

# Role of Energy Efficiency for Low Carbon Transformation of India

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Globally there is a greater commitment among national governments towards the achievement of the global 2 °C temperature stabilisation target and doubling the rate of energy intensity improvement. India's energy demand and energy imports have risen sizably over the past two decades. In 2014, India imported 83 % of its oil, 29 % of coal and 68 % of natural gas demand. Improving energy efficiency (EE) is identified among the prominent options in India's Nationally Determined Contributions (NDC) communicated to the Paris Agreement. EE, other than mitigating carbon emissions, also contributes to improving energy security and air quality. EE measures are hence pervasive as they anchor efficient and cleaner technologies in the supply-chain covering production, distribution and consumption. This paper analyses role of EE technologies, policies and measures in India under global carbon emissions mitigation scenarios that target temperature stabilisation 'well-below 2 °C'. The analysis is carried out using ANSWER-MARKAL, an energy system optimisation model. The analysis focuses on high impact opportunities including the energy intensive industry sectors (electricity supply, industry and transport). The results are reported for medium-term (year - 2030) and long-term (year - 2050). The analysis concludes that energy efficiency measures reduce CO<sub>2</sub> emissions, promote cleaner production by reducing fossil-based energy and deliver benefits of energy security and improved air quality. The paper finally highlights the elements of the policy roadmap for transitions towards clean and energy efficient technology future in the medium and long-term.

## 1. Introduction

Energy efficiency (EE) is widely recognised approach to achieve a low carbon sustainable energy transition. EE measures and technologies are viewed as low hanging fruits for their ability to deliver wide ranging benefits at lower cost. Some of these benefits accrue from behavioural changes, e.g. maintenance of cars, air pressure of car tyres, switching off of lights/appliances, car pool etc. Many EE measures, especially in developing countries require infrastructures (e.g. road networks to avoid congestion, metro networks,) but these also provide opportunities for low cost transitions towards sustainable low carbon societies. The global SE4ALL initiative of the United Nations envisages a sustainable energy transition with a key focus on improving energy access, increasing share of renewable energy and improving EE.

Achieving clean and sustainable energy transition is a priority for the Government of India and a means for achieving the Nationally Determined Contribution (NDC). Within the overarching ambit of the Energy Conservation Act 2001, the Government of India has prioritised EE in several national programs. These demand side EE measures compliment the supply interventions of renewable energy technologies to achieve the low carbon sustainable energy transition. Notable programs include Perform Achieve Trade (PAT) for industrial efficiency, fuel efficiency standards for cars, codes for green buildings and appliance labelling. An analysis of such national programs and their contribution to the NDC of India has been done in a recent study (Vishwanathan et. al., 2017) however; a comprehensive assessment of NDC and 2 °C scenario has not been done. Understanding the relevance of EE in the low carbon context is important since rapid decarbonisation can result in higher renewables, which can reduce attractiveness of efficiency improving technologies such as combined heat and power (Phillip et. al, 2016).

## 2. Methodology

### 2.1 Scenarios

The paper assesses three future scenarios for India i) NDC Scenario ii) 2 °C scenario iii) SE4ALL plus 2 °C scenario. The scenarios span a time period till 2050. The projections for socio economic drivers are derived using logistic regressions and expert judgement for asymptotic values. Gross Domestic Product (GDP) growth happens at a Compound Annual Growth Rate (CAGR) of 7.1 % resulting in a growth of over fifteen times in 2050 relative to 2010. Growth rates for population and urbanisation follow the UN projections (UN, 2015)

#### 2.1.1 NDC scenario

This scenario considers that India follows the policy regime aiming to meet the Nationally Determined Communications (NDCs) communicated to the UNFCCC. The NDCs envisage a 33 - 35 % reduction in CO<sub>2</sub> emissions intensity of GDP by 2030 relative 2005. In subsequent period (2030 - 2050), India will continue to follow the low carbon policies aligned with NDCs.

#### 2.1.2 2 °C scenario

This scenario assumes a global carbon 'cap and trade' market and/or a 'carbon tax' regime that follows a globally cost-effective carbon price trajectory. An identical carbon price (or tax) trajectory applies to India. For this scenario, the carbon price is assumed to increase from 40 USD per t CO<sub>2</sub> in 2020 to 130 USD per t CO<sub>2</sub> in 2050 (Lucas et al. 2013). This scenario further assumes that the Indian economy would be market driven, and the social and environmental goals are 'internalised' via the instruments (e.g., carbon price) that operate through the 'invisible hand' of the market.

#### 2.1.3 SE4ALL plus 2°C scenario

This scenario follows the 'sustainability' rationale, similar to the IPCC SRES B1 global scenario (IPCC, 2000) or the pathway one of the shared socio-economic pathways (SSP1). This scenario integrates view of the social, economic and environmental goals to decouple economic growth from a resource intensive path of the 2 °C scenario. The SE4ALL scenario has the same carbon space, i.e. the available carbon emissions budget as the EE scenario and compared to the EE scenario has a more diversified portfolio of investments that include higher investments in education and health, which leads to lower fertility rates (Dreze & Murthy, 2001) and therefore lower population than EE scenario (Table 1).

Table 1: GDP and population across scenarios

	2010	NDC & 2 °C Scenario 2030	SE4ALL plus 2 °C Scenario 2030	2 °C Scenario 2050	SE4ALL plus 2 °C Scenario 2050
Population (million)	1,206	1,476	1,434	1,620	1,509
Households	247	365	356	502	473
GDP (2010 Billion USD)	1,397	6,489	6,002	25,664	23,007
GDP per capita GDP (USD)	1,158	4,397	4,186	15,842	15,247

### 2.2 Model

Scenario analysis is carried out using ANSWER MARKAL, a bottom-up energy system model. The model has detailed descriptions of end - use technology, fuels and investment options. The model optimises the overall energy system costs, while keeping consistency with system constraints such as energy supply, demand, investment and emissions (Loulou et. al., 2004).

## 3. Results and policy analysis

### 3.1 National level

The demand for energy would increase across all the three scenarios on the back of robust economic growth. A strong decoupling happens across all the three scenarios. The decoupling is stronger in the SE4ALL plus 2 °C scenario (Figure 1). The Sustainable Energy for all (SE4ALL) has put an annual target of 2.6 % at the global level for EE improvements till 2030 and in case of India this target can be met in all the three scenarios since all the three scenarios consider a robust economic growth.

The CO<sub>2</sub> emissions show a rapid increase in NDC scenario with time however due to a stronger decoupling in the 2 °C and SE4ALL plus 2 °C scenarios, the CO<sub>2</sub> emissions peak by 2040 and in the EE scenario (Figure 2). In the SE4ALL scenario these flatten out after 2020. The NDC of India has a target of reducing the emission

intensity of GDP by 33 to 35 % from 2005 level in 2030. The paper is only looking at energy related CO<sub>2</sub> emissions and here this target can be achieved in all the three scenarios.

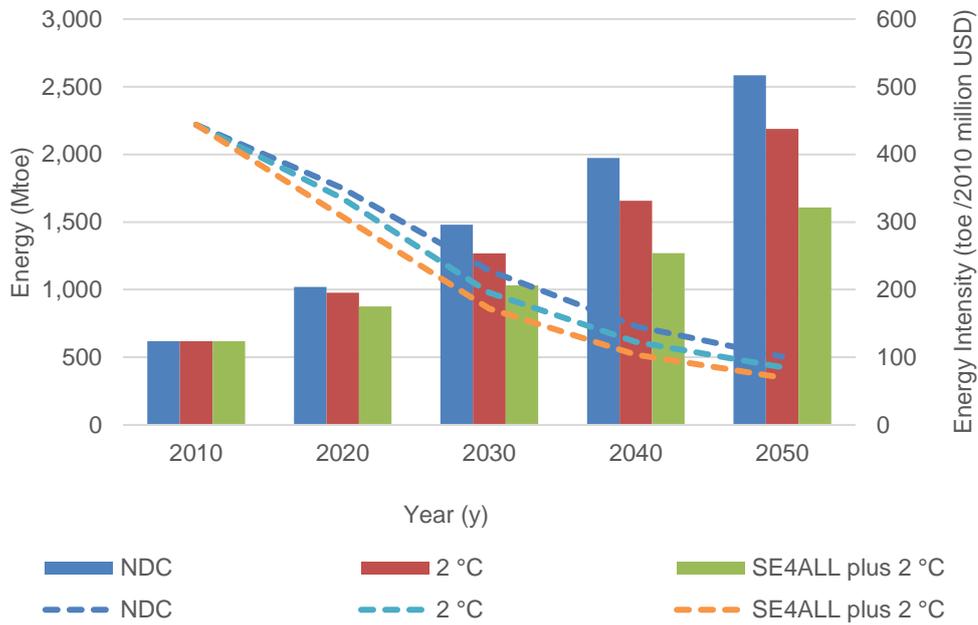


Figure 1: Energy and energy intensity across scenarios

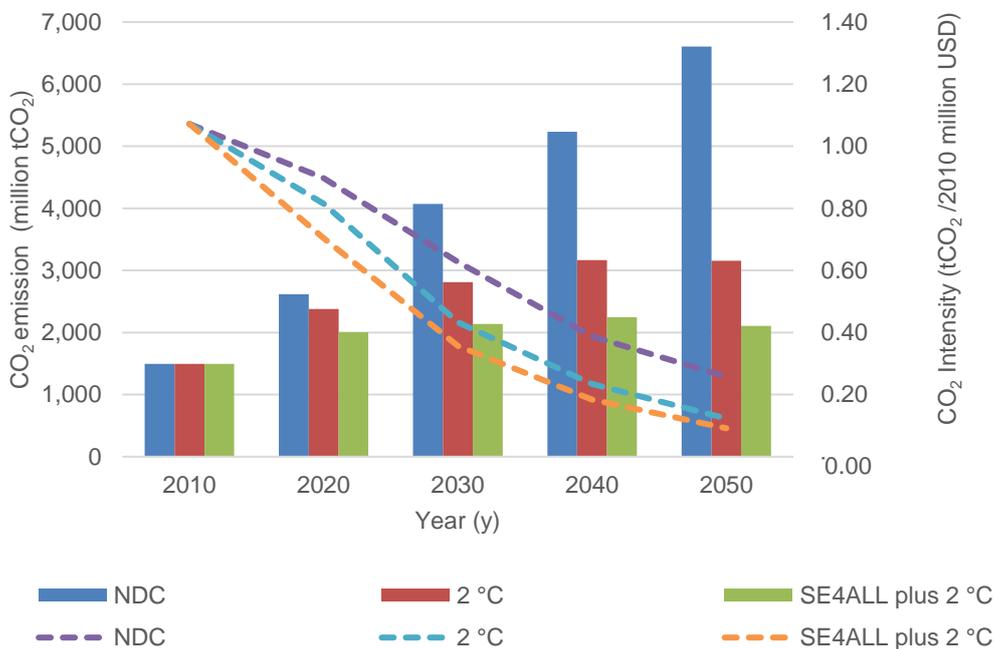


Figure 2: CO<sub>2</sub> emissions and emission intensity across scenarios

### 3.2 Electricity sector

Electricity generation increases across all scenarios however the increase in demand is slower in the SE4ALL plus 2 °C scenario (Figure 3). Electricity demand increase is faster than growth in energy since electricity plays a larger role in transportation and residential sector. Electricity generation is currently associated with the largest share of energy related CO<sub>2</sub> emissions and local air pollution.

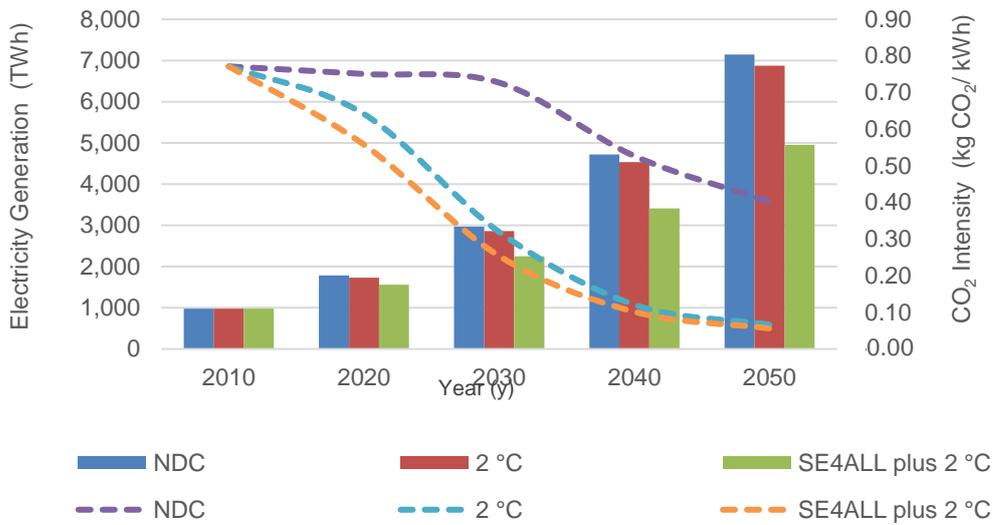


Figure 3: Electricity generation and CO<sub>2</sub> intensity of electricity

There is a strong decoupling of electricity generation from CO<sub>2</sub> emissions across all scenarios. Driven by the global sustainability goals, the SE4ALL scenario displays i) a higher EE of fossil fuel generation (Figure 4a) ii) greater diffusion of cleaner energy sources including renewables and nuclear (Figure 4b).

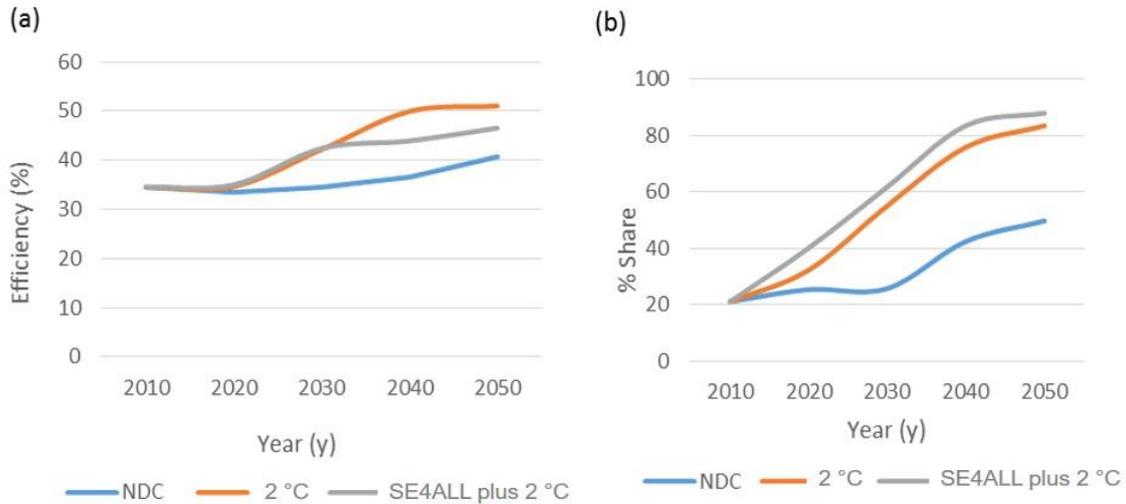


Figure 4: (a) EE of fossil-fuelled generation and (b) share of non-fossil power generation

### 3.3 Industry sector

Industry will remain the most significant energy-consuming sector. The existing per capita consumption of energy intensive products including steel, cement, aluminium, chlor-alkali, fertiliser, etc. is much below the global average (Vishwanathan et. al., 2017). This is expected to change with major growth in energy demand expected across the three scenarios.

The energy EE has shown improvement since the liberalisation of the Indian economy in 1990's. In 2008, India introduced the market-based program Perform Achieve and Trade (PAT) to incentivise and create a market for EE in eight energy intensive industries. The government is extending the scheme to more sectors and more consumers under PAT II. Despite these measures, the average EE in energy intensive sectors such as steel, cement, aluminium, and etc. in India remains below global average (Garg. et. al., 2017). In the future, rapid improvements are expected in these sectors (Figure 5b). These would help to reduce energy demand (Figure 5a) and lower CO<sub>2</sub> emissions.

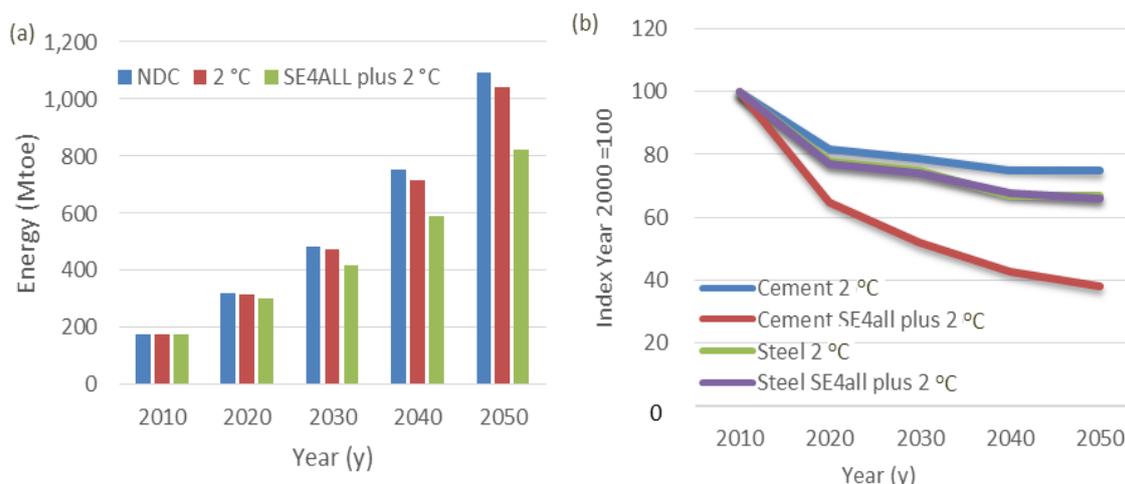


Figure 5: (a) Energy demand from industrial sector and (b) energy efficiency improvement in steel and cement sectors with respect to year 2000 which is taken as 100

### 3.4 Transport sector

The per capita passenger and freight demand in India would increase in future with the rise in incomes. The NDC and the 2 °C scenarios show a rapid increase in demand for energy from transport sector. Transport sector would take a growing share of energy and low carbon policies alone would not improve the EE in this sector (Dhar et al., 2016). The share of transport sector in final energy accordingly increases from around 15 % in 2010 to around 20 % in 2050 in the NDC and 2 °C scenario.

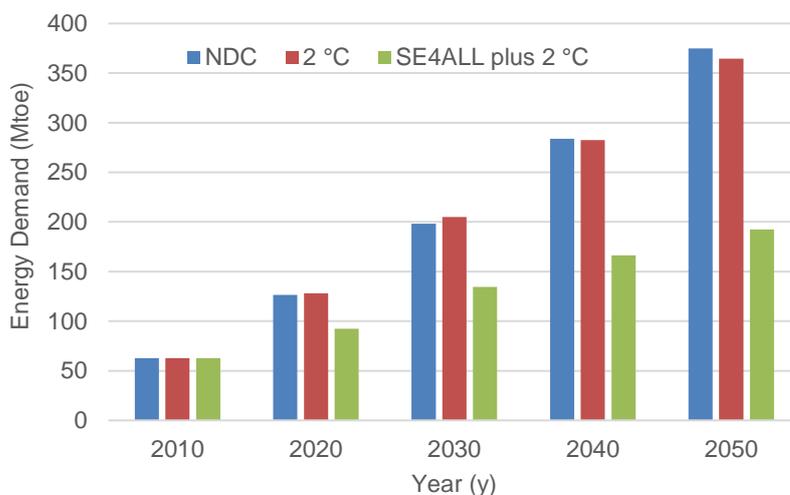


Figure 6: Energy demand from transport sector

For the NDC and 2 °C scenario, the transport energy intensity increases. In the SE4ALL plus 2 °C scenario, interventions that improve conditions for walking and cycling; provision of public transport, etc. reduce the energy intensity for passenger transport and accordingly the overall energy demand comes down (Figure 6).

## 4. Conclusions

It is desirable to achieve low GHG emission targets while decoupling the economic growth from high emissions, pollution, and resource use (Lee et al., 2016). EE is one of the accepted strategies to achieve this. Traditionally, EE was viewed as a technological intervention. By anchoring EE with SE4ALL, and broader sustainability related actions, this paper takes a departure from the conventional techno-centric approach and argues that socio-economic approach to EE provides an anchor for transformative change towards a sustainable low carbon transition.

Results show improvements in energy intensity at an aggregate level across all three scenarios. These are sufficient for meeting India's emission reduction target stated in the NDC. In the long run, EE coupled with a higher share of renewable energy will facilitate the shift towards cleaner and sustainable electricity. This has significant implications for India's low carbon transition as electricity is expected to play a greater role in residential, industry, and transport sectors. Despite advances over the last two decades, the industry sector has a large scope for improvement in EE. Low carbon policies can drive EE in the industry sector in line with national policies and programs. EE measures complement low carbon policies and sustainability actions in the SE4ALL plus 2 °C scenario driving down the overall energy intensity of the transport sector. This paper has shown that aligning EE with SE4ALL delivers multiple co-benefits. In the short run, soft measures on the demand side including technological efficiency improvements and behavioural changes can deliver quick and inexpensive solutions. In the longer time frame, the focus should be on the transformations such as towards the circular economy wherein the scope expands from EE towards dematerialisation, cleaner consumption (demand side) and production (supply side).

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