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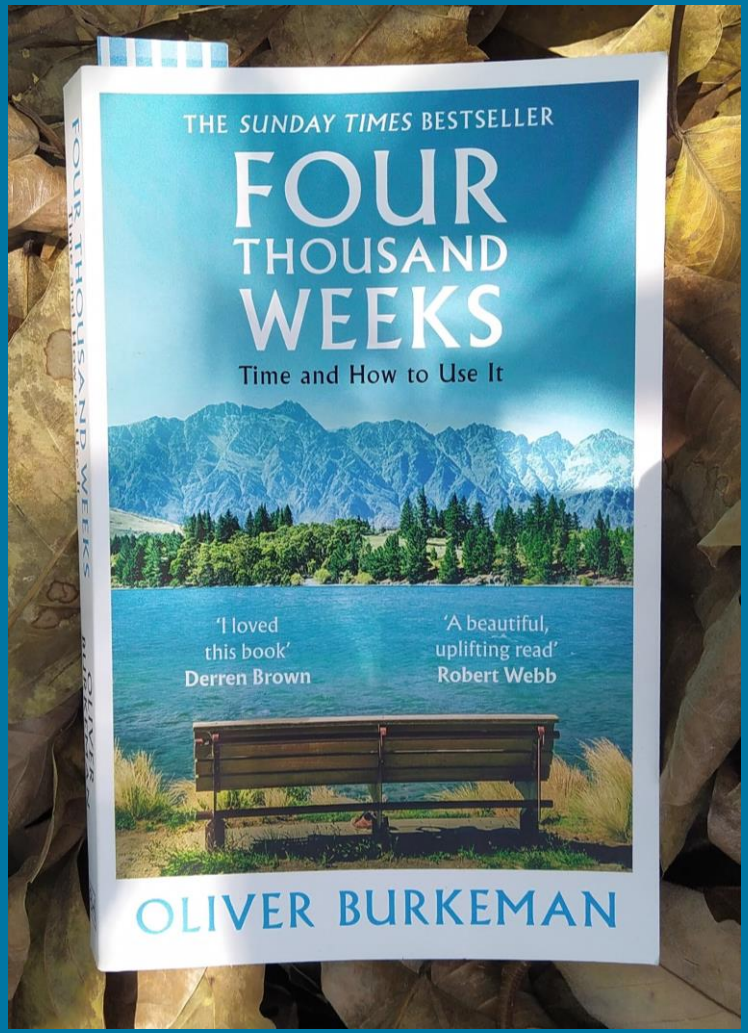
ICEMF webinar on long-term modelling pathways to achieve India's energy and net-zero goals
29th March 2022

Modeling decarbonization pathways for India

https://india.energypolicy.solutions



A model is just a thought…

"It's an expression of your current thoughts about how you'd ideally like to deploy your modest influence over the future.

The future, of course, is under no obligation to comply."

Energy Policy Simulator (EPS) for India

- Free and **open-source systems dynamics model** with **web interface**
- Created by Energy Innovation and adapted for India with WRI India
- Expert consultations during 2019-2021 to vet scenarios and assumptions
- Covers electricity, industry, transport, buildings, and land use
- Users can create “what-if” policy scenarios through 2050
- Integrates India’s input-output model (2015) to give GDP & jobs outputs
- Includes module on government revenue
- Optimizes costs in electricity & transport (subject to policy mandates)
- Technology costs assumed to fall based on projected global prices and endogenous learning
- All monetary estimates are in 2018 constant prices (1 US$ = 68.42 INR)

india.energypolicy.solutions/scenarios/home

ENERGY POLICY SOLUTIONS

ENERGY INNOVATION POLICY & TECHNOLOGY LLC v3.1.3

POLICY SCENARIO SELECTOR

Long-term Decarbonization

- Transportation
- Buildings and Appliances
- Electricity Supply
- Industry
- Agriculture, Land Use, and Forestry
- District Heat and Hydrogen
- Cross-Sector
- Research and Development
- Control Settings
- Government Revenue Accounting

POLICY SETTINGS

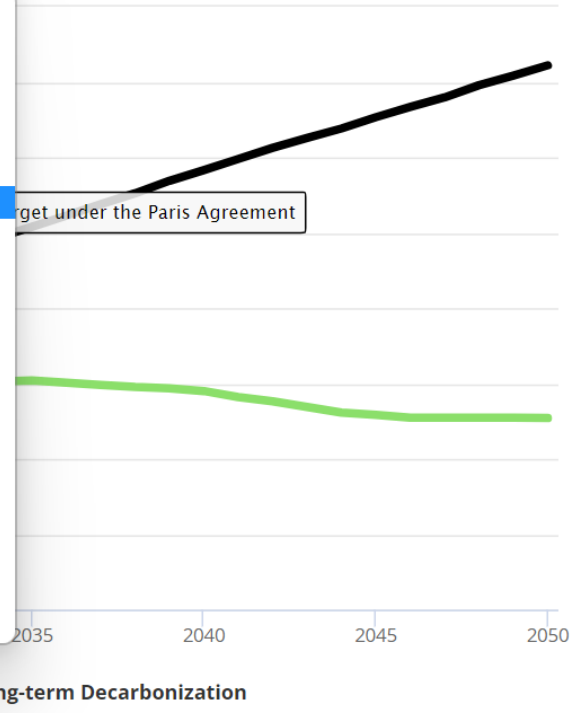
- Transportation
  - Conventional Pollutant Standards
    - LDVs PM10: 50%
    - LDVs PM2.5: 50%
    - HDVs PM10: 50%
    - HDVs PM2.5: 50%

OUTPUT GRAPH SELECTOR

Emissions: CO2e

Total (includes land use)

- Emissions: CO2e
- Emissions (by Pollutant)
- Emissions: Energy-Related CO2
- Effects by Policy: CO2e Wedge Diagrams
- Effects by Policy: CO2e Abatement Cost Curve
- Financial: Policy Package Cost/Savings
- Financial: Jobs, GDP, and Earnings
- Financial: Direct Cash Flow Changes
- Human Health & Social Benefits
- Electricity Generation, Capacity, and Demand
- Electricity: Levelized Costs, Curtailment and Water Use
- Transport: Vehicles by Technology
- Transport: Travel Demand, Fuel Use, and Emissions
- Industry: Fuel Use
- Industry: CO2e Emissions
- Buildings: Energy Use
- Energy Consumption
- Energy Exports, Imports and Production
- Fuel Costs (by Fuel, by Sector)
- Technology Costs



WORLD RESOURCES INSTITUTE

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TECHNICAL NOTE

A TOOL FOR DESIGNING POLICY PACKAGES TO ACHIEVE INDIA'S CLIMATE TARGETS

Methods, Data, and Reference Scenario of the India Energy Policy Simulator

DEEPTHI SWAMY, APURBA MITRA, VARUN AGARWAL, MEGAN MAHAJAN, AND ROBBIE ORVIS

ABSTRACT

India is currently the world's third largest emitter of greenhouse gases (GHGs) after China and the United States (WRI 2019), and is set to experience continued growth in its population, economy, and energy consumption. Exploring low-carbon development pathways for India is therefore crucial for achieving the goal of global decarbonization. India has pledged to reduce the emission intensity of its gross domestic product (GDP) by 33–35 percent relative to 2005 levels by 2030 through its Nationally Determined Contribution (NDC), among other related targets for the renewable energy and forestry sectors (GoI 2016). Further, countries, including India, are expected to respond to the invitation of the Conference of the Parties (COP) to the Paris Agreement to communicate new or updated NDCs with enhanced ambition and long-term low-GHG development strategies for 2050.

To design effective policy packages to support the planning and achievement of such climate targets, policymakers need to identify policies that can reduce GHG emissions in a timely and cost-effective manner, while meeting development-related and other national objectives. The India Energy Policy Simulator (India EPS), an open-source system dynamics (SD) model, can enable an integrated quantitative assessment of different cross-sectoral climate policy packages for India through 2050 and their implications for key variables of interest such as emissions, GDP, and jobs.

The tool was developed by Energy Innovation LLC and adapted for India in partnership with World Resources Institute. It is available for open access through a Web interface as well as a downloadable application. This technical note describes the structure, input data sources,

CONTENTS

Technical notes document the research or analytical methodology underpinning a publication, interactive application, or tool.

Suggested Citation: Swamy, D., A. Mitra, V. Agarwal, M. Mahajan, and R. Orvis. 2021. "A Tool for Designing Policy Packages to Achieve India's Climate Targets: Methods, Data, and Reference Scenario of the India Energy Policy Simulator." Technical Note. Washington, DC: World Resources Institute. Available online at: https://doi.org/10.46830/writn.21.00108.

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ENERGY INNOVATION POLICY & TECHNOLOGY LLC

WORKING PAPER

PATHWAYS FOR DECARBONIZING INDIA'S ENERGY FUTURE: SCENARIO ANALYSIS USING THE INDIA ENERGY POLICY SIMULATOR

DEEPTHI SWAMY, APURBA MITRA, VARUN AGARWAL, MEGAN MAHAJAN, AND ROBBIE ORVIS

EXECUTIVE SUMMARY

Highlights

- This working paper explores two climate policy packages for India through 2050 using the India Energy Policy Simulator (EPS), an open source, systems dynamics model. The analysis considers:
  - The NDC-SDG Linkages (NDC-SDG) scenario: Policies that leverage interconnections between India's climate actions and Sustainable Development Goals (SDGs) for 2030.
  - The Long-Term Decarbonization (LTD) scenario: Policies with high potential for greenhouse gas (GHG) emissions abatement in the long term.
- In the NDC-SDG scenario, GHG emissions are reduced by 24 percent by 2030 and 37 percent by 2050, compared to business-as-usual (BAU) levels. In the LTD scenario, the corresponding emissions reductions are 30 percent by 2030 and 65 percent by 2050. A small number of policies are responsible for most emissions reductions.
- Both scenarios yield health co-benefits from a reduction in air pollution. Relative to BAU projections, from 2020 to 2050, 5.7 million premature deaths from air pollution could be avoided in the NDC-SDG scenario and 9.4 million in the LTD scenario.
- Both scenarios lead to net cost savings in the medium to long term and show a positive impact on employment and output, relative to BAU. A carbon tax is an essential policy lever in realizing these positive impacts.

CONTENTS

Working Papers contain preliminary research, analysis, findings, and recommendations. They are circulated to stimulate timely discussion and critical feedback and to influence ongoing debate on emerging issues.

Suggested Citation: Swamy, D., A. Mitra, V. Agarwal, M. Mahajan, and R. Orvis. 2021. "Pathways for Decarbonizing India's Energy Future: Scenario Analysis Using the India Energy Policy Simulator" Working Paper. Washington, DC: World Resources Institute. Available online at https://doi.org/10.46830/wrirep.21.00096.

Long Term Decarbonization (LTD) Scenario compared with Reference Scenario (2030)

	Present	Reference Scenario (2030)	LTD Scenario (2030)
Installed non-fossil electricity capacity	157 GW	448 GW	500 GW
Share of renewable energy in electricity generation	20%	40%	52%
Emissions intensity of GDP compared with 2005	-24%*	-49%	- 61%
Cumulative emissions reduced between 2021 and 2030 relative to EPS reference scenario			- 4.8 billion tonnes

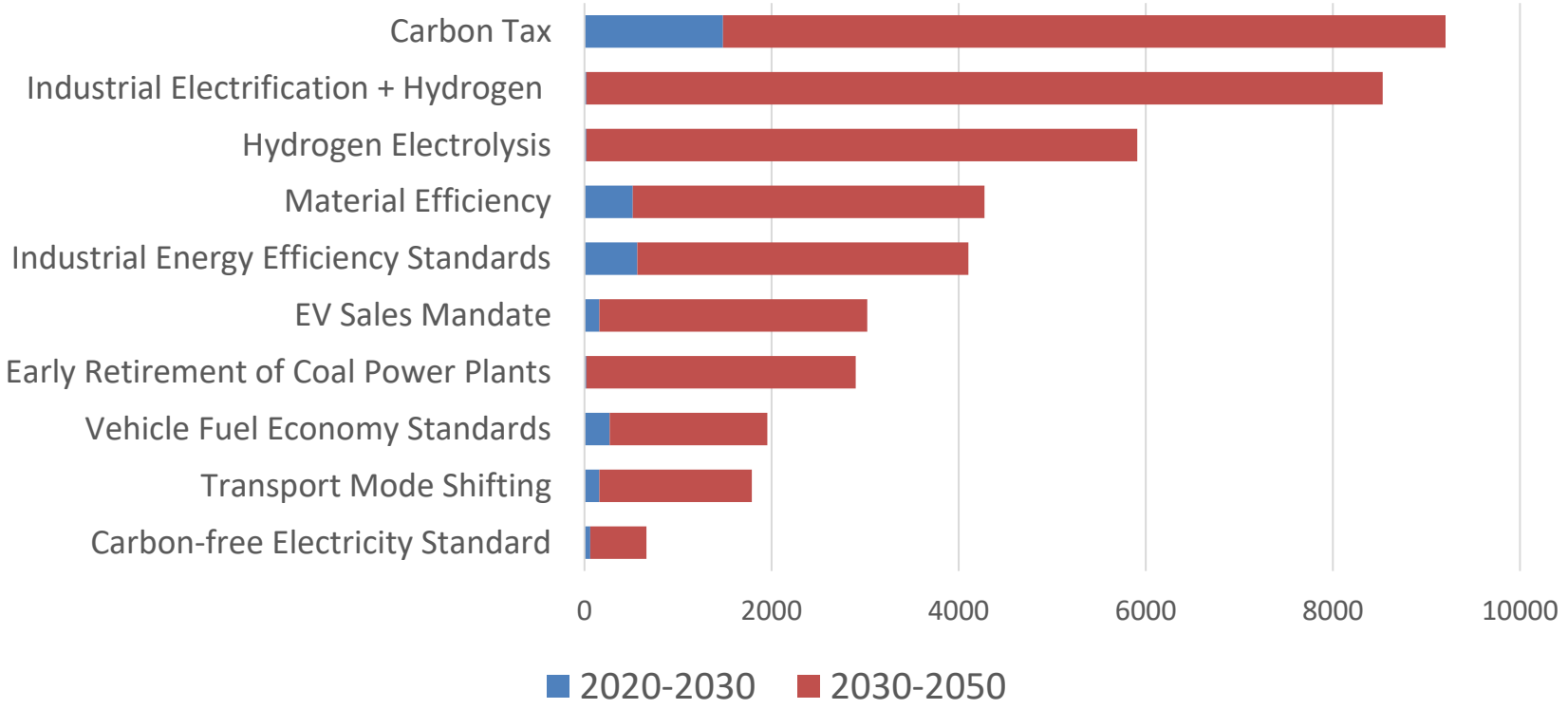
LTD Scenario is consistent with India's net-zero 2070 target and India's fair share of the 1.5°C carbon budget (according to Equal Cumulative Per Capita burden sharing approach)

*As of 2016, as reported in India's Third Biennial Update Report submitted in 2021

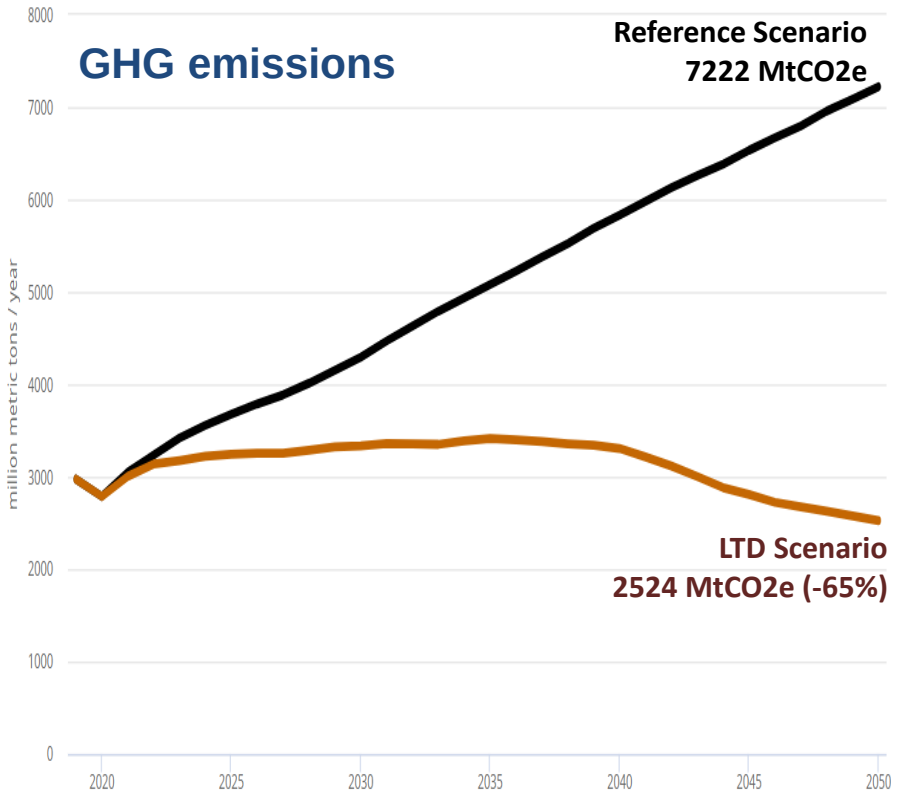
Key policy settings in Long Term Decarbonization Scenario (2050)

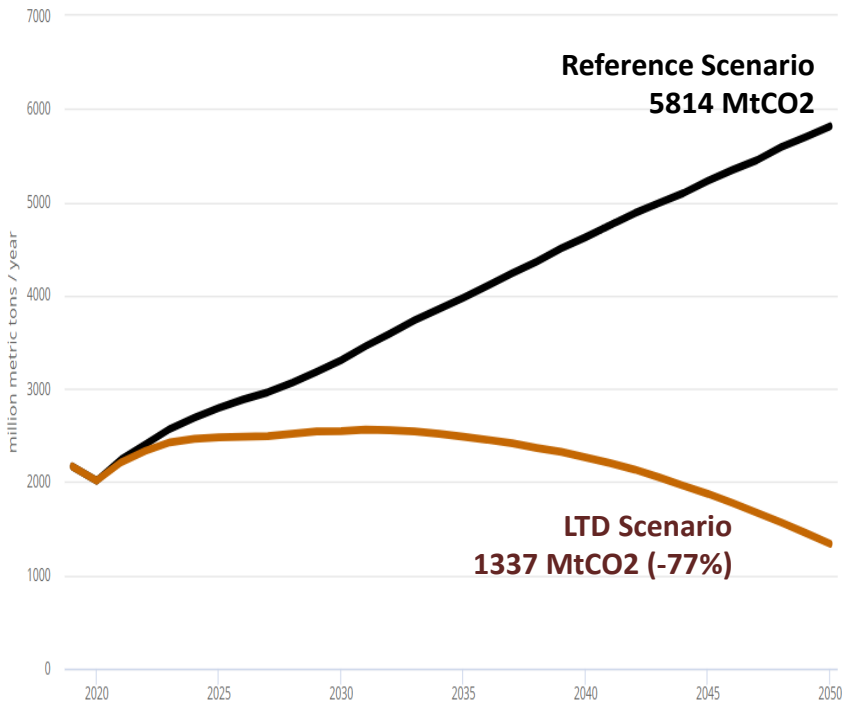
Electrification & hydrogen substitution of fossil fuels in industry (linearly increasing from 0 in 2030)	50%
Hydrogen production via electrolysis (linearly increasing from 0 in 2025)	100%
Carbon tax per tonne of CO2e (linearly increasing from 2020)	INR 5000 (USD 73)
EV sales mandate (% of new sales) Passenger LDV, Passenger HDV Freight LDV, Freight HDV 2W, 3W	 70%, 50% (+25% H2V) 80%, 15% (+45% H2V) 100%, 100%
Material efficiency (demand reduction w.r.t. Reference Scenario)	Cement: 15%, Iron & steel: 25% Water & waste: 20%
Mandated minimum % of **carbon-free electricity generation**	75%
Early retirement of otherwise non-retiring coal power (linearly increasing from 300MW/year in 2027)	6 GW/year

Top policy drivers of cumulative emissions reduction during 2020-2050 in Long Term Decarbonization Scenario wrt Reference Scenario (in MtCO2e)



LTD Scenario reduces GHG emissions by 65% and CO2 emissions by 77% in 2050 compared with Reference Scenario





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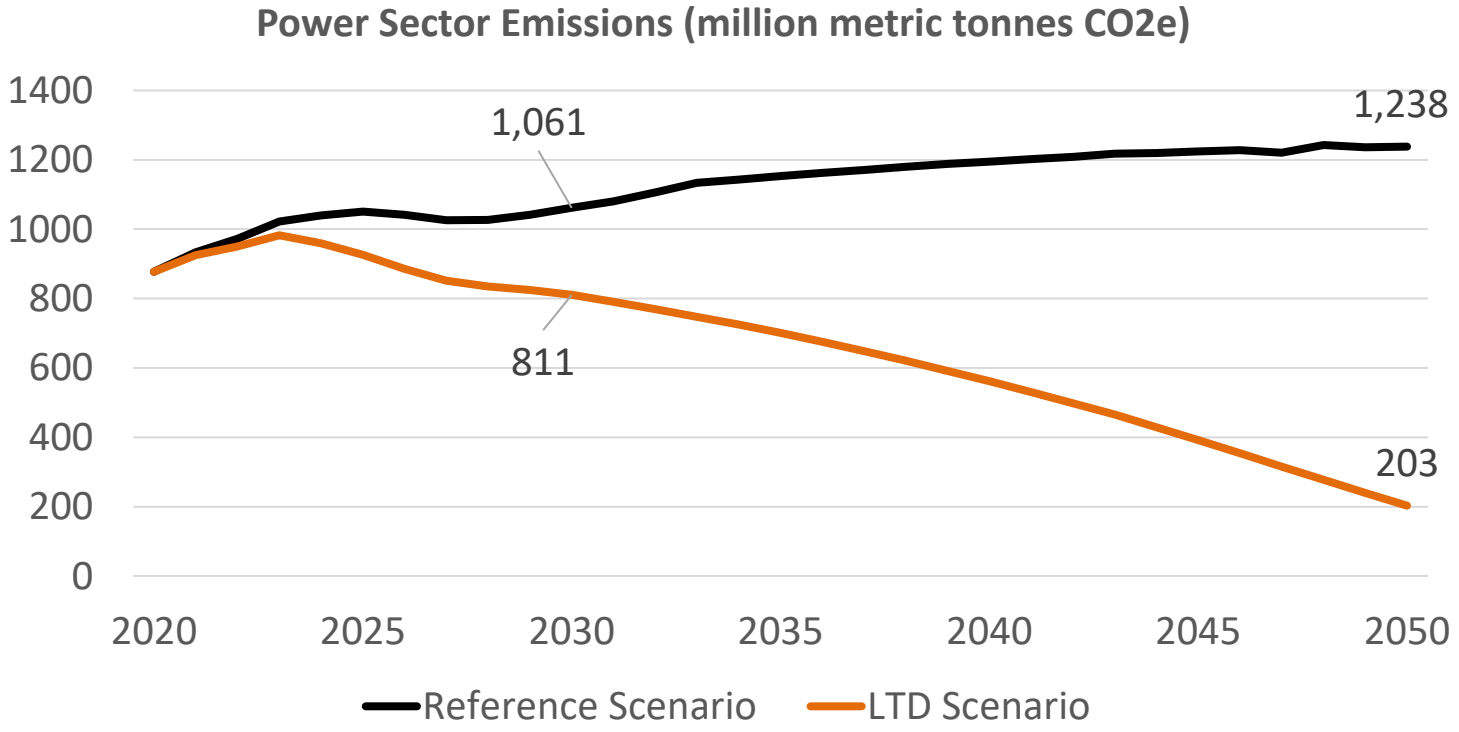
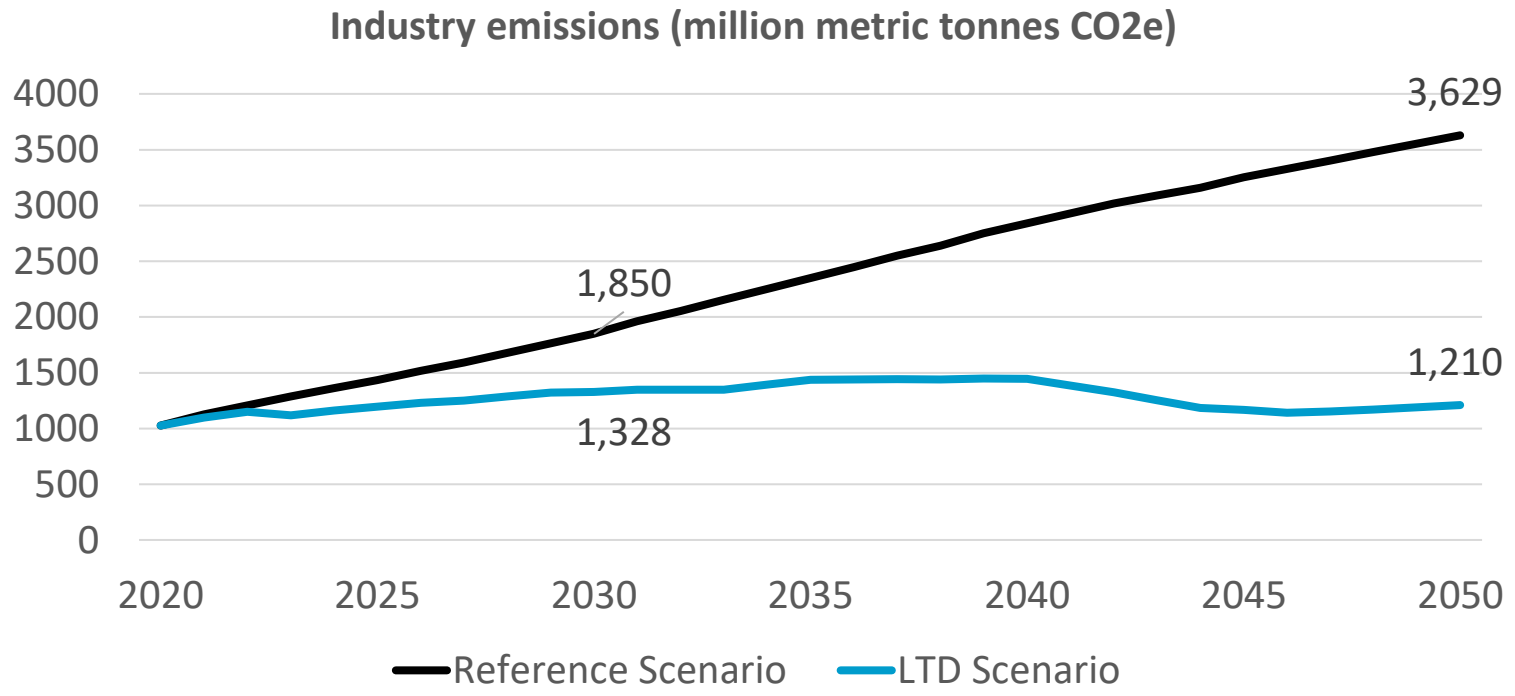
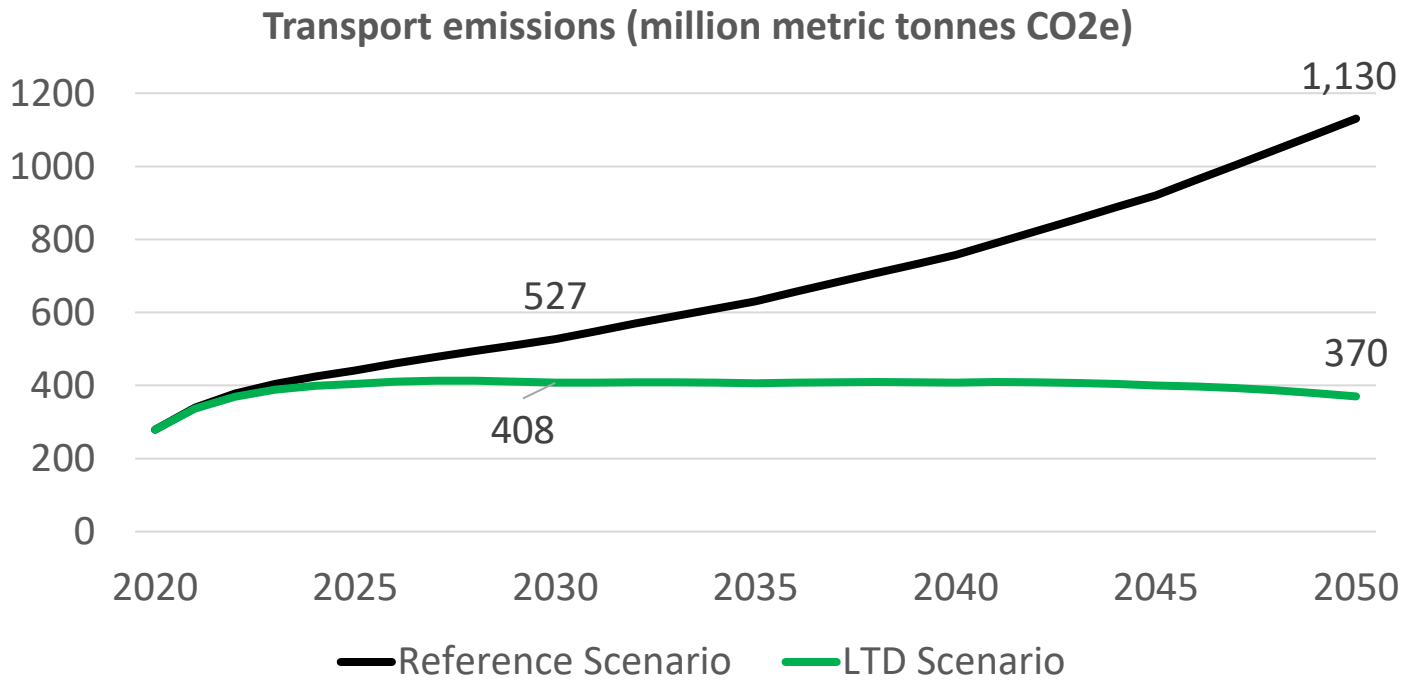
Power sector emissions reduce by 24% by 2030 and 84% by 2050 compared to Reference Scenario



Industry emissions reduce by 28% by 2030 and 67% by 2050 compared to Reference Scenario

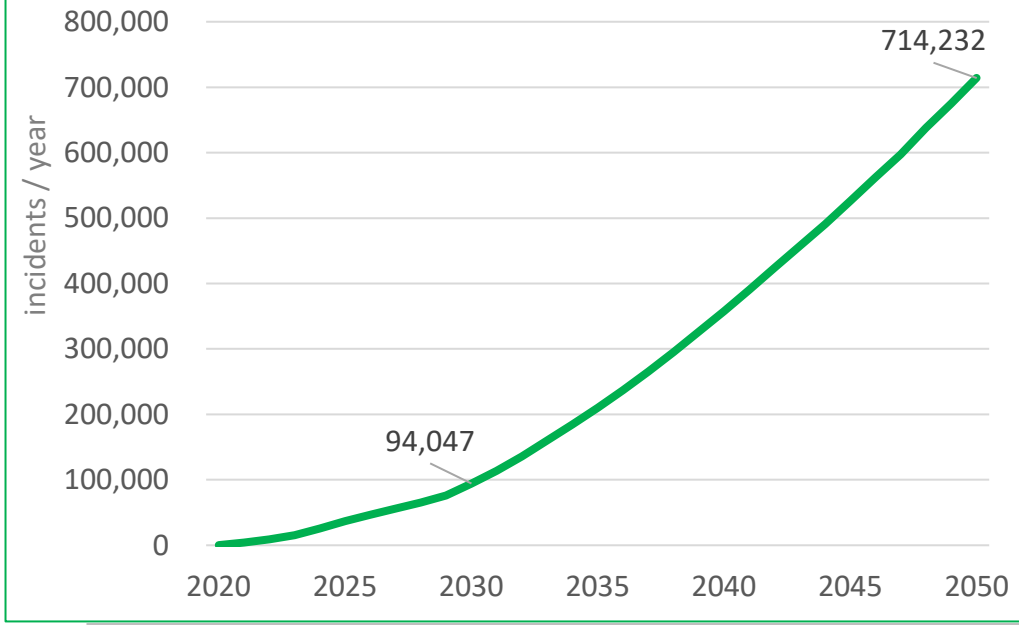


Transport emissions reduce by 23% by 2030 and 67% by 2050 compared to Reference Scenario

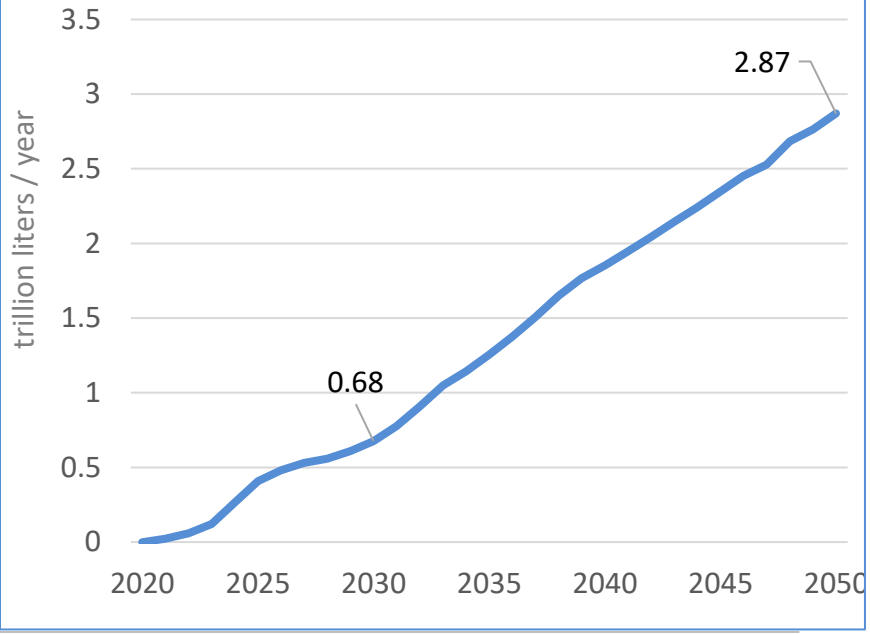


Air & water benefits of long-term decarbonization

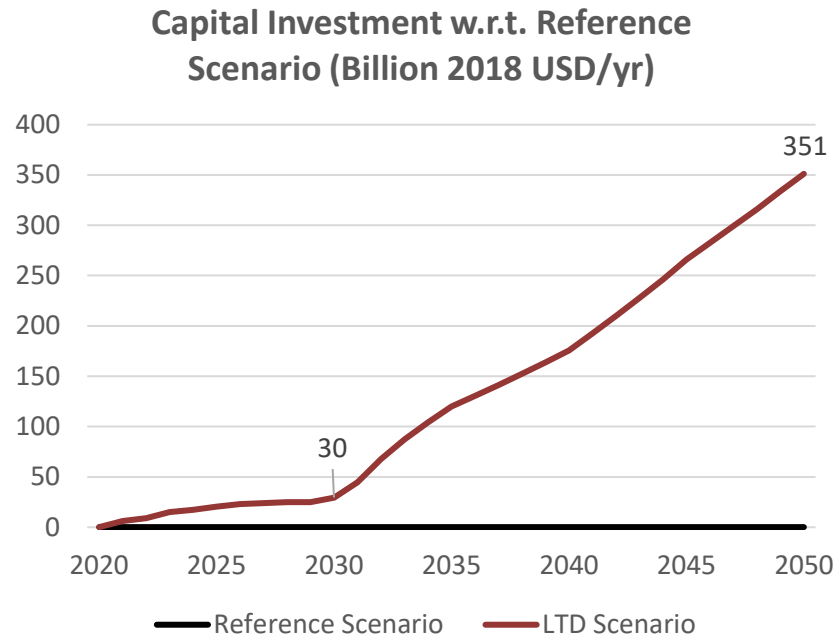
8.2 million premature deaths avoided during 2020-2050 due to reduced emissions of SOx, NOx & PM in power, industry & transport wrt Reference Scenario

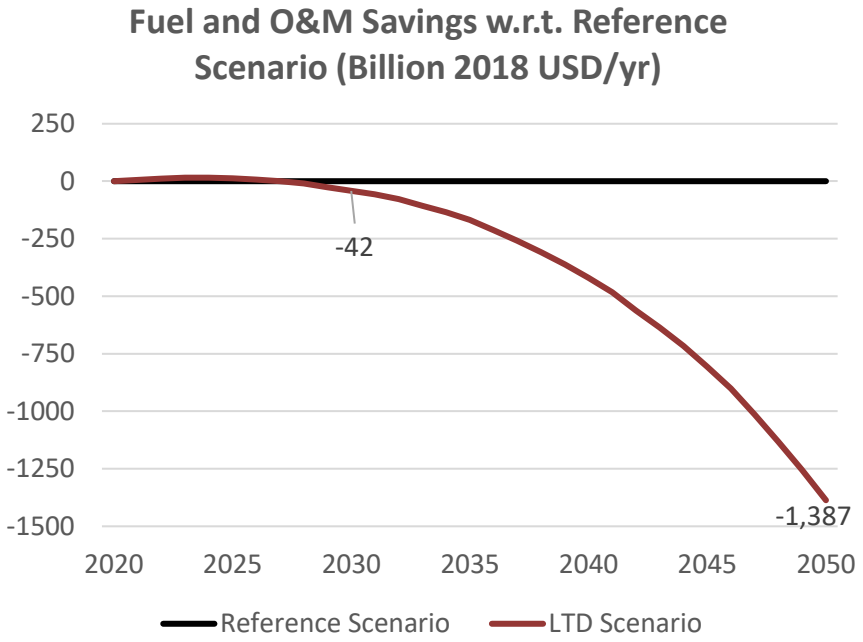


41 trillion liters of water saved in power sector during 2020-2050 wrt Reference Scenario



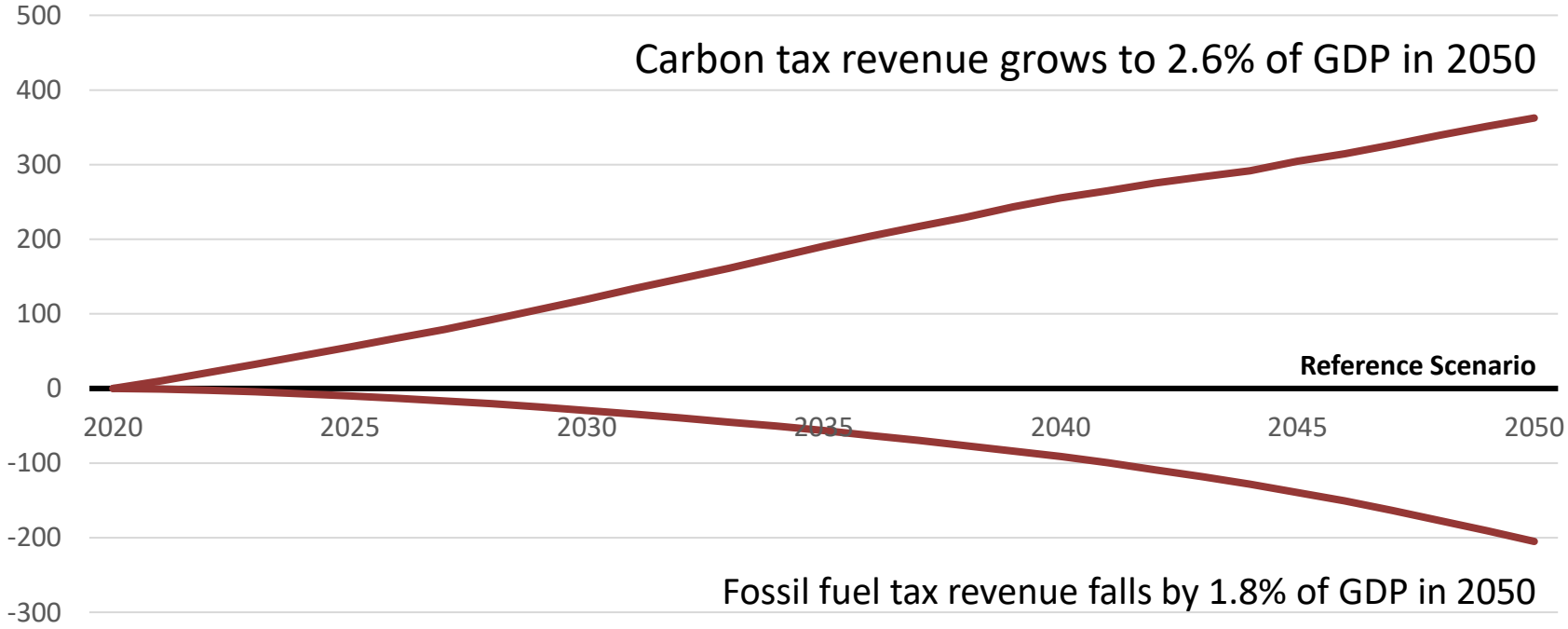
Capital investment & savings



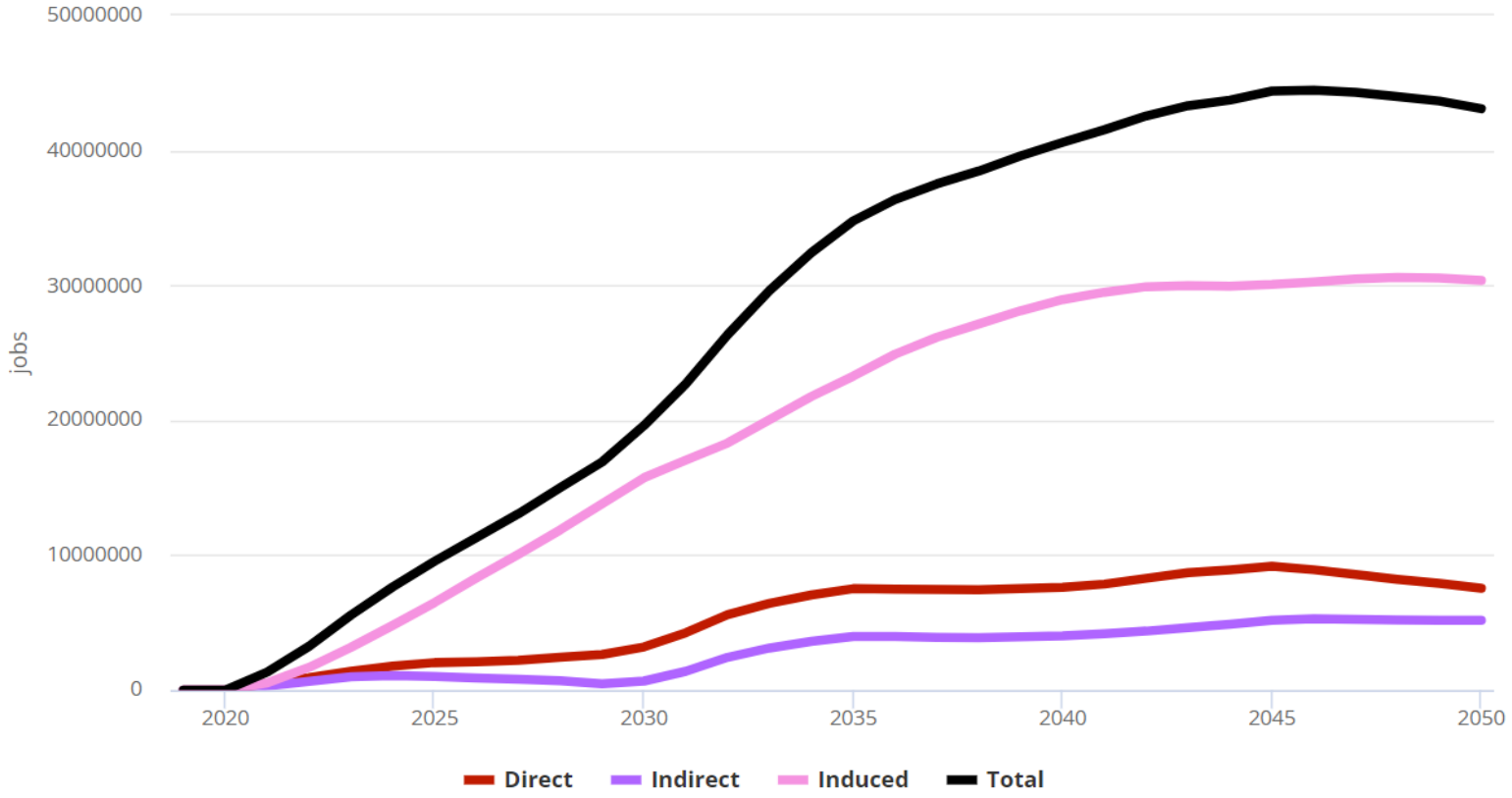


Additional capital investments over the Reference Scenario (~0.5% of GDP in 2030 and ~2.7% of GDP in 2050) are required for the low-carbon transition. However, savings on fuel and O&M costs (~0.7% of GDP in 2030 and ~10% of GDP in 2050) begin to outweigh additional investment within this decade.

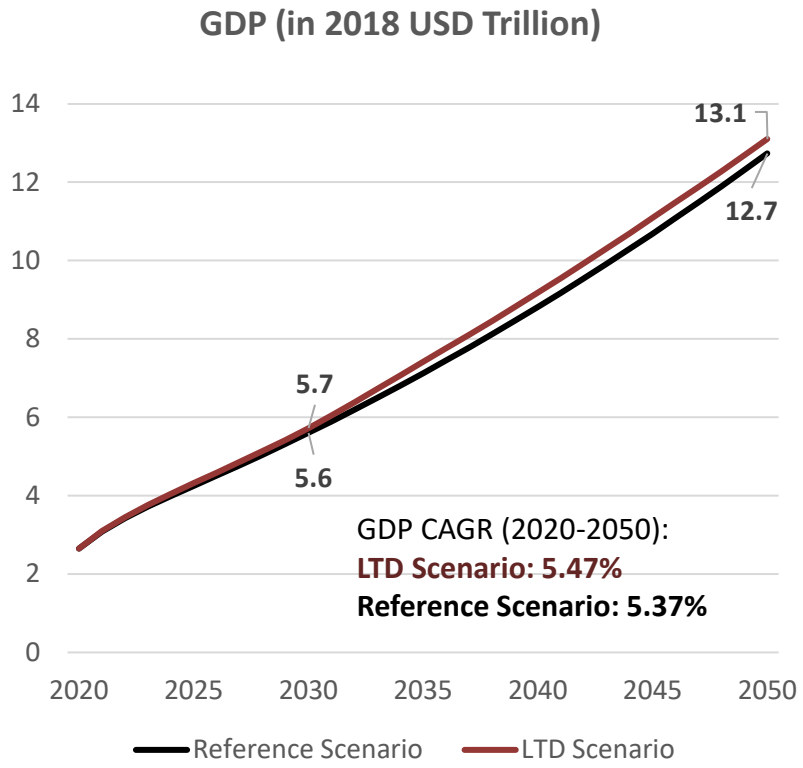
Change in government tax revenue wrt Reference Scenario (2018 billion US$/year)

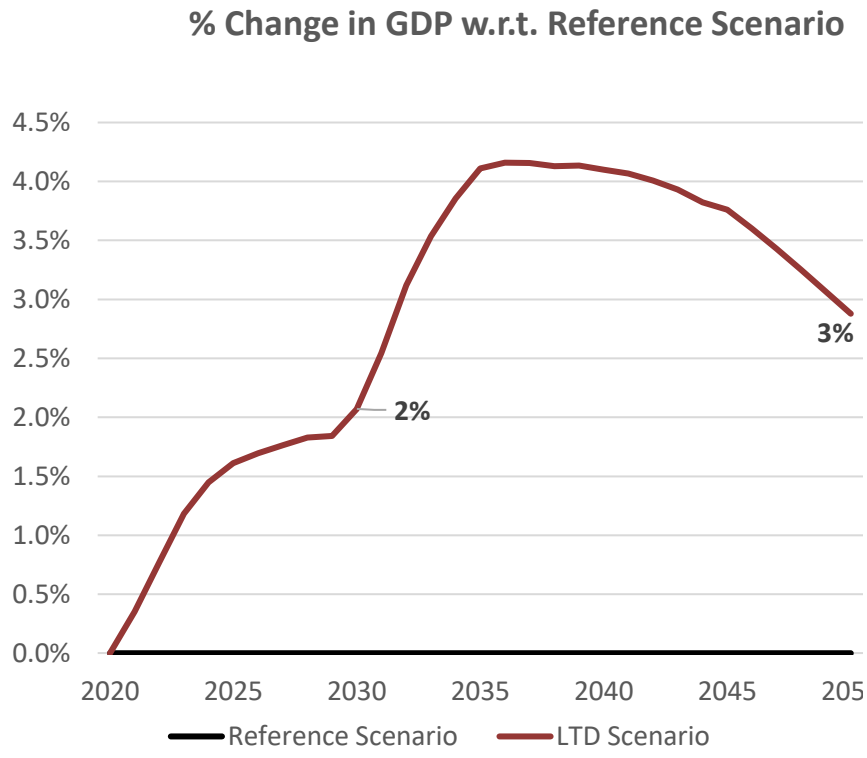


Change in jobs wrt Reference Scenario

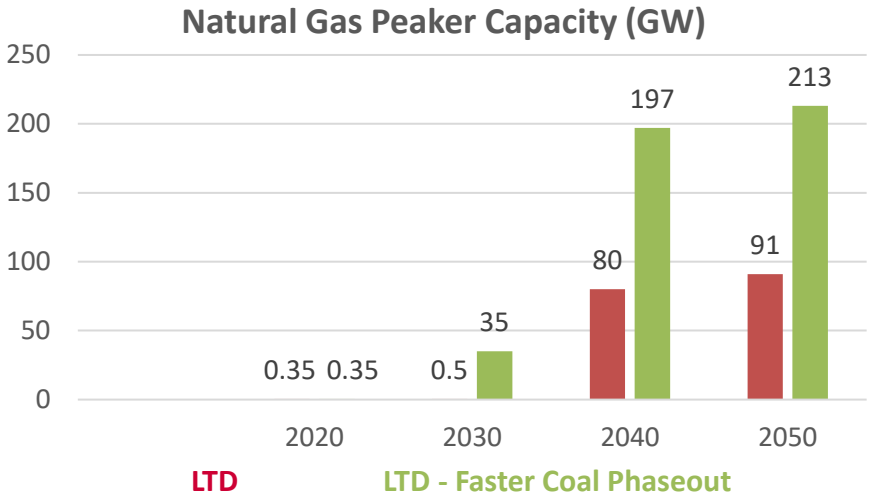


Change in GDP wrt Reference Scenario

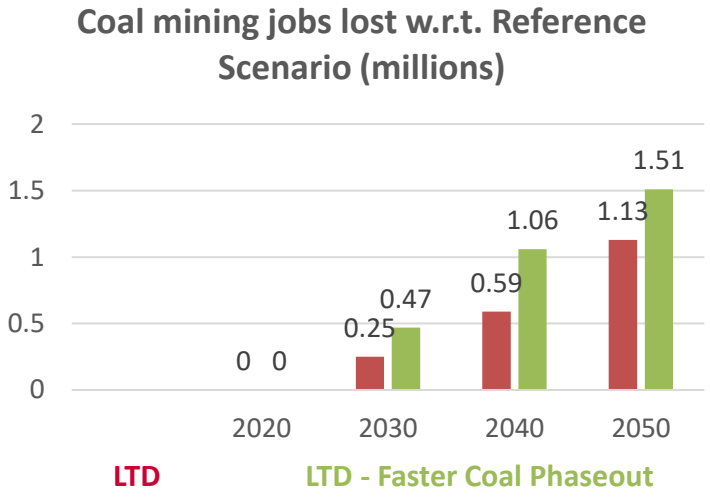




Alternative decarbonization pathways: Example of coal retirement



A faster coal phase out could more than double the requirement of natural gas peaker plants for grid flexibility (before battery costs fall sufficiently to make it cost-competitive), potentially increasing reliance on gas imports and creating the risk of stranded assets



~0.4 million more coal mining jobs could be lost by 2050 in a faster coal phase-out pathway

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THANK YOU

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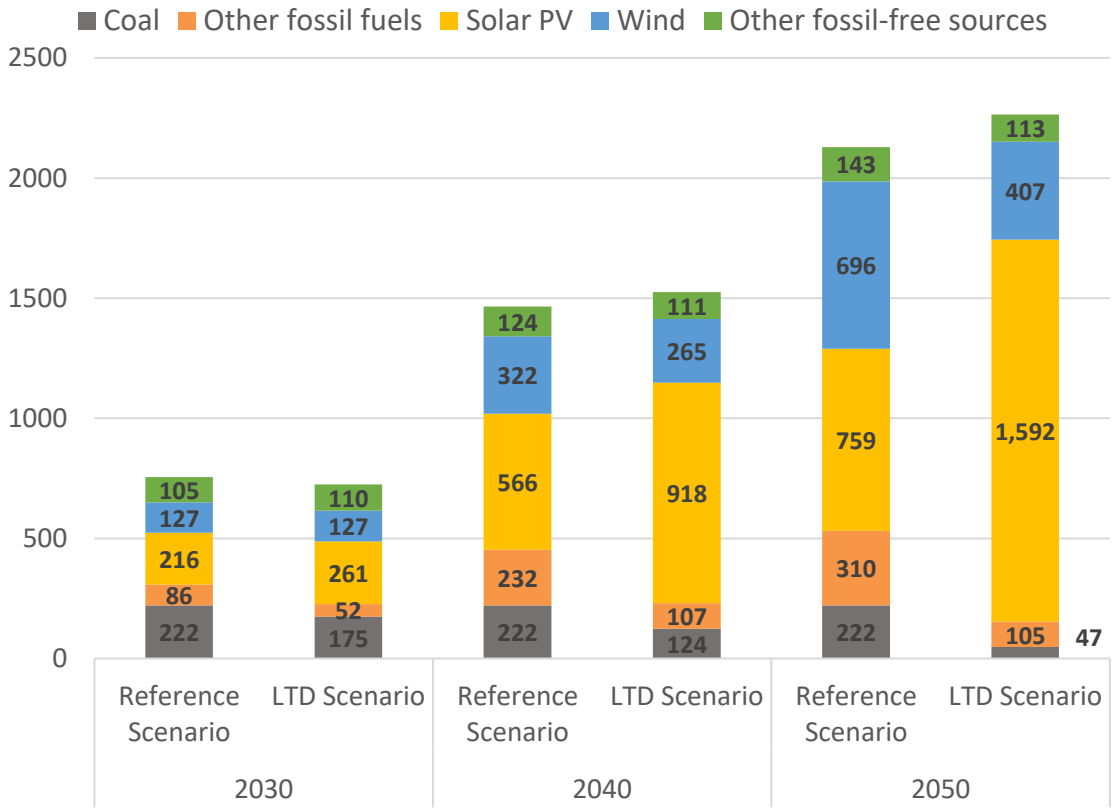
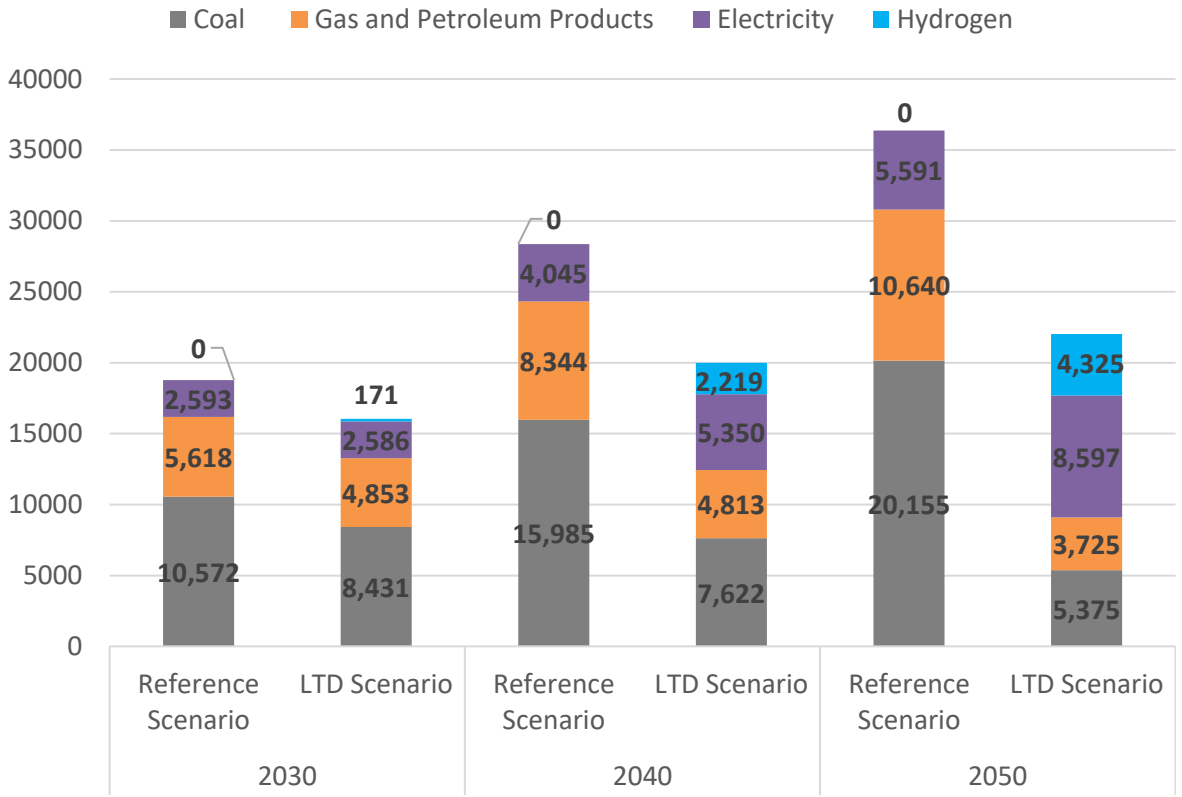
Installed electricity capacity (GW)



Fossil-free capacity GW (% in total)		
Year	Reference Scenario	LTD Scenario
2030	448 (59%)	500 (69%)
2040	1012 (69%)	1294 (85%)
2050	1598 (75%)	2112 (93%)

Grid battery storage capacity (GW)		
Year	Reference Scenario	LTD Scenario
2030	34	79
2040	47	204
2050	74	409

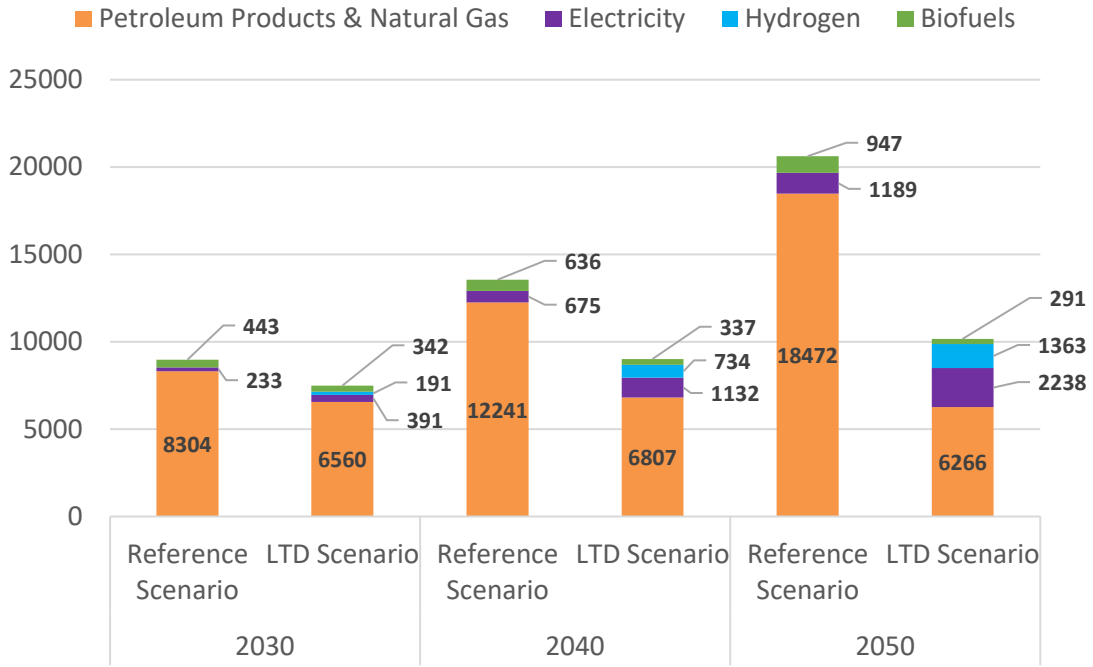
Industrial energy consumption by fuel (in PJ)



Share of Electricity in Total		
Year	Reference Scenario	LTD Scenario
2030	14%	16%
2040	14%	27%
2050	15%	39%

Share of Hydrogen in Total		
Year	Reference Scenario	LTD Scenario
2030	0%	1%
2040	0%	11%
2050	0%	20%

Transport energy consumption by fuel (in PJ)



Share of Electricity in Total		
Year	Reference Scenario	LTD Scenario
2030	3%	5%
2040	5%	13%
2050	6%	22%

Share of Hydrogen in Total		
Year	Reference Scenario	LTD Scenario
2030	0%	3%
2040	0%	8%
2050	0%	13%