Brazil introduced electricity auctions that allowed for contracting renewables. The auctions replaced feed-in tariffs (FIT) as mechanisms to increase the share of renewables. As a result of the competitive bidding mechanisms, auction winners signed long-term power purchase agreements (PPAs) in which the utility is the offtaker. The policy was designed based on three pillars: (1) competition for the market (auctions), awarding long-term PPAs to the most competitive bid – which corresponds to the lowest offer for the right to supply electricity; (2) mandatory output purchase by long-term PPAs from electricity distribution companies (DisCos) (20–35 years) – the right to supply DisCos; (3) renewable energy – supported by subsidies policy based on reduced transmission and distribution tariffs paid by electricity consumers.

In India, auctions for solar power were launched in 2010 and the first ever for wind energy was conducted in 2016 by the Solar Energy Corporation of India (SECI). When the National Solar Mission was initially rolled out, neither government agencies nor developers had much experience in installing solar power projects, nor was there a supply chain in existence. With subsequent auctions, intense competition to get into a new sector resulted in aggressive bidding, leading to continued drops in tariffs.⁴ Various regulatory interventions and fiscal incentives have encouraged the private sector to actively invest in the renewables sector, resulting in its rapid growth. One of the major milestones for the sector was the transition from the FIT regime.

Since 2011, South Africa has been procuring renewables under the South African Renewable Energy Independent Power Producer Procurement Programme (REIPPPP). The competitive auction process was designed to facilitate private-sector investment into grid-connected renewable energy (RE) generation. IPPs are invited to submit bids for onshore wind, solar photovoltaic (PV), concentrated solar power (CSP), small hydro, biomass, biogas or landfill gas projects. Since its inception (to 2019) five rounds have taken place.

Success, scalability and challenges

In Brazil, electricity auctions allowed for adding 20GW of wind power generation, and solar has gained momentum. At least 15 countries in Latin America and the Caribbean have adopted auctions to develop renewable capacity, including successful undertakings in Colombia (in 2019), as well as in Argentina, Chile, Peru, Mexico and Jamaica. The World Bank adapted the mechanisms to South-East Asia (Philippines, Indonesia, Vietnam) and Africa (South Africa, Zambia, Morocco, Senegal). Between 2015 and 2019, the auctions allowed for \$50 billion of investments in non-conventional renewable energy projects in Latin America and the Caribbean. Decreasing prices were observed, ranging from \$60 to \$20/MWh in Mexico and Chile, and most of the projects were completed on time, so the cost overruns were not shifted to consumers.

In India, solar installations in 2010 were only 18MW. But by 2018 there was an uptick in the total solar PV and wind energy awarded capacity through the auction mechanism. Solar tender capacity awarded increased from 6GW in 2017 to 13GW in 2018. Wind capacity awarded at auctions increased from 2.6GW in 2017, the first year of wind power procurement, to nearly 7GW in 2018. By October 2019, utility-scale installed capacity of solar PV was over 29GW and wind was more than 37GW. At present, the total renewable capacity in India stands at 83GW, with solar and wind accounting for 66GW. The remaining 17GW is contributed by small hydro plants, waste-to-power, rooftop solar and biomass. However, these are not included in the competitive bidding process.

In South Africa, the REIPPPP resulted in the successful procurement of 6,422MW, which was procured from 112 bidders and consisted of: predominantly onshore wind and solar photovoltaic with some concentrated solar power and

other sources, of which 3,976MW is already grid-connected and operational. Since its inception, REIPPPP has resulted in: (1) 38,184GWh of energy generated from renewable energy sources; (2) carbon emission reductions of 38.8 Mton CO₂; and (3) water savings of 45.8 billion litres.

REIPPPP will continue to contribute to the security of energy supply and to ensuring a diversified energy mix in accordance with the Integrated Resource Plan (IRP – the long-term energy plan and proposed energy mix for South Africa up to 2030). In addition, REIPPPP will support the installation of up to 27.8GW of new renewables capacity between now and 2030 (made up of: 6.4GW PV, 14.4GW wind, 2.5GW hydro and 4.5GW distributed energy, cogeneration, biomass and landfill).

Competition for market entry based on auctions was largely adopted in emerging markets. However, the biggest challenge to government stems from incumbents (fuel suppliers, power generators), triggering debates on technology neutrality. In some countries, such as Colombia, the winning bidders were subsidiaries of the incumbents. Also, competitive bidding mechanisms could be justified in the initial stages of renewables technologies, but, given the development that has been achieved, the disregarding of competition as an entry mechanism to deployment of renewables is no longer justified.

Useful links:

- Ghosh, A. 2015. “The big push for renewable energy in India: What will drive it?” *Bulletin of the Atomic Scientists*, 71(4), July/August, 31-42. <http://bos.sagepub.com/content/71/4/31.abstract>
- The Economic Times. 2018. “Reverse bidding in renewable energy sector to continue”. <https://bit.ly/35L1yDN>
- Shrimali, G., Konda, C., Ali Farooquee. A., and Nelson, D. 2015. “Reaching India’s Renewable Energy Targets: Effective Project Allocation Mechanisms”. *Climate Policy Initiative*. <https://bit.ly/2TKrSSI>
- Saji, S., Kuldeep, N., and Tyagi, A., 2019. “A Second Wind for India’s Wind Energy Sector Pathways to Achieve 60GW”. *Council on Energy, Environment and Water*. <https://bit.ly/3a41nXz>
- Soto, D. D. L., et al., 2019. “Advancing the Policy Design and Regulatory Framework for Renewable Energies”. *IDB Monograph 785*. <https://bit.ly/3a8Wkp8>
- Department of Energy, National Treasury and Development Bank of Southern Africa (DBSA). “Independent Power Producers Programme (IPPPP): An Overview’ as at 30 June 2019”. <https://bit.ly/36P3NHL>
- Yuen, K. S. E., Luciani, G. and Zuma, J. 2018, “REIPPPP – a New Dawn for South African Renewables?”. <https://bit.ly/2QNFVyr>

Adjustment of social norms

UK Climate Change Act

The Climate Change Act was passed by the UK parliament in 2008 to provide a clear direction and vision for future energy use. A legally binding end target for emissions was set across the economy, independently monitored, accountable to the legislature, with clear interim milestones set in five-year budget periods 12 years in advance that establish the transition pathway to the end state. The goal was initially to achieve an 80% reduction in UK emissions by 2050 from a 1990 baseline, and it has since been reset to net zero emissions in 2019. The Climate Change Act has been instrumental in reducing the UK’s GHG emission in the past decade, and has helped to maintain consensus cross-party; however, reform will be needed to meet the net zero emissions law that was passed.

Success, scalability and challenges

The target was to deliver economy-wide emissions reduction. In 2018, GHG emissions were 44% below 1990 levels, and therefore the UK has met the first two carbon budgets (2008–2012 and 2013–2017) and is on track to meet the third (2018–2022). So far, there has been great progress on decarbonizing power – for example, coal generation decreased from 40% in 2012 to 5% in 2018. The focus is now shifting to the tougher targets with regard to industry and heat. Having an established mechanism in place has enabled the UK to lead the world in both declaring a net zero target and, critically, writing it into law.

What made it a success was the cross-party support at inception, which has been maintained through several changes of government. The establishment of a monitoring and milestone-setting body (the Committee on Climate Change) ensures that emissions targets are evidence-based and independently assessed; the committee provides annual progress reports to Parliament and a technical justification for greater accountability and ambitious action. Clear and unambiguous targets have driven government action – for example, elimination of coal-powered generation – and provided longer-range certainty of outcomes for the private sector. So far, the first two milestones have been met, the third is on target, but the fourth and fifth (to 2032) are challenging and galvanizing action.

The replicability of the Climate Change Act will be a function of national constitutional arrangements, but the principles lend themselves to adoption in multiple jurisdictions. Scalability is clear – this policy has shaped national outcomes. A breakdown of political consensus could be a potential barrier. To enable longevity, a legacy of multiparty support and repeal entailing a very high-profile act of primary legislation are the mitigators, which are all reinforced by current popular sentiment. Regular progress reporting and budget-setting highlights future challenges and barriers, including the identification of gaps in performance against the targets of current specific policies.

Useful links:

- UK Legislation, “The Climate Change Act 2008 (2050 Target Amendment) Order 2019”. <https://bit.ly/35N6CHS>

Reconfiguration of societies and markets

Direct intervention

CO2 emission performance standards for new passenger cars in Europe

The European Commission sets targets for the maximum CO2 emissions from passenger cars and vans sold every year in the EU. These limits – in gCO2 per km – apply to the average emissions of automotive manufacturers' sales. This rule is part of the EU's overall GHG emissions reduction policy and will contribute towards those goals by forcing the reduction of CO2 output from cars and vans sold in Europe.

The regulation is in principle technology-neutral. However, the stringency of the targets, as well as the intention to continue lowering them, implies that a substantial share of new sales will have to be zero-emission or very low emission vehicles. These will mostly be electric vehicles and it is expected that up to half of new sales in 2030 will have to be electric to meet the targets in Europe.

Such regulatory schemes are effective in reducing CO2 emissions from cars, and pushing the adoption of alternative and cleaner technologies in other places, as well. For example, the fuel efficiency regulations in China are combined with other policies – such as EV sales quotas – to drive the adoption of electric cars. In contrast, the current review of similar rules in the US may result in relaxed emissions targets, and several automotive manufacturers seem to be holding back on further deployment of EVs there.

Success, scalability and challenges

In 2020 and 2021, the target is 95 gCO2/km; in 2025 it will be 15% lower than that and in 2030 37.5% lower than 2021 levels. Some flexibilities are available to meet the targets – such as for introducing new technologies and electric vehicles. By 2030, new cars sold in Europe will have to emit on average one-third of what they did in 2000. Missing the targets results in high penalties, at €95 for every gCO2/km above the target.

The average CO2 emissions from new passenger cars dropped by 30% between 2000 and 2018. Most of the reduction has happened since 2007, when the European Commission announced its intention to regulate emissions. However, in 2017 and 2018 CO2 emissions from cars actually increased and the automobile industry as a whole will probably miss the 2020 and 2021 targets. The main reasons for that outcome is the rapid decline in diesel vehicle sales in Europe and consumers' choice of heavier and less efficient vehicles. The automobile industry has responded to that, with several companies committing to the development of battery electric (BEV) and plug-in hybrid

electric vehicles (PHEV) as a means of reaching their targets. The 2025 and 2030 targets are stringent and are the biggest force behind the acceleration of electrification investments by practically all car manufacturers selling in the EU.

Emissions targets from cars have to balance the requirement for quick CO2 reductions with the relatively longer timescale of automotive technology development. It can be challenging to achieve this in a technology-neutral manner while allowing companies to generate profits. Flexibilities, such as credit trading (which is implemented in the US), give companies the opportunity to comply with the rules and navigate the volatile automobile market.

Useful links:

- European Commission. 2019, “Reducing CO2 Emissions from Passenger Cars”. <https://bit.ly/2FLgLKB>
- European Commission. 2019, “Post-2020 CO2 Emission Performance Standards for Cars and Vans”. <https://bit.ly/2NloX8C>
- European Environment Agency. 2019, “Monitoring of CO2 Emissions from Passenger Cars – Regulation (EC) No 443/2009”. <https://bit.ly/36KnVux>

Market adjustment

Canadian carbon tax

The emissions that drive climate change – most notably, carbon dioxide (CO2) – are referred to as externalities, because, without intervention, the full social cost of these emissions is not taken into account in the decisions that consumers or producers of goods make. Putting a price on carbon dioxide emissions is an essential framework policy for reducing emissions, as it changes the incentives that consumers and producers face at a massive scale. Taxing carbon increases the cost of carbon-intensive goods, increasing the relative competitiveness of low-carbon goods, helping these low-carbon goods diffuse more rapidly.

The Canadian system for carbon pricing – while still nascent – represents a promising approach for reducing emissions while maintaining political support and improving distributional equity. Many Canadian provinces – including British Columbia – have had carbon pricing schemes in place for years. However, many provinces have not. As of April 2019, a federal “backstop” carbon price will be applied in all Canadian provinces without their own programme in place. (Alberta's backstop programme will start in 2020.) The backstop carbon price will start at CAN\$20 per ton of CO2 and rise to CAN\$50 per ton. This tax is applied to fuels

such as oil and natural gas. For very large emitters – such as industrial companies and power plants – a benchmark-based system will penalize companies that emit more than an efficient alternative and reward those producers that emit less than the alternative. Over time, the benchmark increases in stringency. The plan alone is expected to reduce emissions by 8.3% by 2020 – a significant impact in a very short period of time.

The revenues from carbon taxing schemes can be used in any number of ways. For example, they can be used to support investment in new low-carbon energy, sent back to individuals as a rebate or paid out to emitters to help lower the burden of the emissions pricing scheme. The Canadian carbon tax system uses a combination of these approaches. Rebates for lower emitters are given to individuals such that the average family is expected to see a net benefit (that is, make money). Further, additional rebates and support are targeted at potentially vulnerable communities such as rural communities and indigenous peoples. Finally, some revenues are used to incentivize low-carbon alternatives.

The primary goal of the carbon pricing scheme is to reduce harmful GHG emissions and accelerate clean energy growth. These were also among the primary goals in the Canadian case. The carbon pricing scheme is considered a critical part of the Canadian government's plans to meet its targets under the Paris Climate Agreement. An additional goal of the Canadian carbon pricing scheme was to protect vulnerable populations. This is achieved through its targeted rebate scheme. Because of the rebate design and the fact that low-income individuals emit less carbon on average than higher-income individuals, low-income populations are expected to see the largest benefits from the programme.

As noted above, the programme is expected to drive substantial emissions reductions. The existing GHG pricing schemes have already delivered substantial emissions reductions. For example, the tightening of the old emissions pricing scheme in Alberta between 2017 and 2018 drove a roughly 10% year-on-year reduction in coal generation. Further, the clean energy economy in places such as British Columbia has expanded rapidly since 2010, generating billions in revenues.

Useful links:

Government of Canada. 2019, "Pricing Pollution: How It Will Work". <https://bit.ly/36OjajN>

The Globe and Mail. 2018, "Carbon Pricing in Canada: A Guide to Who's Affected, Who Pays What and Who Opposes It". <https://tgam.ca/2NkKT3O>

Government of Canada. 2019, "Backgrounder: Climate Action and Indigenous Peoples". <https://bit.ly/2RbUxH1>

Swedish carbon tax

Sweden's carbon tax has been the single most important policy promoting renewable heat. The aim has been to help reach the government's climate and energy transition

goals by increasing the cost of fossil-fuel consumption. It was introduced in 1991 alongside the existing energy tax and is levied on all motor and heating fuels in line with their carbon content. Having begun at SEK250 (€24) per metric ton of CO₂, the carbon tax reached SEK1,180 (€114) in 2019 – making it the highest carbon tax in Europe. Industry has paid a reduced rate, depending on the sector, but these concessions are being phased out.

The carbon tax has been effective not only due to its tax rate but also because it has been increased gradually, giving consumers and industry time to adjust. In addition, the increases have often been combined with tax reliefs elsewhere in the economy to avoid a rise in the overall level of taxation.

Success, scalability and challenges

Sweden has a long history of environmental taxes, having begun taxing energy sources in the 1920s, and the revenues from the carbon levy are allocated to the general budget. These funds may be used for specific purposes linked to the tax such as mitigating negative distributional consequences or financing climate-related measures. Such factors have helped to build support from the public for environmental taxes. As a result, the carbon levy played a key role in the 35% increase in energy consumption from district heating (heating that comes from a central plant within the district) for residential and commercial usage between 1991 and 2016. In addition, the share of biomass in the input energy used by district heating expanded from 14% to 62% over the same period.

A carbon tax can be an effective way to promote energy efficiency, switching to cleaner fuels, etc. But it depends significantly on the rate and base, including any concessions. It is cheaper to implement and administer than an emission-trading programme, for example. Any distributional effects should be taken into account and revenue may be used to boost public acceptance. In the case of Sweden, consumers also had access to alternatives to fossil fuels – through the expansion of the district heating network and the increase in renewable power. If a carbon tax is too high and is imposed on a sector exposed to global competition, there could be a risk of carbon leakage. In Sweden, industries covered by the EU emissions trading system (ETS) have been exempt from the carbon tax, while those outside the emission-trading programme initially paid a reduced rate.

Useful links:

– Government Offices of Sweden. 2019, "Sweden's Carbon Tax". <https://bit.ly/30g8mZ7>

Western Energy Imbalance Market (EIM). Enhancing coordination of electricity production in the western United States

The rapidly expanding western Energy Imbalance Market – or EIM – in the US is a recent example of the success of regional electricity markets. The EIM is a real-time electricity market that enables power producers to trade energy to find the least-cost way to meet load at any given time.

As the penetration of renewable energy grows, the challenge of balancing renewables production and demand will become increasingly pressing. Organized energy imbalance markets and wholesale electricity markets represent a promising avenue to enabling this supply-demand balancing across wide areas. Enhanced balancing can reduce renewables curtailment, enable further diffusion of renewable and zero-carbon energy and bring other economic benefits. A broad portfolio of policies and market constructs is needed to develop a well-functioning electricity market that efficiently drives emissions to zero. Nonetheless, recent experience and research have shown the potential benefits of wide-area trading and electricity system operation for the integration of zero-carbon renewable energy.

In the absence of wide area markets, utilities balance supply and demand within their own borders and through bilateral contracts with neighbouring utilities. However, during particularly windy or sunny periods, utilities outside of organized markets may curtail the production of renewables, even if utilities in neighbouring regions would like to have used this energy. Organized electricity markets prevent these and other inefficiencies by enabling utilities across wide areas to coordinate in real time. Additionally, organized electricity markets enable consumers to more easily procure energy, creating a route for zero-carbon energy to reach consumers.

The EIM is made possible by a portfolio of policies and regulatory bodies. First, policies at the federal level established regulatory authority over the regional electricity trade. This regulatory body (the Federal Energy Regulatory Commission) established a number of regulations – most notably, Order 888 in 1996 – that require utilities to provide “open access” to transmission infrastructure. This regulation provided the initial framework for organized electricity markets in the US. The EIM was established in 2014 following regulatory authorization from the California Public Utilities Commission and the Federal Energy Regulatory Commission. Since its establishment, nine members have joined across eight US states and the Canadian province of British Columbia. Eleven additional members plan to join by 2022. In most cases, these member utilities must be granted regulatory approval by state and federal regulators before joining.

Success, scalability and challenges

The EIM was established to improve the efficiency of electricity production, and has been an astounding success to date. The market estimates that it has delivered more than \$800 million in economic benefits – such as lower energy costs and transmission revenues – to its member

utilities from its inception in 2014 through October 2019. Further, the EIM has reduced renewable energy curtailment by more than 976,000Mwh, lowering carbon dioxide emissions by more than 418,000 metric tons. This is the equivalent of removing 1 billion passenger road miles or reducing coal usage by more than 200,000 metric tons. Further, the EIM enabled an acceleration in corporate renewables procurement. In fact, corporate renewables procurement accounted for nearly 25% of all new renewable energy purchases in the US in 2018.

The EIM’s success is enabled by a variety of factors. Participation in the EIM is voluntary, meaning that utilities and their regulators can choose to leave or join based on the perceived benefits. Joining is preceded by a robust study of the potential impacts of joining, enabling all parties to understand these impacts. Stakeholder processes also enable affected parties to have their voices heard. Finally, governance of the EIM is split between several committees, with input provided by various stakeholders, independent observers and the EIM’s members. While the EIM’s unique structure may not be directly replicable in other regions, the experience with – and potential benefits of – wholesale electricity markets can be and has been replicated globally.

Useful links:

- Western Energy Imbalance Market. 2019, <https://www.westerneim.com/>

Adjustment of social norms

Cooking fuel access in India – “Give up subsidy” campaign: Direct Benefit Transfer for LPG (DBTL), Give It Up campaign and Pradhan Mantri Ujjwala Yojana (PMUY)

There is greater access to clean cooking energy in urban India than in its rural counterpart, with a significantly higher proportion of urban households primarily using liquified petroleum gas (LPG). Keeping in mind the United Nations Sustainable Development Goal (SDG) 7 to ensure access to affordable, reliable, sustainable and modern energy for all, the Government of India has made efforts to significantly enhance access to clean cooking energy through a series of transition policies to increase the access and affordability of LPG across India.

The Direct Benefit Transfer for LPG (DBTL), Give It Up campaign and the Pradhan Mantri Ujjwala Yojana (PMUY) subsidy reforms had several approaches: to reduce diversion of subsidised LPG by eliminating the price difference between commercial and domestic cylinders, encouraging well-to-do households to voluntarily give up their subsidy, and increasing adoption of LPG among poorer households. The aim of these cooking fuel policy reforms was to encourage and enable poor people to access modern energy services. PMUY and the Unified Guidelines for the Selection of LPG distributorships addressed the high upfront cost of an LPG connection for poor households and its unavailability in rural areas, respectively.

The overall objective has been to enable a permanent shift from traditional fuels (a significant source of household air pollution [HAP]) and empower women in rural sectors. The policy interventions have been a combination of subsidy reform and targeting, behavioural nudges, direct support to households and improving the clean cooking fuel retail network. These have been delivered via four schemes within the LPG programme: (1) Pratyash Hanstantrit Labh (PaHaL) or Direct Benefit Transfer for LPG Subsidy (DBTL); (2) the Give It Up campaign; (3) Pradhan Mantri Ujjwala Yojana (PMUY); and (4) the Unified Guidelines for Selection of LPG distributorships.

The application of these policies has been pan-India. DBTL was initially launched as a pilot programme in 2013, then on 1 January 2015 was implemented nationwide, with subsequent changes and improvements from the pilot programme. The Give It Up campaign was launched in March 2015, following which the PMUY was introduced in May 2016, and the Unified Guidelines for Selection of LPG distributorships became effective in all locations from June 2017.

Success, scalability and challenges

The schemes have achieved much of the intended impact with respect to reaching low-income and marginalized groups, including a majority of the population. As of September 2019, 80 million families had already been provided an LPG connection under the PMUY. As of March 2019, 42.3 million duplicate, fake/non-existent or inactive LPG connections had been blocked from receiving the subsidy, due to checks instituted under Know Your Customer and DBTL. DBTL itself was implemented via a combination of financial inclusion (Jan Dhan, or the opening of bank accounts for poor households) and biometrics-based identification (Aadhaar). The schemes have focused on inclusion and equity, along with improved efficiency.

In order to achieve significant progress in sustained clean cooking energy access, there is a need to develop a coherent strategy that integrates access to clean cooking energy with broader programmes for rural and human development. Consumers along the spectrum of poverty may require different amounts of subsidy to afford the use of LPG. Improved targeting and rationalization of use-based subsidies would provide a greater pool of subsidy to the poorest households. Even though the Give it Up campaign attempted to remove the subsidy from economically well-to-do households (about 10 million households surrendered their subsidy voluntarily), 90% of India's non-poor population still receive the LPG subsidy. Following the launch of PMUY, the government started LPG Panchayat, a community-level platform to facilitate interaction among new and old LPG installations, particularly aimed at women, to educate them about the benefits of LPG and address their queries on its use.

However, given the multidimensional nature of poverty, access to an LPG connection does not necessarily translate into sustained use. For PMUY consumers, the recovery of the loan taken during connection acts as a hindrance when they have to pay the market price for the first few cylinders until

the loan is recovered. These households have been identified as the most deprived as per government data, reinforcing the need to think about affordability of the recurring cost of LPG for such households. There are also challenges of awareness at the beneficiaries' end regarding the receipt of subsidy transfer, information gaps and lack of financial inclusion that limit many households from using it regularly.

Useful links:

- Ghosh, A. and Ganesan, K. 2015, "Rethink India's Energy Strategy". *Nature* 521, 14 May, 156–157. <http://www.nature.com/news/policy-rethink-india-s-energy-strategy-1.17508>
- Patnaik, S., Tripathi, S. and Jain, A. 2019, "Roadmap for Access to Clean Cooking Energy in India". The Council on Energy, Environment and Water. <https://bit.ly/2NmFDN1>
- Soman, A., Gerasimchuk, I., Beaton, C., Kaur, H., Garg, V. and Ganesan, K. 2018, "India's Energy Transition: Subsidies for Fossil Fuels and Renewable Energy, 2018 Update". The International Institute for Sustainable Development and the Council on Energy, Environment and Water. <https://bit.ly/2sgeLqy>

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Endnotes

- 1 ARPA-E History, <https://arpa-e.energy.gov/?q=arpa-e-site-page/arpa-e-history> (link as of 30/1/20).
- 2 APRA-E Impact, <https://arpa-e.energy.gov/?q=site-page/arpa-e-impact> (link as of 30/1/20).
- 3 Rocky Mountain Institute, “World’s Leading AC Manufacturers and Innovative Technology Companies in Running for the Global Cooling Prize”, <https://bit.ly/2S0RKB1> (link as of 30/1/20).
- 4 The Economic Times, “Solar Tariffs in India Have Fallen by 73 Percent Since 2010”, 24 March 2017, <https://bit.ly/2U833tN> (link as of 30/1/20).



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