PART 2: SUPPORT ENERGY EFFICIENCY AND LOW-CARBON CHOICES

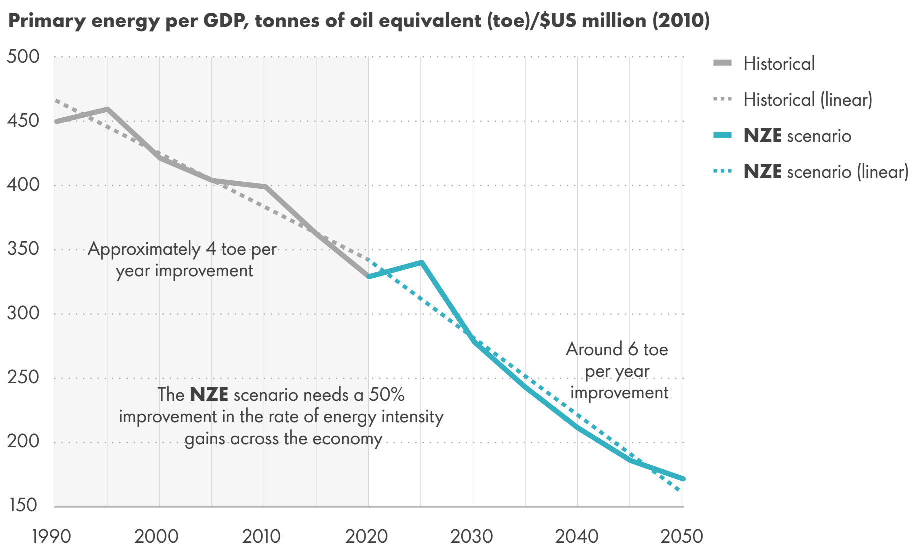
The main challenge India faces in developing a net-zero emissions energy system is how to effectively adopt and deploy new and efficient technologies and avoid expanding the economy through legacy systems and approaches. Targeting net-zero emissions by around mid-century sets a tight adoption timeline and will challenge the widespread use of current energy technologies. New energy technologies and efficient practices will need to be advanced in all sectors of the economy. Every choice made from now on will be important, due to the long lifespan of energy infrastructure.

Specific challenges could be overcome through modal shifts, such as a focus on high-speed rail as an alternative to domestic air travel or the use of 3D printing technologies for local manufacturing, rather than relying on long-haul freight from manufacturing centres. Shape-forming materials will still require haulage, but they may be common across a wide range of goods, leading to efficient distribution into cities.

Energy efficiency

A transition towards more efficient processes, technologies and end uses will further improve the energy intensity of the economy. This is critical for decarbonisation and is already a key component of India's energy security and climate mitigation strategies. Improvements in energy efficiency are particularly significant in the industrial, residential, commercial and agricultural sectors.

Figure 9: Efficiency improves the energy intensity of the economy



Source: TERI and Shell analysis based on IEA, World Bank and TERI data

As renewable power generation increases, decarbonisation of the commercial sector will require a transition towards more efficient buildings that are powered only by electricity. The success of the **NZE** scenario depends on creating an enabling environment for commercial builders to follow the Energy Conservation Building Code 2017[13] that renders a complete shift to efficient buildings by 2050. Furthermore, public infrastructure such as lighting should meet the highest achievable efficiency standards by 2050. Such a move would build on the current national street lighting programme that is targeting replacement of all India's conventional street lights with more efficient LED variants.

In the residential sector, benchmarking of energy-efficient appliances with star-labelling to inform consumer choices can facilitate a complete switch to efficient electric appliances by 2050.

Energy is used at various stages in the agricultural sector, ranging from tilling and irrigation to harvesting and threshing; the most energy-intensive operations being land preparation and irrigation. A pathway towards net-zero-carbon emissions in the agricultural sector requires targeted efficiency interventions at these stages, such as a complete switch to efficient agricultural machinery including pumps, tractors and tillers.

Industry sector decarbonisation requires attaining maximum levels of industrial energy efficiency, along with electrification of processes or switching to zero-carbon or low-carbon fuels. The focus on improving industrial energy efficiency through programmes such as Perform Achieve and Trade[14] should continue, so that efficiencies in core industries reach the global best levels by 2050 in all sub-sectors.

While the transport sector relies heavily on fossil fuels at present, electrification drives significant efficiency improvements and emission reduction aspirations in the sector.

As India rapidly develops, with growth around 5% annually on average through to 2050, efficiency measures and electrification of energy services limit growth in primary energy demand to double that of current levels. This represents an improvement in energy use per GDP of nearly 60% and a rate of improvement well above historical levels.

Carbon pricing and a vibrant market

Putting a cost on CO_2 emissions continues to be the preferred driver for change in the energy system. Carbon pricing can be enacted in many ways, with the most direct and effective approaches being taxation (e.g. British Columbia's Carbon Tax) or the development of an emissions trading system such as that of the EU. These approaches result in an explicit carbon price; governments can even set specific prices in the case of taxation. India currently has a compensation rate on coal production, called the Goods and Services Tax Compensation Cess, which is set at 400 rupees per tonne.

Many countries are considering adopting carbon pricing as the implementation of the Paris Agreement gains global momentum. However, there are also concerns that carbon pricing could leave the country exposed competitively. There are several ways of addressing this issue, the most popular being the implementation of border tax adjustments based on the carbon footprint of imported goods. Countries without domestic carbon pricing could find their export industries undermined by such developments.

The government can use the revenue raised by explicit domestic carbon pricing to compensate people and communities for the price impact that the mechanism creates. Alternatively, governments might consider introducing an implicit carbon price, through a carbon standard implemented within the energy value chain. In such cases, the financial impact is still there but it is far less transparent.

Should the government implement a carbon pricing system underpinned by tradable compliance units, consideration could be given to allowing the units to be exported or permitting equivalent units to be imported from other countries for compliance. This trade would be governed by the rules of Article 6 of the Paris Agreement; it offers flexibility and a likely lower-cost route for India to deliver on its nationally determined contributions. Export of carbon units could bring valuable foreign investment into the energy system as project developers seek to make use of the market opportunity presented by the Article 6.4 mechanism.

Material efficiency[15]

By 2050, half of India's population will live in cities, and municipal solid waste could increase to more than 400 million tonnes a year. This is considerably more than the 62 million tonnes of municipal solid waste generated by cities in 2016. Only 70% of that waste was collected, with the remainder disposed of in open landfills, without proper treatment or containment. In rural areas, agricultural waste, including crop and animal residues, are often burnt in the fields or used as traditional household fuels. Much of this waste could be used beneficially as renewable energy or materials, but new transformative solutions are needed rather than incremental improvements.

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In the circular economy, industrial and consumer waste will replace virgin materials, in effect eliminating inefficient and harmful waste disposal. Many existing waste streams are underused. For example, 85% of municipal solid waste comprises a mixture of biomass and other combustible materials, offering a potential energy-rich fuel. Likewise, coal combustion residues from power plants – such as fly ash, bottom ash, boiler slag and flue gas desulfurisation residues – can be used in concrete and cement production, structural fills and some building products.

By collaborating across industry boundaries, companies can avoid landfill costs and reduce material procurement expenditure by converting industrial or municipal waste into feedstock for other industrial processes, thus turning waste into profit. Policy intervention will be required to drive substantial change, and successful implementation will require stimulus for innovative demonstration programmes at local and regional levels.

Consumer and business choices

Simple domestic changes across a very large country such as India can lead to huge transitional impacts and potential economic opportunities. For example, in the USA more than 80% of Americans have flown in a plane,[16] but most people in India have yet to do so. This will change rapidly as household income rises, but high-speed rail running on renewable electricity could offer a much lower carbon emissions alternative, at least for domestic travel. At the local level, Indian families occupy dwellings with an average size of 50 square metres,[17] but in Japan an average dwelling is nearly twice the size[18] and double that again in the USA.[19]

India has a population of almost 1.4 billion people in some 300 million households. At the household level, ownership of domestic appliances such as washing machines, refrigerators and air conditioners is relatively low, varying between 15% and 30%, depending on the appliance.[20] As the country develops over the coming 30 years, appliance ownership may well head towards the 90% level seen in much of the world. Once in use these appliances will consume energy, so the choice of model and efficiency rating will be important. These appliances could add 300-500 terrawatt-hours a year to electricity demand, nearly a third of that generated in 2019, but lower efficiency choices might double this amount.

India has already committed to the further development of its vast rail network through the introduction of high-speed trains. In 2016, the National High Speed Rail Corporation Limited was incorporated with the objective to finance, construct, maintain and manage the proposed high-speed rail corridors between major cities in India. Several high-speed rail corridors have been identified, and a survey of the proposed link between Delhi and Varanasi is already under way.

In the transport sector, vehicle choices will be important. Set foot in any city in India and it is the ubiquitous three-wheeler, often known as a tuk-tuk or auto rickshaw, that is bound to offer a ride within moments. Today, there are some 10 million three-wheelers offering taxi services, ride-sharing and local freight haulage in India. The majority are running on diesel fuel, but compressed natural gas is also popular.

The government has initiatives under way to electrify three-wheelers, with the goal of all sales (currently around 650,000 a year) being electric by 2030. But a rapid transition towards net-zero emissions needs to see the entire fleet operating on electricity by 2030. Choices made by drivers as they enter the tuk-tuk market or buy a new vehicle will be critical for a faster rate of change.[21]

A three-wheeler transition also offers the opportunity for Indian businesses to develop and deliver the first generation of electric transport infrastructure, gaining experience and technological advantage in a market that needs to change. With the large export market for three-wheelers, such a transformation could further strengthen India's position in the global market.

PART 3: REMOVE UNAVOIDABLE EMISSIONS

Focusing on the available levers should not divert attention away from the need to address the unique issues related to hard-to-abate sectors. These are sectors where the pathway to decarbonisation may not be apparent or where it rests on technologies which are still in development. Foremost among these is aviation, which is growing rapidly in India. By 2050, air traffic in India could reach the same level as the USA in 2019. However, long-haul freight will also grow quickly. Both aviation and heavy transport will require solutions ranging from synthesised hydrocarbon fuels, initially from biomass, to the use of hydrogen or possibly stored electricity for some short routes. These could take several decades to mature, which requires balancing the emissions from these sectors with carbon removal using nature or technology.

Significantly, the **NZE** scenario does not plot a pathway to full decarbonisation. Fossil fuel dependency remains through to mid-century and beyond, although in the **NZE** scenario this is largely limited to the industrial sector. The ongoing use of fossil fuels points to the need for India to deploy CO_2 sinks in some form.