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

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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

Concluding Comments

Investments & Emissions
The MESSAGE$_{ix}$ framework
• transparency and reproducibility of research

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

MESSAGE-GLOBIOM – Integrated Assessment Model
MESSAGE\textit{iX}: Rapidly prototyping a national scale Model

Step 1: Rapid prototyping

- MESSAGE\textit{iX-GLOBIOM} Global Integrated Assessment Model
- Country level datasets from globally available data sources
- Add additional country level input data
- Passing information needed at country level

Regional model

Country level model

Output: Preliminary baseline scenario

1. Extract regional information from global model
2. Passing information needed at country level
3. Add additional country level input data
4. Updating, disaggregating and match country level information e.g. demand, capacity

Step 2: Stakeholder engagement

- Country level datasets e.g. NREL, IEA, USGS
- National Policies

Output: Refined baseline scenario

5. Data vetting process

6. Model refinement based on national datasets provided by stakeholders

7. Incorporation of national policies based on inputs from stakeholders

Step 3: Scenario development

Output: Sustainable scenarios

- Sustainability scenarios
- Climate mitigation scenarios
Pakistan - Socio-economic overview

Population

GDP
Pakistan - Exposure to key risks

Exposure to key risks

1.5° 2.0° 3.0°

- Cooling degree days (Rank 38)
- Agricultural water stress (Rank 7)
- Water stress (Rank 29)
- Multi-sector-risk (Rank 12)
- Heat stress (Rank 117)
- Clean cooking access (Rank 54)
- Hydroclimate risk to power ... (Rank 61)

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 to electricity and 71% of population lack access to 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
Scenario Design

Baseline

NDC commitments
• 25% share of renewables by 2030
• Improved Efficiency in electricity system by 2030

National Energy policies

SDG Scenario

SDG7

Increased Share of renewables (50% in 2030 and 100% in 2050)

Access to energy
• 100% Access to electricity in 2030
• 100% Access to clean cooking fuels by 2030

Increased efficiency in Electricity System

SDG13

50 % Total Carbon Emissions reductions by 2030

100% by 2060 from 2010 levels
Energy Access – Electricity

Adjusted electricity demands in SDG scenario

Adjusted Residential Electricity Demands

<table>
<thead>
<tr>
<th>Tiers</th>
<th>Consumption level per capita (KWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 1</td>
<td>≥4.5</td>
</tr>
<tr>
<td>Tier 2</td>
<td>≥73</td>
</tr>
<tr>
<td>Tier 3</td>
<td>≥365</td>
</tr>
<tr>
<td>Tier 4</td>
<td>≥1,250</td>
</tr>
<tr>
<td>Tier 5</td>
<td>≥3</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Year</th>
<th>% population w/o access to electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>77</td>
</tr>
<tr>
<td>2025</td>
<td>90</td>
</tr>
<tr>
<td>2030</td>
<td>0</td>
</tr>
</tbody>
</table>

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 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.

<table>
<thead>
<tr>
<th>Tiers</th>
<th>Consumption level per capita (GWa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 1 (for traditional fuel)</td>
<td>9.58904E-08</td>
</tr>
<tr>
<td>Tier 2 (for non-tradition/improved cooking)</td>
<td>1.27854E-07</td>
</tr>
</tbody>
</table>
• Significant increase in overall demands due to high population growth rates
• Residential/commercial is a major contribution due to increased temperatures & climate vulnerability
• Rapid transformation in prim mix from coal and gas to renewables in SDG scenario
• High solar & hydro potential in country
• 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
Comments

• Suite of tools & functions for energy systems modelling
  o MESSAGEix – open source energy system model
  o 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;
  o High potential for adopting solar and hydro for adopting renewables
  o Investments for provision of 100% access to energy
  o Costs shifts towards renewables rather than coal & oil

Thanks for your attention!