

ENDNOTES

Shell and TERI wish to thank the many people consulted externally in the development of this sketch. Special thanks go to the following for the use of source data and references: the India Ministry of Statistics and Programme Implementation, the International Energy Agency, the World Bank, the World Steel Association, the Energy Transitions Commission, and the Forest Service of India. Data used by TERI for the analysis has been derived from diverse sources, including annual statistical publications from different ministries and national organizations, statistical handbooks, annual statistical reports and journal articles.

- 1 Like the **Sky 1.5** scenario developed by Shell, **NZE** is a normative scenario. That means we deliberately look for pathways that result in a rapid transition to net-zero emission energy services, driven by market and policy trends, rather than exploring how the energy system and the provision of energy services might evolve of their own accord.
- 2 In this sketch, net-zero emissions in the energy system includes carbon dioxide (CO₂), methane (CH₄) and nitrogen oxides (NO_x) emissions related to the provision of energy. This is referred to in terms of CO₂ equivalent or CO₂e.
- 3 A Better Life with a Healthy Planet, published by Shell in 2016: [Link](#).
- 4 Carbon Dioxide Information Analysis Center, Environmental Sciences Division, Oak Ridge National Laboratory, Tennessee, USA.
- 5 The first India NDC presented at the time of the Paris Agreement: [Link](#).
- 6 As a starting point for this work, TERI developed a baseline case for India. It follows a business as usual trajectory and results in a significant rise in national emissions. Total energy demand grows by 170% through to 2050 and fossil fuel more than doubles in the same timeframe. Solar PV still has the fastest growth over the period, increasing by a factor of five.
- 7 Intergovernmental Panel on Climate Change Special Report: [Link](#).
- 8 In developing this sketch we have drawn on data and analyses available within TERI and Shell and on data from external sources such as the International Energy Agency, the World Steel Association, the World Bank and the International Renewable Energy Agency. Data used by TERI for the sketch has been derived from diverse sources, including annual statistical publications from different ministries and national organisations, statistical handbooks, annual statistical reports and journal articles.
- 9 Explore the impact of the COVID-19 pandemic in two sets of Shell scenarios, looking at the 2020s then more broadly at the shifting energy landscape through the 21st century.
 - Rethinking the 2020s: [Link](#).
 - The Energy Transformation Scenarios: [Link](#).
- 10 Muller et. al., Patterns of Iron Use in Societal Evolution, Environmental Science & Technology, Vol. 45, No. 1, 2011.
- 11 In the IPCC SR15, Table 2.2 gives a maximum carbon budget of 420 Gt CO₂, at the 67% point of the normal distribution of temperature outcomes, measured from 2018 onwards, for limiting temperature rise to 1.5°C.

- 12 Duncan G. Fullerton, Nigel Bruce and Stephen B. Gordon, Indoor air pollution from biomass fuel smoke is a major health concern in the developing world, Transactions of the Royal Society of Tropical Medicine and Hygiene, 2008, 102(9), pp.843–851: [Link](#).
- 13 Energy Conservation Building Code, Bureau of Energy Efficiency, India: [Link](#).
- 14 The Perform Achieve and Trade (PAT) scheme is a programme of the Bureau of Energy Efficiency: [Link](#).
- 15 Joseph Fiksel, Praveena Sanjay, Kavya Raman, Steps toward a resilient circular economy in India, Clean Technologies and Environmental Policy, October 2020: [Link](#).
- 16 US Department of Transport.
- 17 National Sample Survey Office, Ministry of Statistics and Programme Implementation, Government of India.
- 18 Japan Statistical Yearbook.
- 19 US Census Bureau.
- 20 The hidden truth behind India's low refrigerator ownership: [Link](#), and an article on the reasons for the comparatively low consumer interest in washing machines in India: [Link](#).
- 21 India's Rickshaw Revolution Leaves China in the Dust; why there are more e-rickshaws in India than battery-powered passenger cars in China: [Link](#).
- 22 TERI analysis assuming the average annual productivity of forests increases over time by some 30% and a doubling of productivity for trees outside forests.
- 23 William J. Schmelz, Gal Hochman and Kenneth G. Miller, Total cost of carbon capture and storage implemented at a regional scale: north-eastern and mid western United States, The Royal Society, August 14, 2020: [Link](#).
- 24 Global Carbon Capture and Storage Institute; Global storage portfolio: a global assessment of the geological CO₂ storage resource potential: [Link](#).
- 25 In comparison, the Shell Quest CCS project in Canada geologically stores about 1 Mt per year of CO₂.
- 26 Madhumitha Jaganmohan, Global module manufacturing production 2000-2019, Feb 2, 2021: [Link](#).
- 27 K. Parikh, J. Parikh and P. P. Ghosh, Can India grow and live within a 1.5 degree CO₂ emissions budget?, Energy Policy, 120, 2018.
- 28 Energy Transitions Commission. Making Mission Possible: Delivering a Net-Zero Economy: [Link](#).
- 29 T. Spencer, N. Rodrigues, R. Pachouri, S. Thakre and G. Renjith, Renewable Power Pathways: Modelling the Integration of Wind and Solar in India by 2030, TERI Discussion Paper, 2020.
- 30 World Employment Social Outlook 2018: Greening with jobs: [Link](#).
- 31 IEA, World Energy Investment 2019: [Link](#).
- 32 Non-commercial energy demand (mainly biomass for residential use) accounted for about 25% of total energy use in 2015-16, mainly comprising biomass for residential use.
- 33 Anil Kumar Jain, Our Rising Energy Imports – What All do [sic]They Mean?, NITI Aayog blog: [Link](#).

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- 34 Economic Times of India, February 27, 2020.
- 35 IPCC Special Report on 1.5°C, published in 2018: [Link](#).
- 36 Quartz India. India needs nearly 30 times more solar power to phase out coal jobs: [Link](#).
- 37 Julie Carré, Nicolas Gatimel, Jessika Moreau, Jean Parinaud and Roger Léandri, Does air pollution play a role in infertility? A systematic review, Environmental Health, July 2017: [Link](#).
- 38 Goulder, L.H. and Pizer, W.A., The Economics of Climate Change, National Bureau of Economic Research, January 2006: [Link](#).
- 39 The Green Energy Corridor Project aims to synchronise electricity produced from renewable sources, such as solar and wind, with conventional power. India's Ministry of New and Renewable Energy sanctioned the Intra State Transmission System (InSTS) project for the development and deployment of large-scale renewable energy.
- 40 Variable renewables, such as wind and solar, generate on an as-available basis rather than on-demand, requiring the sun to shine or the wind to blow to generate electricity. They also have a zero or very low marginal cost of operation once they have been built. In combination, this reduces the ability of existing wholesale electricity markets to deliver the necessary long-term investment in capacity for low-carbon generation and the required flexibility to balance renewables variability.
- 41 Will Hall, Thomas Spencer, G. Renjith and Shruti Dayal, The Potential Role of Hydrogen in India: A pathway for scaling up low-carbon hydrogen across the economy, TERI and ETC, 2020: [Link](#).
- 42 Make in India initiative: [Link](#).

LEGAL DISCLAIMER

In developing this scenario sketch, TERI and Shell have adopted a goal-oriented approach towards achieving net-zero emissions from the energy sector in India by 2050. It is rooted in stretching but realistic development dynamics today, but explores a goal-oriented way to achieve that ambition. We worked back in designing how this could occur, considering the realities of the situation today and taking into account realistic timescales for change. Although ambitious in its goal and assumptions, we believe today it is still a technically possible, but highly challenging pathway for the Indian economy. However, we believe the window for success is quickly closing and without significant action it may take longer for India to achieve a net-zero energy system. Of course, there are other possible paths for India to take towards a net-zero energy system - these depend on the technologies and policies the country prioritises.

This scenario sketch is more ambitious in its goal and assumptions than Shell's **Sky 1.5** scenario in some respects, but not all. For example, the India **NZE** scenario is more ambitious on the 2050 emissions profile of the energy system, but less ambitious on the role of CCS. Shell believes different places and sectors will move towards net-zero emissions at different paces, and all should move as fast as possible for society to achieve the goal of the Paris Agreement. This scenario sketch is not intended to be projections or forecasts of the future. Shell scenarios, including scenarios in this document, are not Shell's strategy or business plan. When developing Shell's strategy, our scenarios are one of many variables that we consider. Ultimately, whether society meets its goals to decarbonize, is not within Shell's control. While we intend to travel this journey in step with society, only governments can create the framework for success.

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