Long-term Energy Planning in Chile

Prospective and Regulatory Analysis Division
November 2018
Chilean context

SEN Installed Capacity

- Natural Gas: 19%
- Solar PV: 10%
- Reservoir: 15%
- Coal: 21%
- Run of river: 14%
- Diesel: 13%
- Geothermal: 0.1%
- Wind On-shore: 6%
- Biomass+Biogas: 2%
- Cogeneration: 0.1%

SEN Generation (Updated Nov-18)

- Biomass: 3%
- Solar PV: 6%
- Diesel: 1%
- Natural Gas: 17%
- Coal: 40%
- Run of river: 15%
- Geothermal: 0%
- Wind On-shore: 5%
- Reservoir: 13%
- Cogeneración: 0%
Energy Scenarios under the electric transmission regulation

In Chile the regulation on electric transmission expansion has two main components:

1. Long-term energy planning (Ministry of Energy): Energy planning. 30 years simulation. Updated every 5 years.

Considerations on the Energy Planning

The energy planning process has to include **energy demand and supply projections**, considering:

1. Renewable generation areas or poles
2. Distributed generation
3. International energy exchanges
4. Relevant environmental policies
5. Energy efficiency goals
6. Strategic energy plans of each region in the country
Long-term Energy Planning

Energy Planning
(Ministry of Energy)

Input Data
Experts committee
Citizen participation

Energy Scenarios

Energy Supply
Energy Demand
Complementary Analysis

Transmission Planning Recommendation
(Electrical Coordinator)

Transmission Planning
(National Energy Commission)
Long-term Energy Planning

- Identify the main variables that have high impact and uncertainty in the future energy sector
- These variables are projected
- Create every scenario as a believable story

- The energy demand model (Econometric simulation base on LEAP) is limited to the available information
- The electric expansion model PET (Co-optimize Gx+Tx) doesn’t include short term constraints.
- The electric expansion model PET doesn’t give the amount of flexibility needed for the future.
- The distributed generation model (Econometric simulation) is focused on the residential sector.

Data Input
Experts committee
Citizen participation

Energy Scenarios

Energy Supply
Energy Demand
Complementary Analysis

Scenarios
Models
# LTEP process

<table>
<thead>
<tr>
<th>Factors</th>
<th>Scenario A</th>
<th>Scenario B</th>
<th>Scenario C</th>
<th>Scenario D</th>
<th>Scenario E</th>
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</thead>
<tbody>
<tr>
<td>1) Projects social disposition</td>
<td>+ Cost &amp; with CCS</td>
<td>Free</td>
<td>Cost &amp; with CCS</td>
<td>+ Cost</td>
<td>+ Cost</td>
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<tr>
<td>2) Energy demand</td>
<td>Low</td>
<td>High</td>
<td>Media</td>
<td>Low</td>
<td>High</td>
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<tr>
<td>3) Battery storage technological change</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
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<tr>
<td>4) Environmental externalities costs</td>
<td>Current</td>
<td>+High</td>
<td>Current</td>
<td>Current</td>
<td>+High</td>
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<tr>
<td>5) NCRE CAPEX</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>6) Fuel prices</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
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LTEP results

The principals result for Chile in the process 2016-2018 process are:

• By 2050 there will be 40% of electric vehicles and 100 % electric buses.
• By 2046, 100-150 000 households with distributed generation.
• By 2030, 60% of renewable generation in all scenarios, and in 2 scenarios we reach 90% by 2046. (Without considering the undergoing process of decarbonization)
• Two scenarios show the need to upgrade LNG regasification terminals.
• The international interconnections shows bidirectional flows, that exports energy during solar hours and importing energy in the night.
Main achievements of first process

• Participatory process in every stage
• First ever long-term energy planning process, including e-mobility, electric heating and distributed generation projections.
• A methodology to define energy scenarios was established
• It has become a validated source of information for the energy sector, and a support for policy analysis and design.
Improvements for next process

**Energy scenarios**

- **Scenarios:** to include other uncertainty factors in order to make more representative scenarios.
- **Models:** to improve current methodology in order to include transmission issues and short-term constraints; continuous improvement of demand model.

**Energy supply**

- **Generation expansion plans:** continuous work with the National Energy Commission for generation expansion plans integration into transmission expansion process.
- **Long and short-term analysis:** to study a methodology to feedback generation expansion model.

**Complementary analysis**

- **Resiliency:** to include other variables linked with the concept, besides climate change.
- **Distributed generation:** to build a model for penetration estimation in commerce and industrial economic sectors.
- **Energy demand profile:** to visualize hourly effects with higher penetration of distributed generation and e-mobility on the energy demand profile and possible impacts onto electrical distribution infrastructure.
Thank you
Long-term Energy Scenarios in Transmission Planning

Juan C. Araneda
Transmission Planning Manager

LTES-CEM Webinar - 29 November 2018
Transmission Planning and Delivery (Electricity Law 20.936/2016)

Long-Term Energy Planning Process (PELP) (Developed every 5 years by Ministry of Energy)

ANNUAL TRANSMISSION PLANNING PROCESS

1. Coordinador proposes Transmission Projects to CNE
   - JANUARY Year 1
2. CNE Transmission Planning Study and Evaluation
   - APRIL
3. Experts Panel resolves discrepancies
   - JANUARY Year 2
4. Enactment of Transmission Expansion Decree
   - MARCH
5. Transmission Projects Tendering (National and Zonal)
   - MAY

Upgrade and Expansion projects tendered by Coordinador (National and Zonal transmission)

Market agents propose transmission projects to CNE
New Transmission Planning Criteria (Electricity Law 20.936/2016)

• Minimize supply risks, considering events, such as:
  ➢ cost increase or unavailability of fuels
  ➢ delays or unavailability of energy infrastructure
  ➢ Natural disasters or extreme hydrology conditions

• Promote the offer and facilitate competition in order to supply consumers at minimum price

• Economically efficient and necessary projects in the different energy scenarios

• Modification of existing transmission facilities in an efficient way

Transmission planning must include roominess and redundancies in order to incorporate all previous criteria
New Transmission Planning Criteria (Electricity Law 20.936/2016)

1. Adequacy:
   - CAPEX < NPV[ Δ(OPEX+CENS)]

2. Security of Service: N-k criteria
   - Resilience: resist LPHI events

3. Competition: Open Access to the Grid

4. Sustainability: Efficient use of Territory

5. Robustness: Long Term Vision and Flexibility

- Minimize supply risks, considering events, such as:
  - cost increase or unavailability of fuels
  - delays or unavailability of energy infrastructure
  - Natural disasters or extreme hydrology conditions

- Promote the offer and facilitate competition in order to supply consumers at minimum price

- Economically efficient and necessary projects in the different energy scenarios

- Modification of existing transmission facilities in an efficient way

Transmission planning must include roominess and redundancies in order to incorporate all previous criteria.
Flexible Transmission Market Oriented

- Transmission support associated to Variable Renewable Energy (VRE):
  - Size and location of reserves
  - Hydro, solar and wind forecasting
  - Inertia constraints
  - Battery Energy Storage Systems – BESS:
    - Expansion deferral
    - Congestion relief

- Flexible AC Transmission Systems: FACTS

- HVDC Transmission Systems:
  - Long distance of Renewable potential
  - Back-to-Back converters (interconnections)

- Smart grid: SIPS, WAMPAC, DLR
TRANSMISSION PLANNING PROCESS 2018
CO-OPTIMIZATION GENERATION – TRANSMISSION

Stage 1
- Generation-transmission optimization multi-node simplified
- Gx optimal location
- Gx investment to minimize Gx+Tx costs.

Stage 2
- One node optimization with long-term operational constraints
- Optimal integration of RVE with operational feasibility
- Flexibility options

Stage 3
- Operational simulation and evaluation of the transmission system
- Optimal Tx expansion proposal per scenario
- Proposal of resources to provide flexibility

Stage 4
- Decision making with robust planning transmission tools
- Optimal Tx expansion plan
- Requirements of resources that provide flexibility

Why to CO-OPTIMIZE?
Transmission expansion must consider Generation options, location and costs, in order to optimize the total system investment and operational costs

Long-term LOCATION SIGNALS via Optimal Transmission
### SCENARIOS OF NEW GENERATION CAPACITY

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<tr>
<th>Main Assumptions</th>
<th>Data according to PELP</th>
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<tr>
<td>CSP</td>
<td>Scenario A-Base: Referential</td>
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<tr>
<td>Solar-PV</td>
<td>Referential</td>
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<td>Wind</td>
<td>Referential</td>
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<td>Geothermal</td>
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<td>Hydro</td>
<td>Referential</td>
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<td><strong>Storage Systems</strong></td>
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<td>BESS</td>
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<td>Hydro Pumping</td>
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<tr>
<td><strong>Investment Costs of other Technologies</strong></td>
<td>Referential</td>
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<tr>
<td><strong>Environmental Constraints and Social Opposition to Projects</strong></td>
<td>High</td>
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<tr>
<td><strong>Fuel Costs</strong></td>
<td>Referential-ITP</td>
</tr>
<tr>
<td><strong>Electricity Demand Forecasting</strong></td>
<td>Base-Coordinador</td>
</tr>
</tbody>
</table>

- Referential cost for all generation technologies
- Low cost for solar-PV and wind technologies
- Low cost for wind technology
SCENARIOS OF NEW GENERATION CAPACITY IN 2030

CHILE

- S/E Kimal
- S/E Taltal
- S/E Lo Aguirre
- S/E Charrúa
- S/E Pichirropulli

**SCENARIO 1**
- Solar: 97%
- Wind: 0%
- Other: 3%

**SCENARIO 2**
- Solar: 99%
- Wind: 1%
- Other: 0%

**SCENARIO 3**
- Solar: 88%
- Wind: 10%
- Other: 2%

Potencia instalada en MW por zonas - Escenario 1

Potencia instalada en MW por zonas - Escenario 2

Potencia instalada en MW por zonas - Escenario 3
NATIONAL TRANSMISSION NETWORK DEVELOPMENT

CHILE

S/E Kimal
S/E Taltal
S/E Lo Aguirre
S/E Charrúa
S/E Pichirropulli

SANTIAGO
3,100 Km

2018

2025

2030

AC
500 kV
220 kV
154 kV

DC
600 kV