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Leveraging new open-source modelling tools to rapidly prototype pathways for achieving SDG7 and mid-century climate targets in Pakistan

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AGU FALL
MEETING

Online Everywhere | 1-17 December 2020



University
of Victoria

Agenda

Modelling Framework

- Introduction to MESSAGEix & MESSAGE-GLOBIOM
- Country Prototype Process



Case Study: Pakistan

- Socioeconomic Overview
- Climate Vulnerability
- Energy System



Accounting for Access to Energy (SDG7)

- Electricity
- Clean Cooking Fuels



Energy System Transformation

- Primary Energy
- Electricity Generation



Investments & Emissions



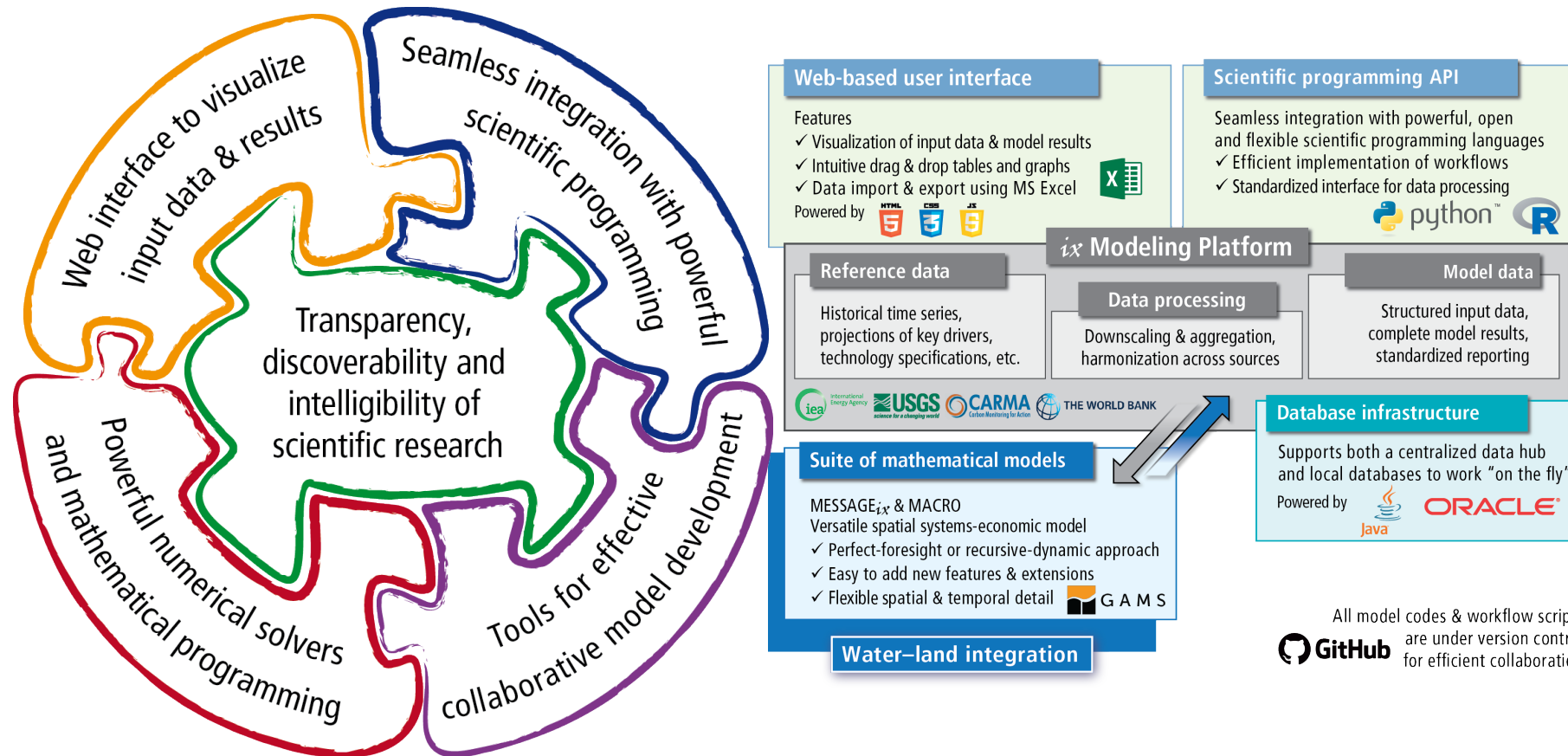
Concluding Comments



The MESSAGE_{ix} framework

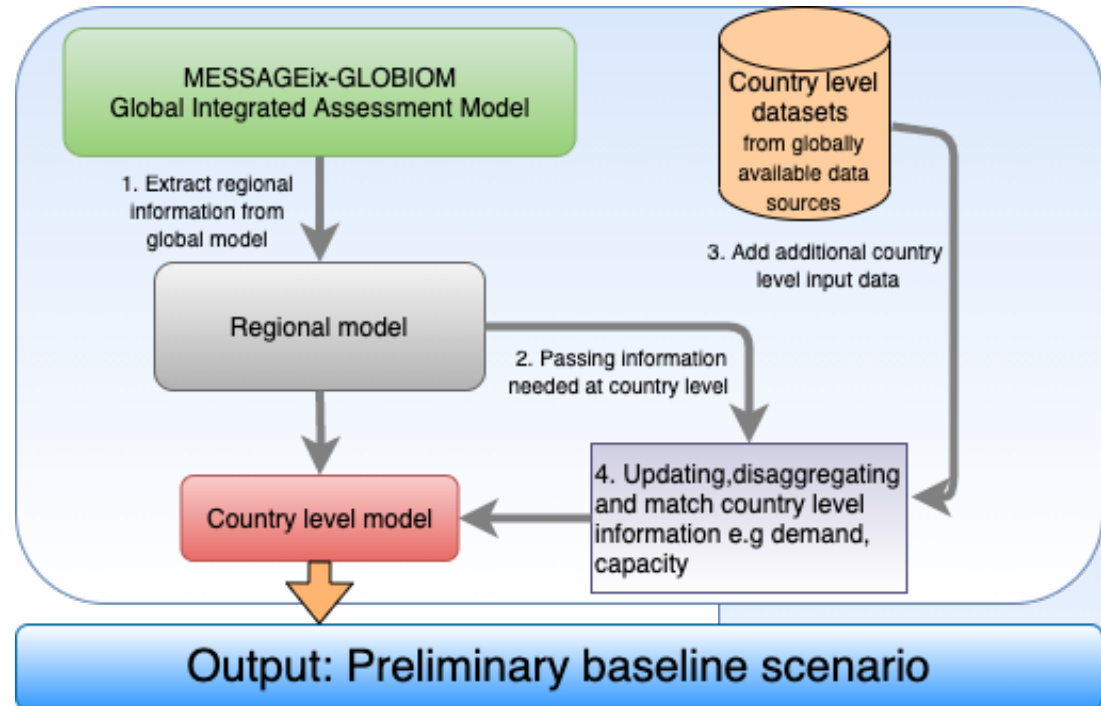
- transparency and reproducibility of research

Model documentation: <https://docs.messageix.org/en/stable/>



MESSAGE_{ix}: Rapidly prototyping a national scale Model

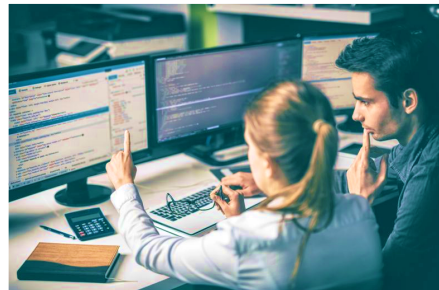
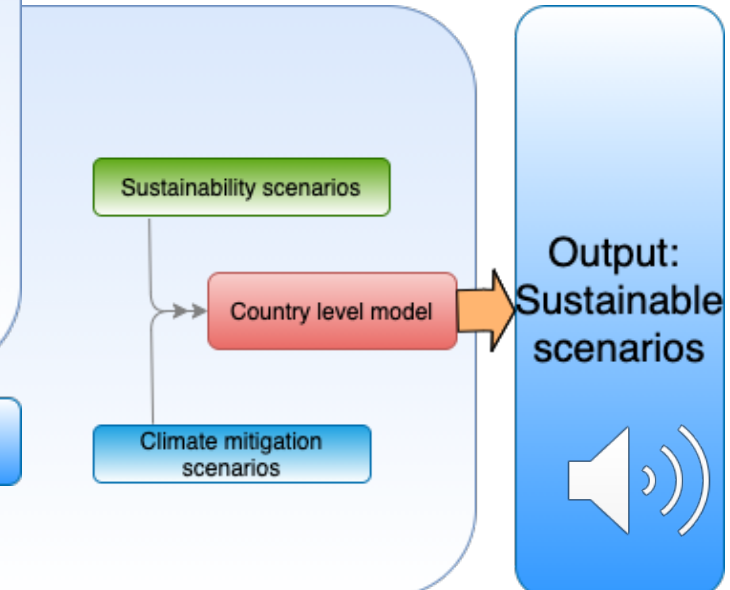
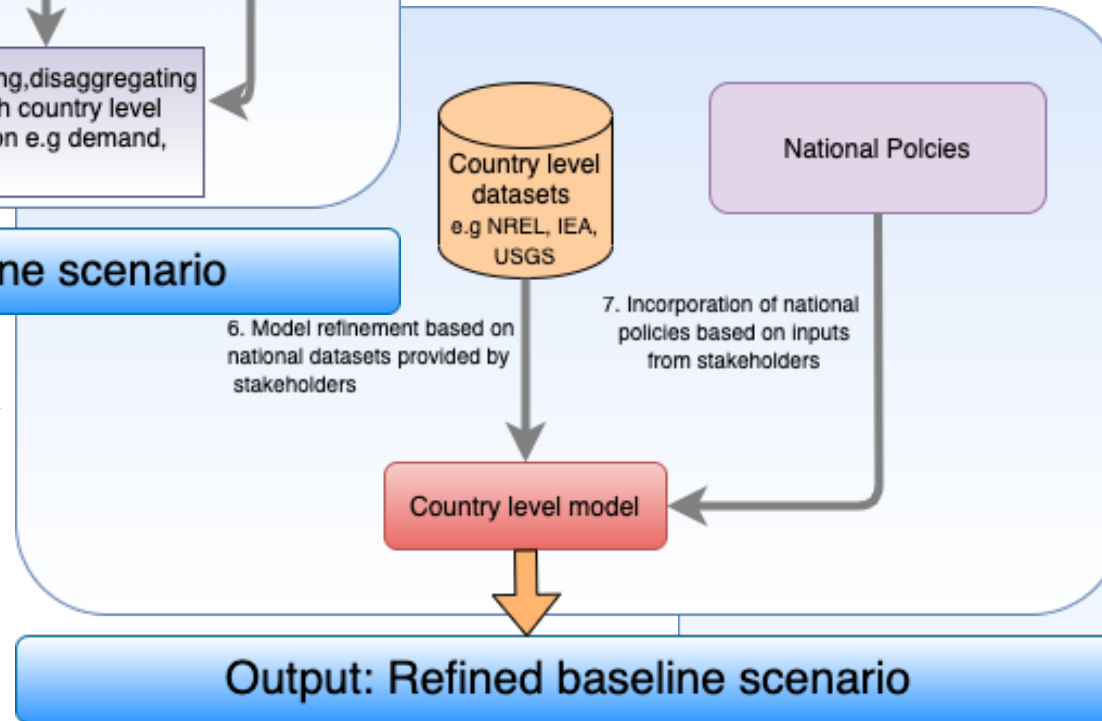
Step 1: Rapid prototyping



Step 2: Stakeholder engagement



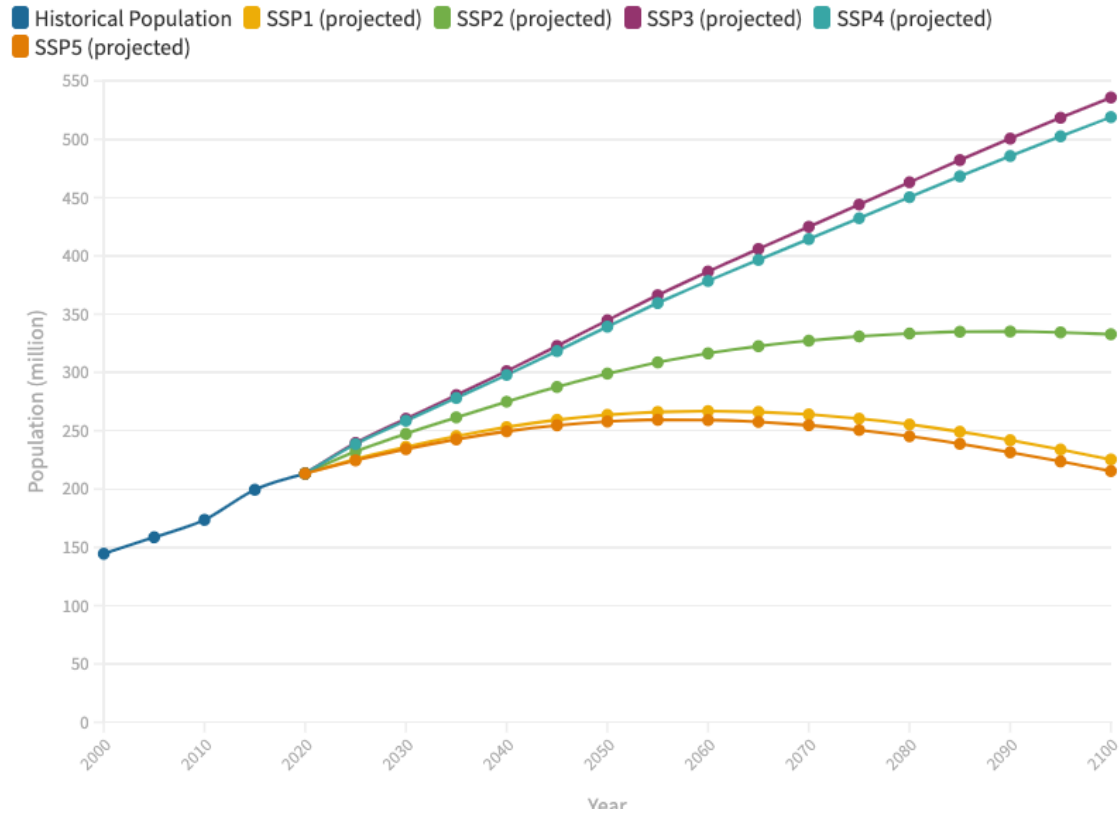
Step 3: Scenario development



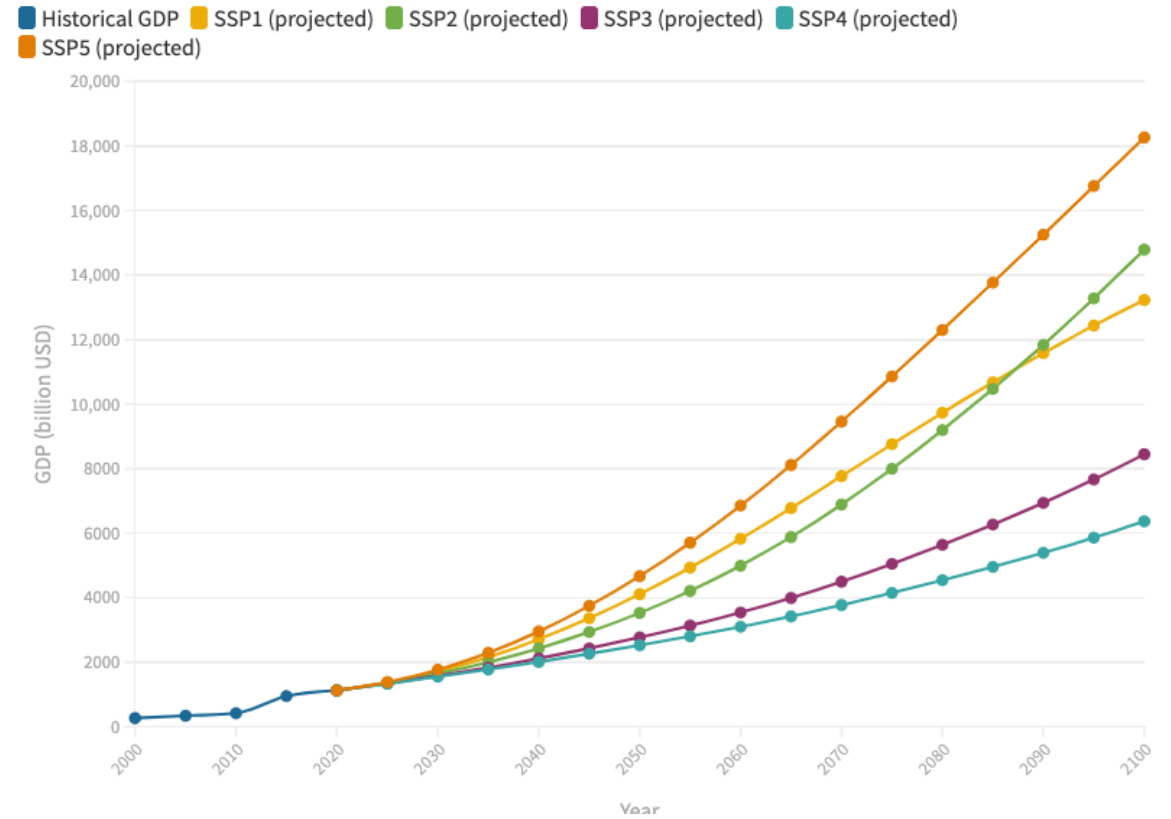
5. Data vetting process

Pakistan - Socio-economic overview

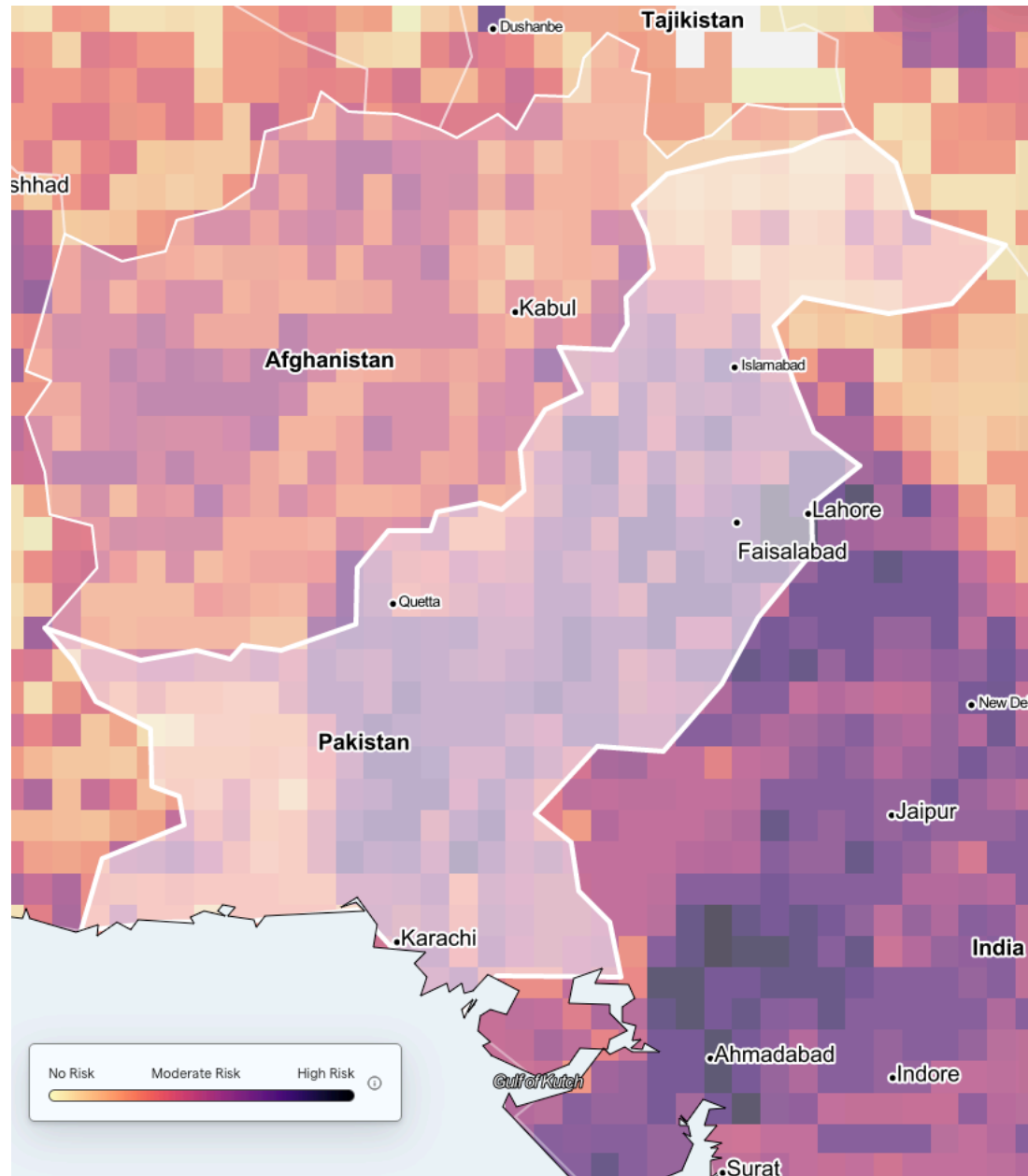
Population



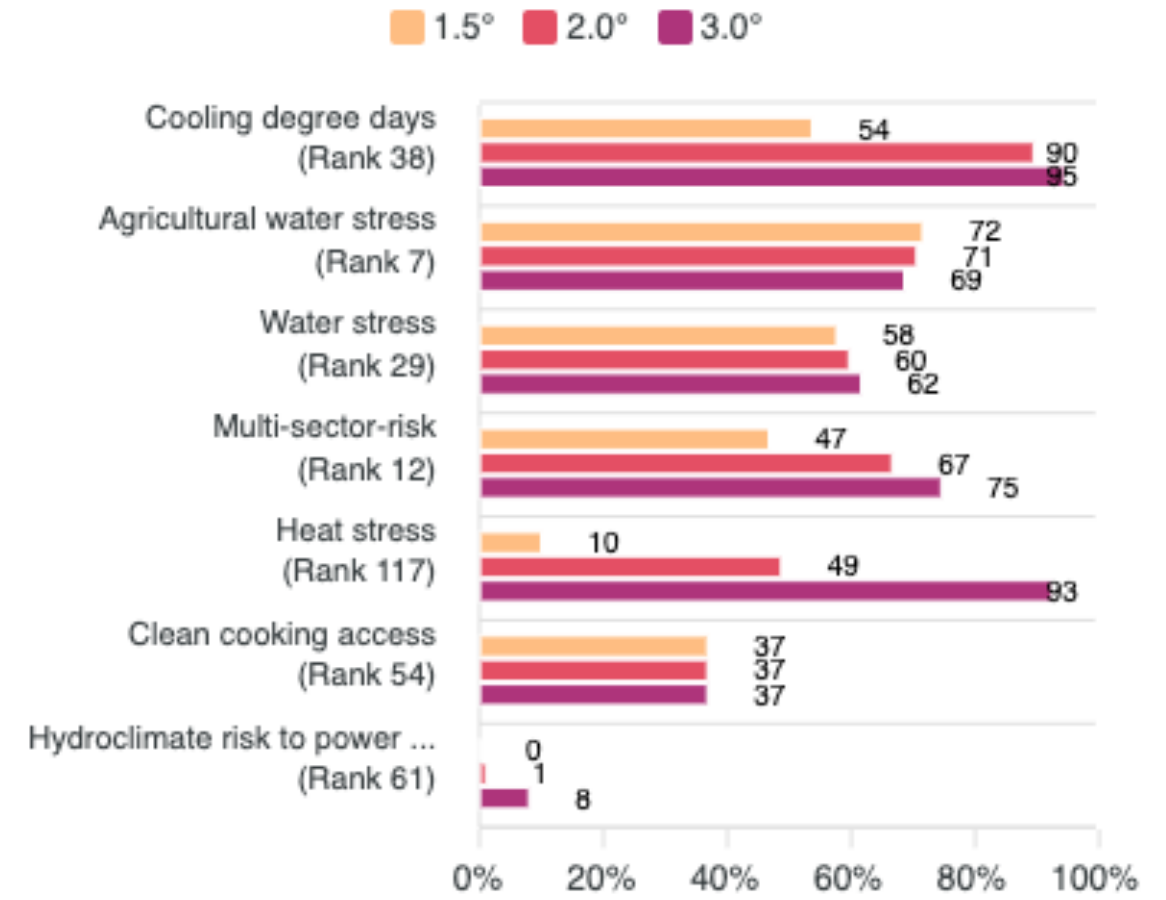
GDP



Pakistan - Exposure to key risks



Exposure to key risks



Byers et al. 2018
 More details at hotspot-explorer.org



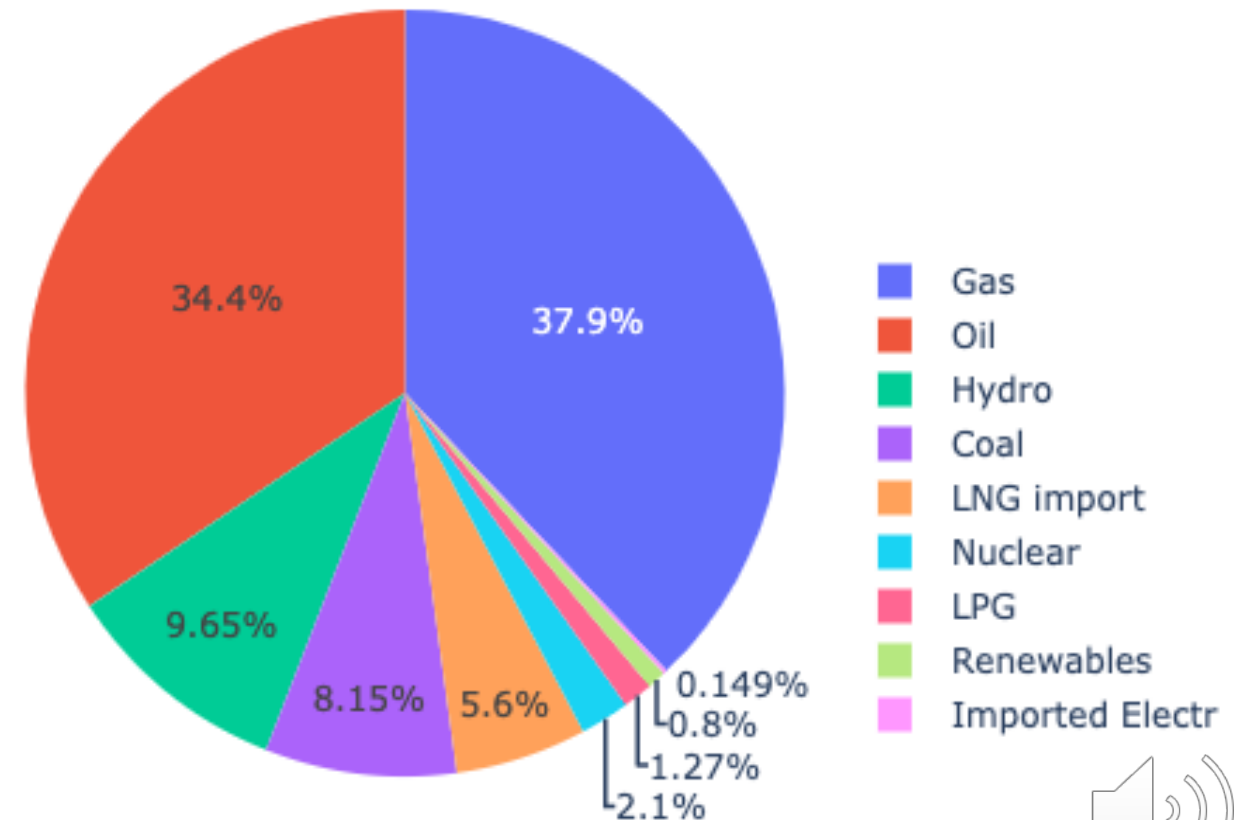
Overview of Energy System

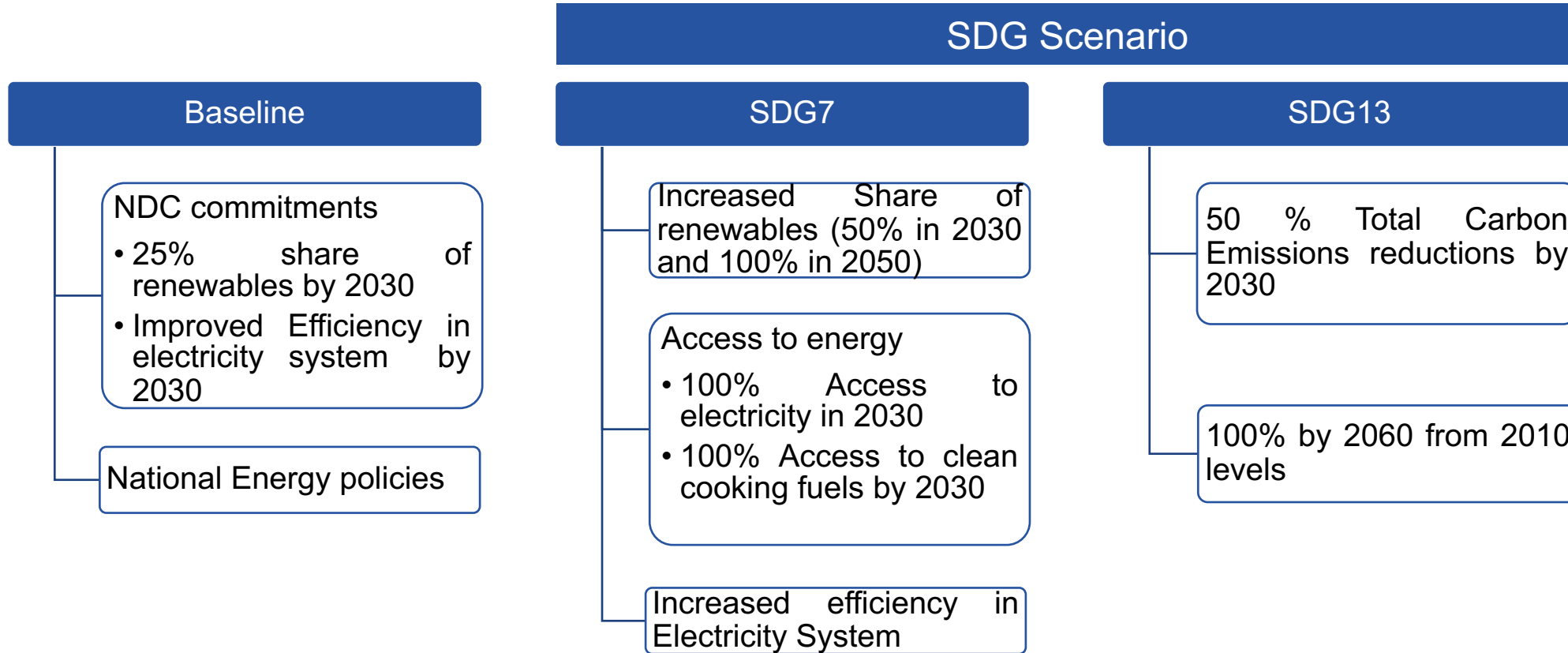
Highlights

- ❖ Reliance on oil and gas in the energy mix
- ❖ Under Utilization of renewable resources
- ❖ About 27% of the population lack access electricity and 71% of population lack access clean cooking facilities
- ❖ Circular Debt hampers smooth functioning of the system
- ❖ Nascent regulatory frameworks
- ❖ Weak governance of distribution companies
- ❖ Energy conservation and efficiency require special emphasis
- ❖ Off-grid electricity solutions have yet to proliferate

Primary Energy Supply by Source (2016/17)

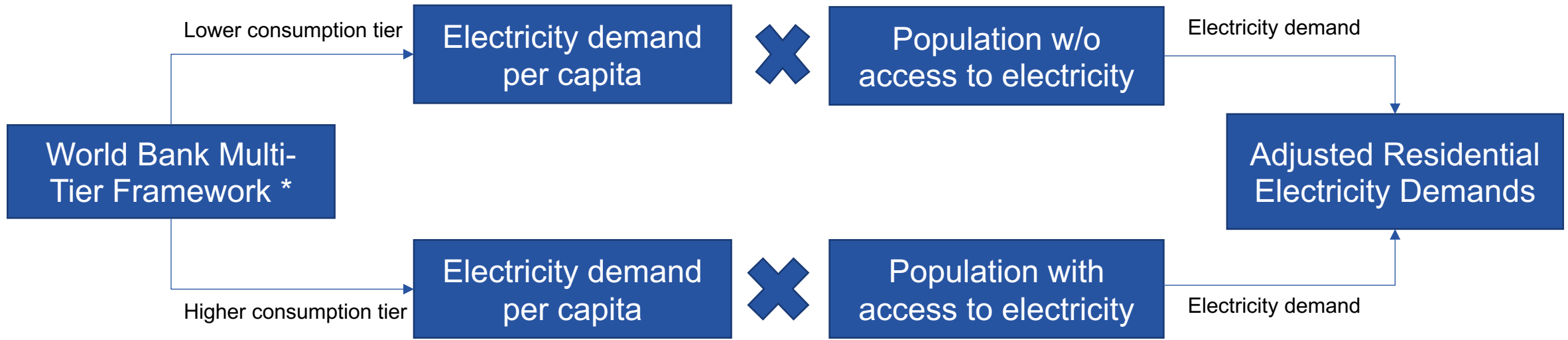
Source: Pakistan Energy Year Book 2017





Energy Access – Electricity

Adjusted electricity demands in SDG scenario



Tiers	Consumption level per capita (KWh)
Tier 1	≥4.5
Tier 2	≥73
Tier 3	≥365
Tier 4	≥1,250
Tier 5	≥3,000

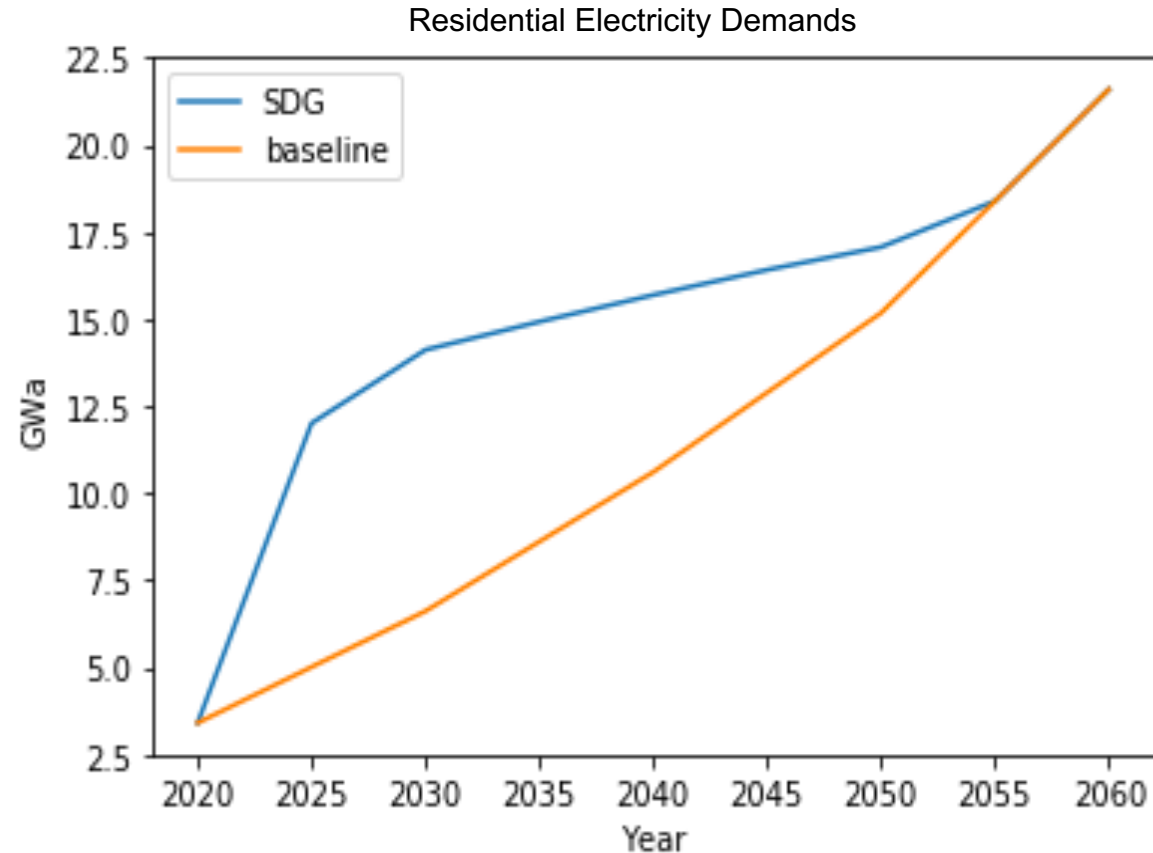
¹⁰ *Bhatia, zM. & Angelou, N. Beyond Connections: Energy Access Redefined (2015)

Energy Access – Electricity

Baseline demands are the actual projected demands from model based on GDP, population and historical activities

SDG demands refer to adjusted demands from multi-tier framework

Year	% population w/o access to electricity
2020	77
2025	90
2030	0

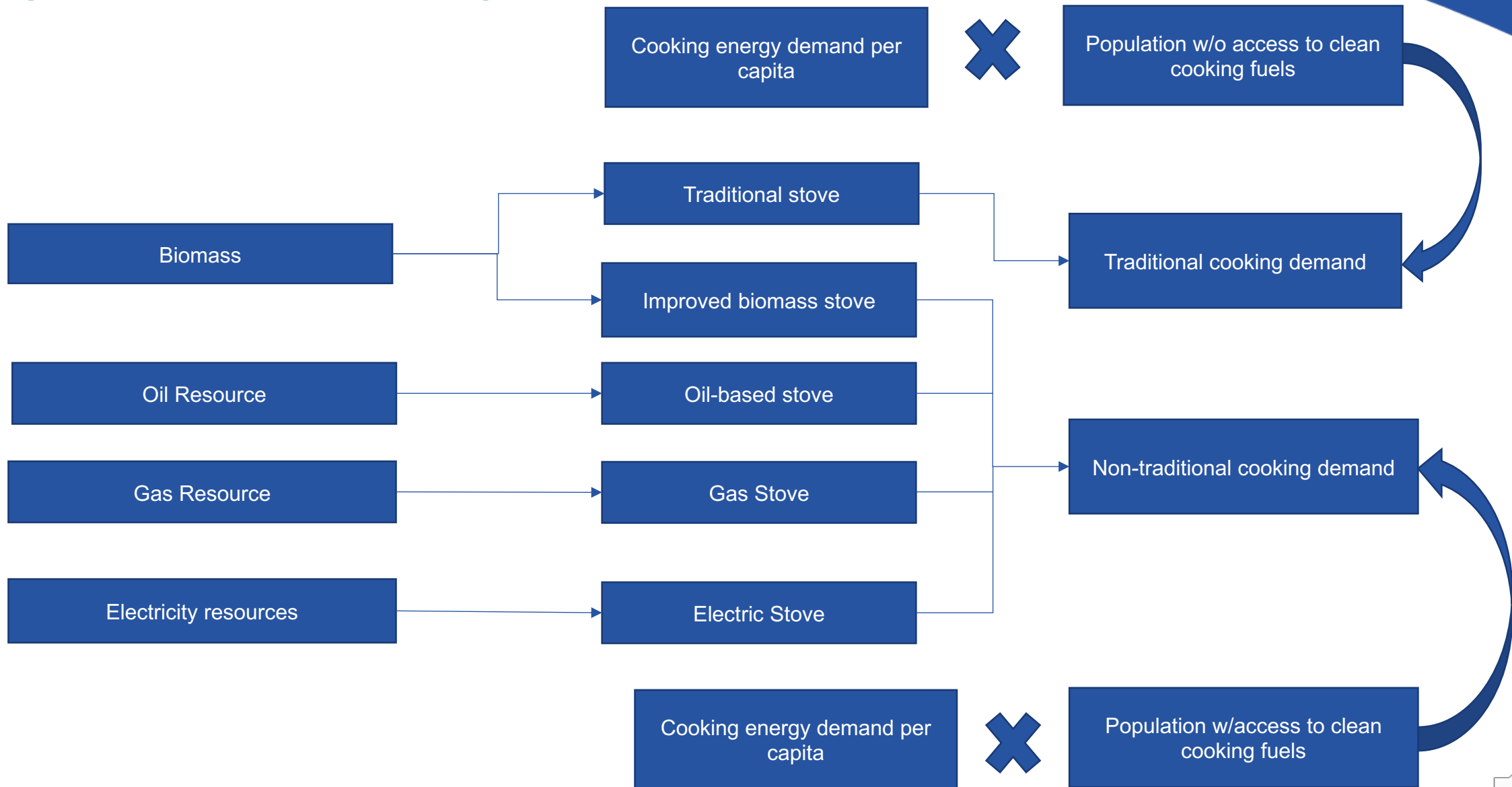


Rapid increase in demands until 2030 to provide 100% access to electricity

SDG demands match baseline demands around 2055

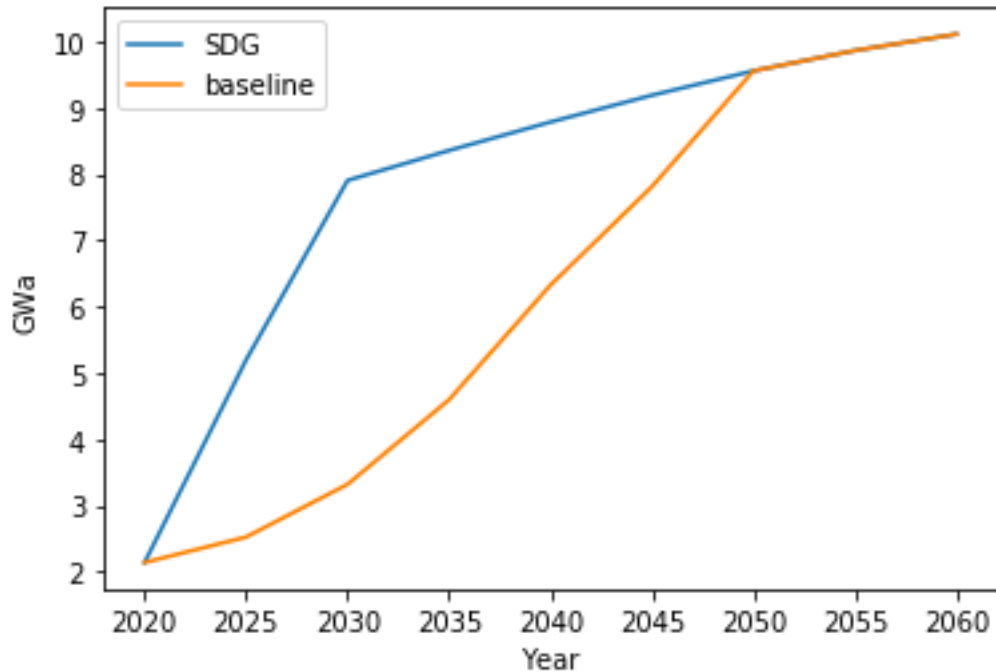


Energy Access – Cooking Fuels

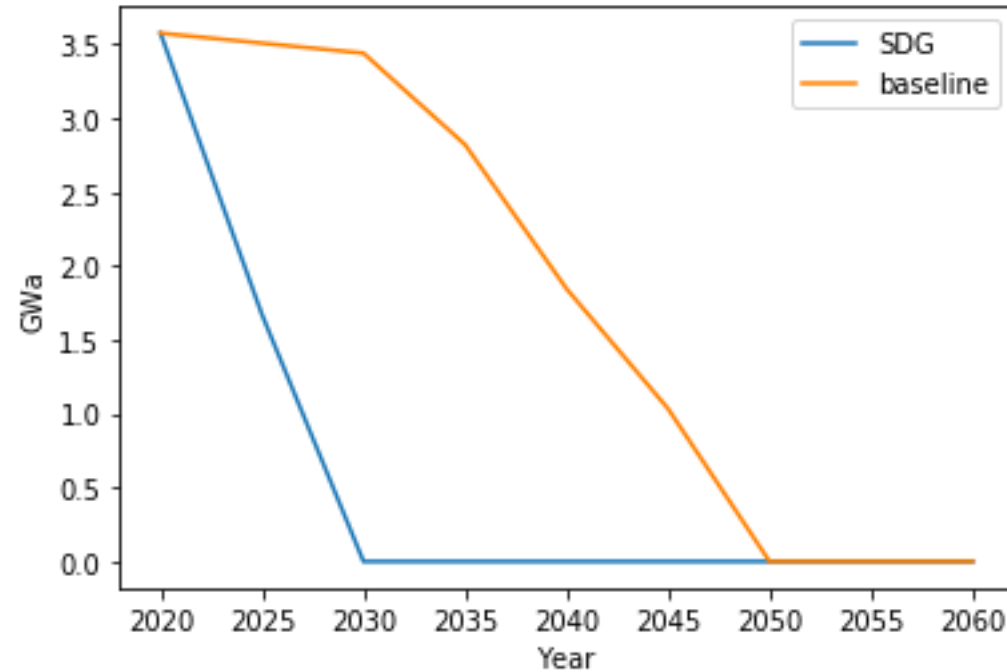


Energy Access – Clean Cooking Fuels

Non-traditional cooking demands



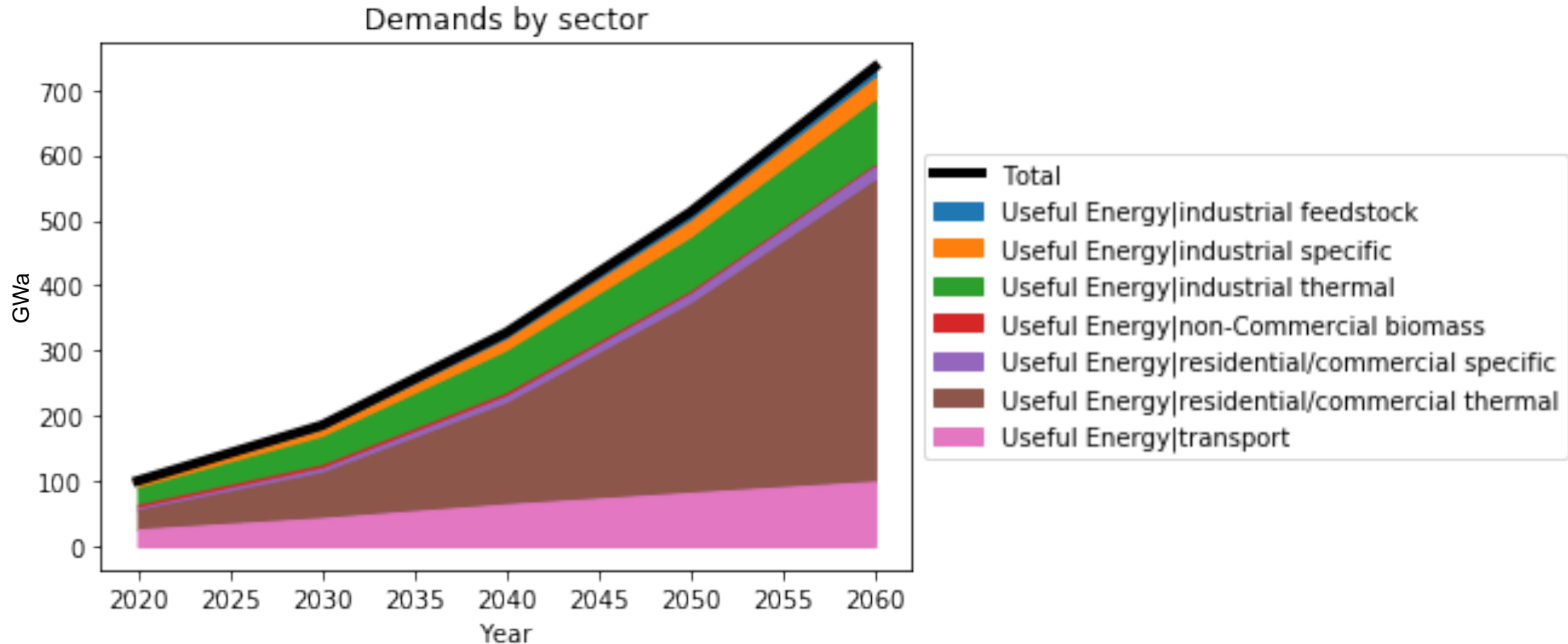
Traditional cooking demands



- Non-traditional cooking energy demand for SDG scenario increase rapidly due to provision of 100% access to clean cooking fuels in 2030 and vice versa for traditional cooking energy demand.
- Baseline scenario assumes 100% access to clean cooking fuels in 2050.

Tiers	Consumption level per capita (GWh)
Tier 1 (for traditional fuel)	9.58904E-08
Tier 2 (for non-tradition/improved cooking)	1.2704E-07

Energy Demands



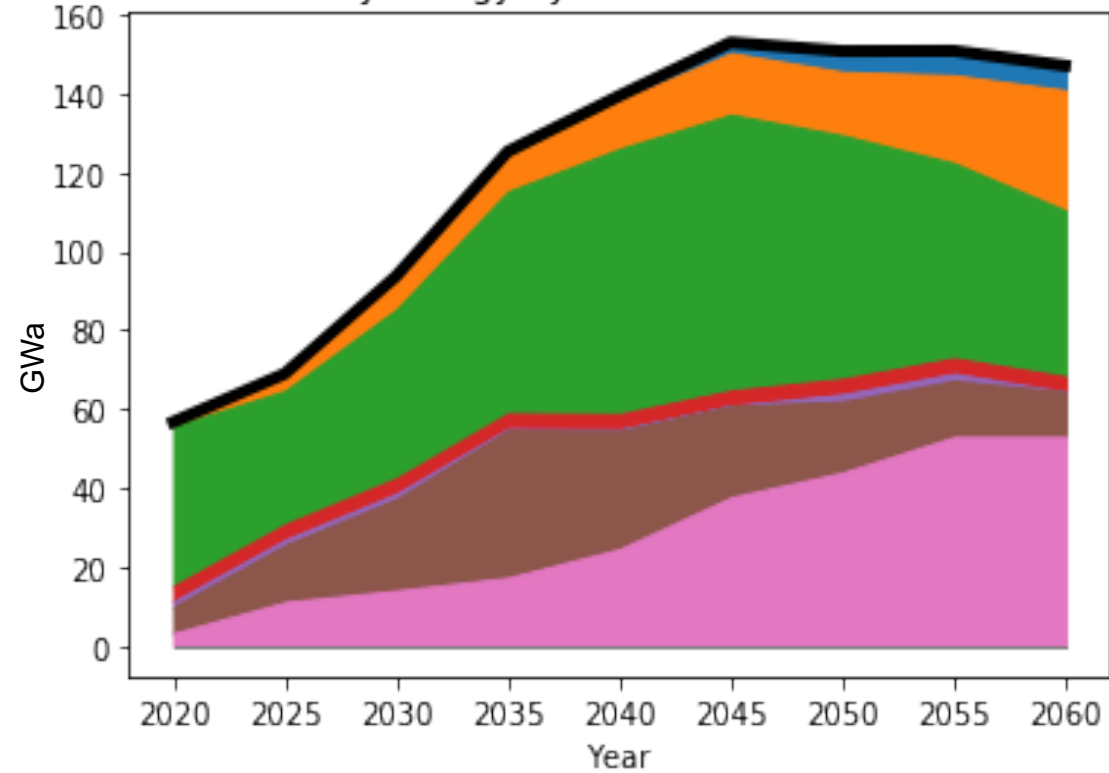
- Significant increase in overall demands due to high population growth rates
- Residential/commercial is a major contribution due to increased temperatures & climate vulnerability



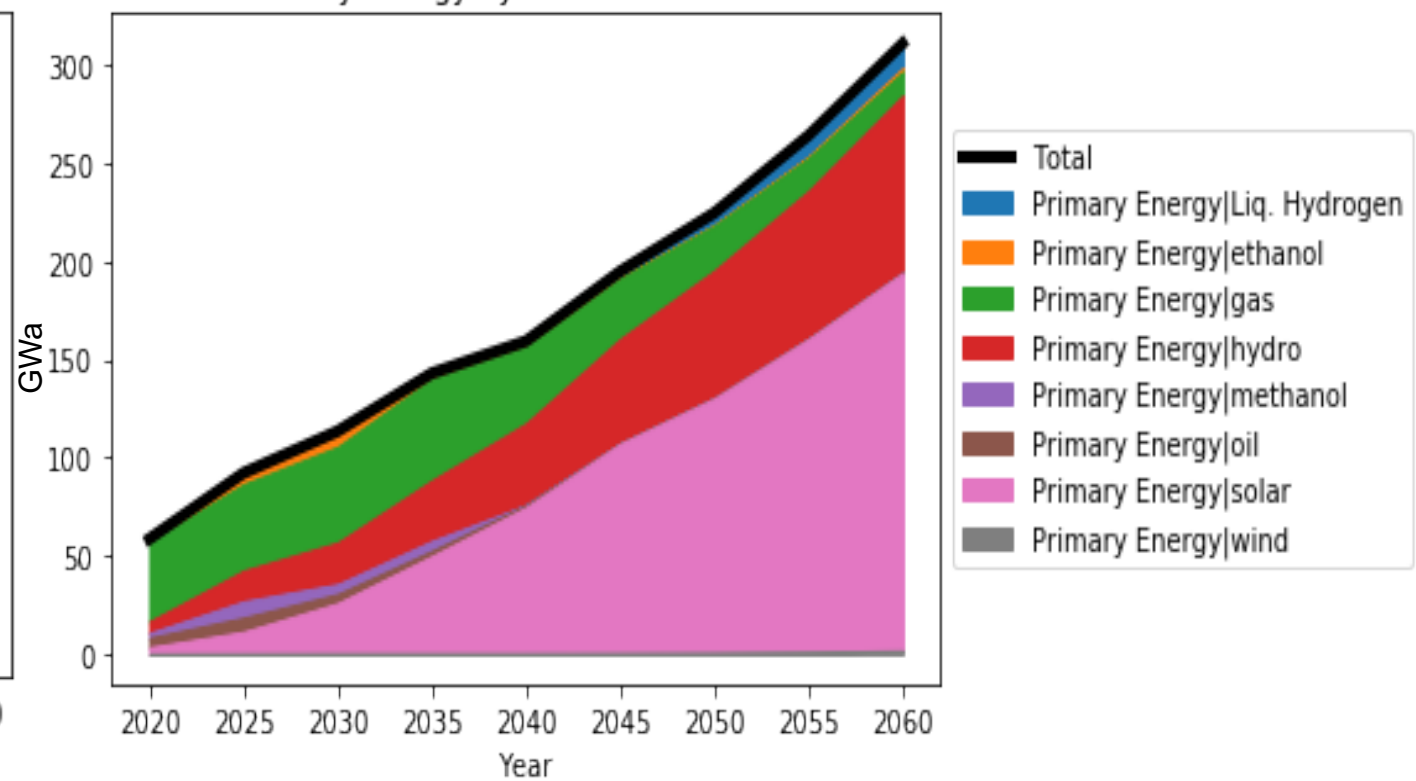
System Transformation

Primary Energy

Primary Energy by fuel - Baseline Scenario



Primary Energy by fuel - SDG Scenario



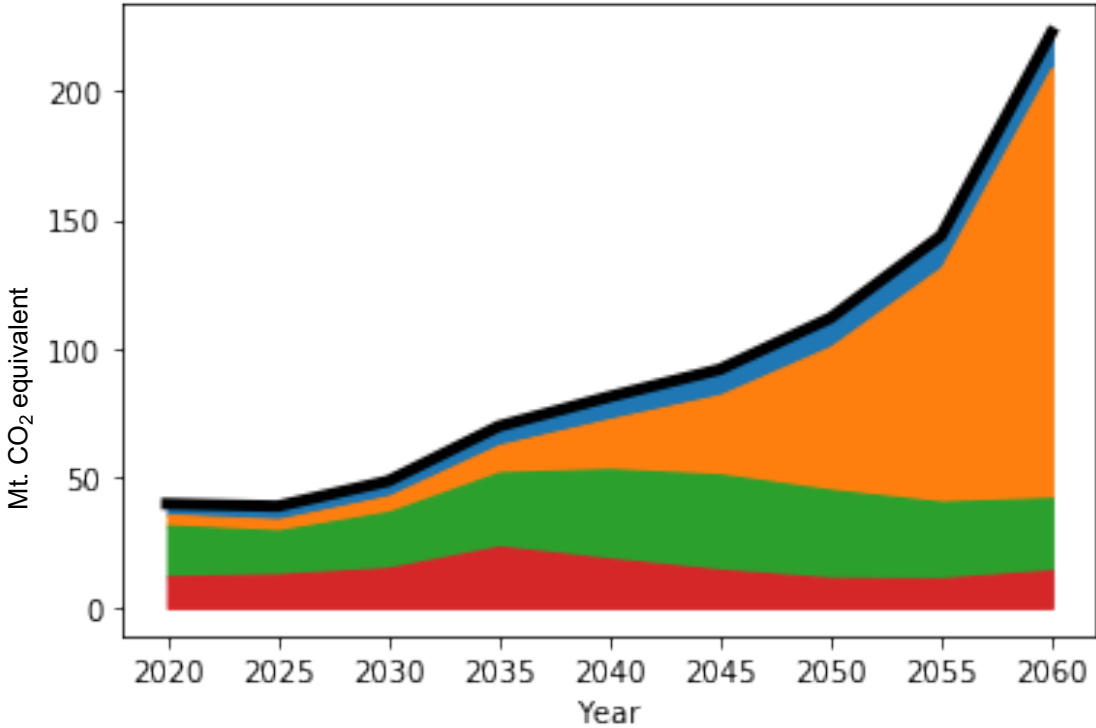
- Rapid transformation in prim mix from coal and gas to renewables in SDG scenario
- High solar & hydro potential in country



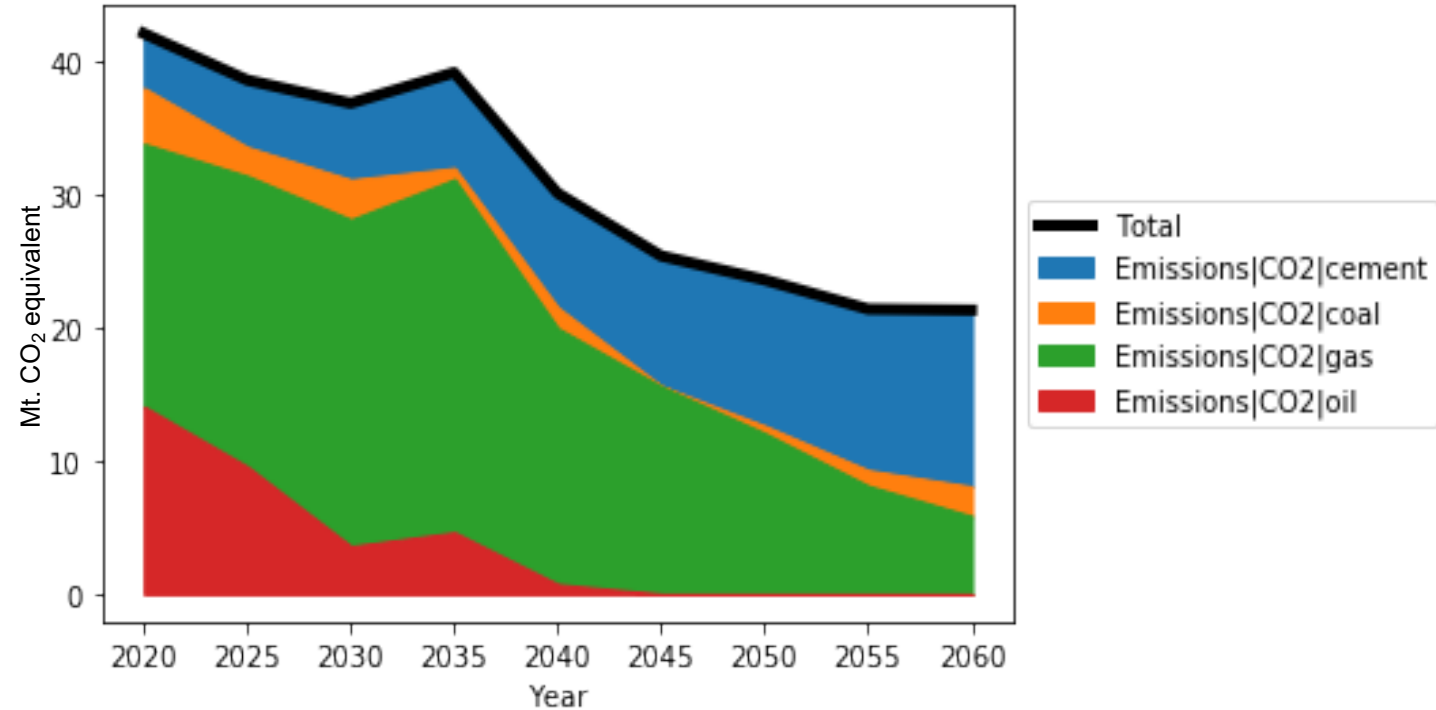
System Transformation

CO₂ Emissions

CO₂ Emissions - Baseline Scenario



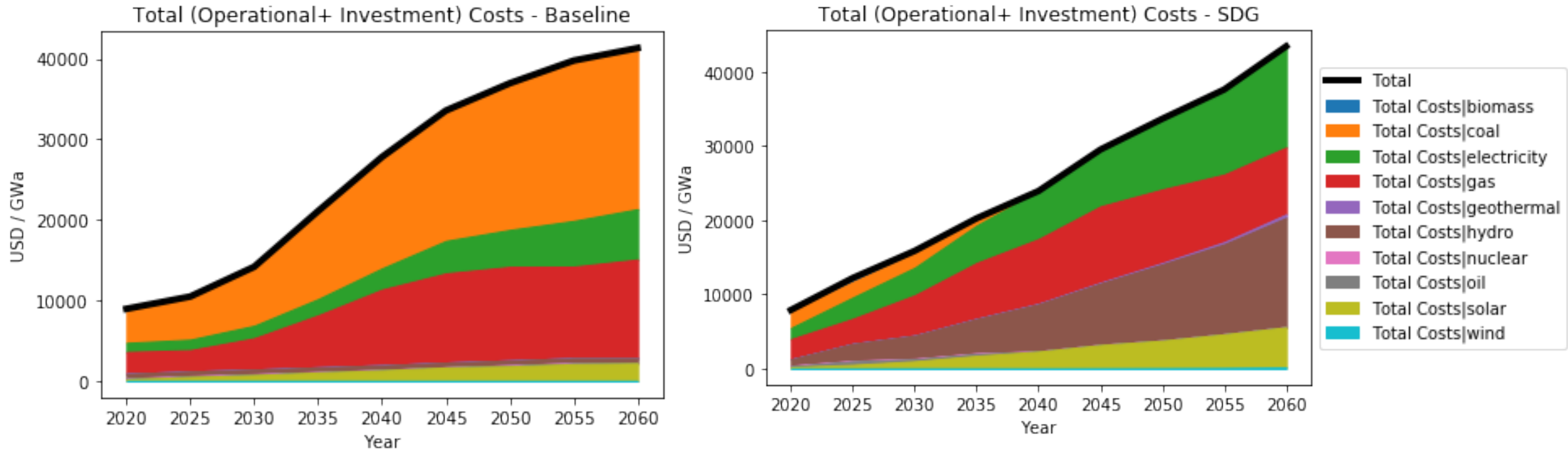
CO₂ Emissions - SDG Scenario



- Rapid reductions of emissions in SDG scenario to be consistent with SDG goals and Paris Agreement
- Emissions from oil and coal are negligible in SDG scenario.
- Gas & cement have higher share in CO₂ in SDG scenario



System Transformation Costs



- 37 % increase in investment costs & 13 % increase in operational costs
- SDG scenario saves investments in coal in the future years and reduce overall costs across horizon
- Costs transformation from coal & gas to distributed renewable sources in SDG scenario



- Suite of tools & functions for energy systems modelling
 - MESSAGEix – open source energy system model
 - Pyam python package for analysing and visualizing input data and results of scenarios for energy systems analysis and sectoral studies.
- The process can be replicated to any country/region for energy transition analysis
- Results indicate;
 - High potential for adopting solar and hydro for adopting renewables
 - Investments for provision of 100% access to energy
 - Costs shifts towards renewables rather than coal & oil

Thanks for your attention!

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