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en virtud de una decisión del Bundestag alemán

Modelling and forecasting the impacts of climate change on energy demand

Executive summary

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IMPRINT

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Leading partners are the German Ministry for Economy and Climate Action (BMWK) and the Chilean Ministry for Energy (ME), together with numerous affiliated institutions. The GIZ is the executive body of the partnership.

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1 Executive Summary

The Ministry of Energy carries out a long-term energy planning process every five years in a continuous process that results in long term scenarios that highlight trends of future development of the energy system. This process is referred to as Long Term Energy Planning (PELP).

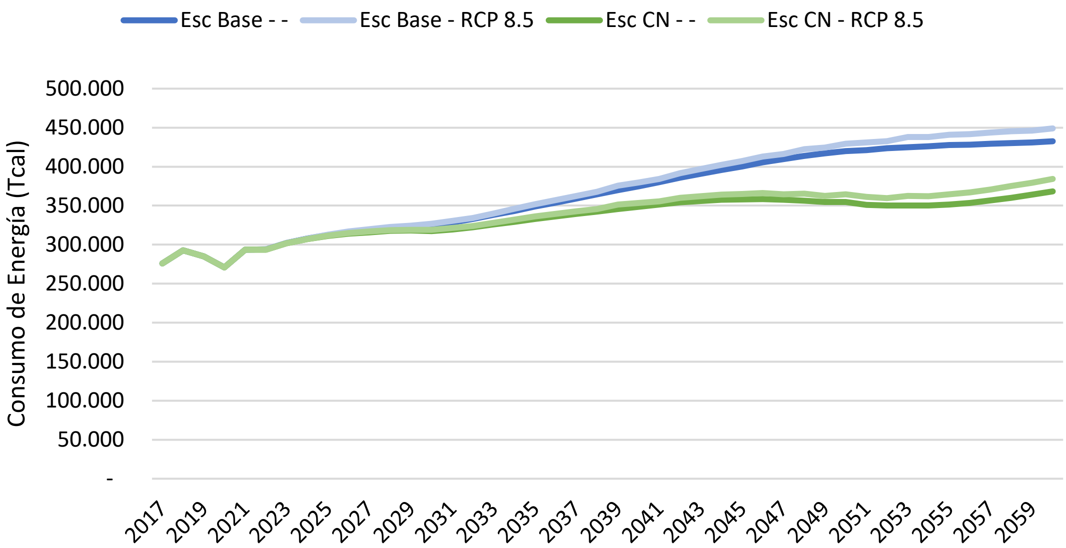
Energy scenarios are essential for multiple functions. They allow better planning of the infrastructure necessary to achieve Chile's environmental goals and commitments, such as carbon neutrality and the coal-fired power plant decommissioning process. They are also important for the integration of renewable energy sources and for guiding the different economic sectors regarding the cleanest energy alternatives and policy anticipation. Overall energy scenarios contribute to a cost effective and reliable energy system.

The purpose of this study is to incorporate climate change impacts on energy demand modelling and forecasting in the Chilean energy planning process. The impacts of climate change on energy systems are diverse. A bibliographical review shows that the effects of climate change on energy supply have been well explored. However, given that the effects of climate change on *energy demand* are less direct, they have not been studied in the same depth.

Energy demand can be influenced by variations in temperature and rainfall. The clearest and most studied effect is the effect of temperature on the thermal demand for cold and heat. Still, demand for water and electricity in industry for cooling and in the agricultural sector for irrigation purposes could also be impacted significantly. In terms of parameters, those potentially affected by climate change include (but are not limited to): the size of the annual energy demand, the duration, and times when peak demand occurs, and the (regional) spatial distribution of demand.

Chile is expected to experience important changes in climate. In general, models predict an increase in temperature throughout the country, especially in the northern and eastern territories. The maximum temperatures under the RCP 8.5 scenario increase in the short-term (2016-2035) of up to 2°C, similar to those observed for minimum temperatures. During the 2046-2065 period the temperature increases deepen even further. In terms of precipitation, simulations reveal a decrease between 5-15% from the Copiapó river basin in the north and the Aysén river basin in the south.

To assess the effects of climate change on energy demand, two energy scenarios previously developed by the Ministry of Energy were considered: the Base Scenario (Base) and the Carbon Neutrality Scenario (CN), both of which did not explicitly include the effects of climate on demand. These scenarios were updated and modified to include the impact of climate variables as projected in the RCP 8.5 climate scenario. As consequence, two additional scenarios inherited from the Base and Carbon Neutrality scenarios were generated.



In the Base Scenario without climate change considerations, energy demand is expected to reach 419 thousand Tcal in 2050 and 432 thousand Tcal in 2060. In the Carbon Neutrality Scenario, energy efficiency and mitigation measures will limit energy demand, which will reach 354 thousand Tcal in 2050, a value 15.5% lower than that observed for the Base Scenario. In 2060, energy demand is expected to reach about 382 thousand Tcal in the Carbon Neutrality Scenario.

When climate impacts are considered (RCP 8.5), energy demand increases, regardless of the selected mitigation scenario. These impacts increase in time. This difference is around 16,000 Tcal by 2060 in both scenarios. Depending on the scenario analysed, the energy demand will increase between 2.3% - 2.8% in 2050, and 3.8% - 4.3% in 2060 only due to climate effects. This higher energy demand in the RCP 8.5 scenario is largely explained by the increase in electricity consumption.

These results are a consequence of increased consumption in the residential, industrial and mining sectors. In the residential sector the expected reduction in demand for heating is compensated by higher demand for air conditioning in the 2050-2060 period. The industrial and mining´s consumption is associated with an increase in electricity consumption employed for water desalination and pumping.

The results obtained in this study reveal, climate change will stress the energy systems. Impacts regarding demand relate to the size of the annual energy demand, the duration and moments in which the maximum demand occurs (load curves) and the spatial (regional) distribution of the demand. Greater resilience of the energy sector is a necessary condition to face the challenges of climate change. This challenge must take advantage of multisectoral synergies between adaptation and mitigation.

Policy recommendations can be provided from the results:

1. The security and resilience of the energy system is key and must be improved. The resilience of the electricity sector is essential considering that the energy transition aims to increase its role in consumption in sectors and uses such as heating and transport. For this reason, it is essential to be clear about the impacts that changes in climatic variables can have on the different segments of the system: generation, transmission, and distribution. The distribution segment explains the largest number of failures in the electricity system, so it should be strengthened considering the expected increase in electricity demand. Fuel infrastructure

should also be assessed, considering its storage capacity is insufficient according to the International Energy Agency's standards. Finally, it is important to build risk maps of critical infrastructure (power stations, transmission and distribution infrastructure, ports, pipelines, storage) to enable plans to anticipate and deal with different contingencies.

2. Move forward in the efficient and resilient penetration of renewable energies in the energy matrix considering climate impacts. The energy sector will meet its decarbonization goals mainly through electricity consumption from renewable sources (including green hydrogen). The massification of renewable energies entails technical, regulatory, and business challenges that involve both the public and private sectors. Changes in consumption levels and patterns deepen this requirement considering that new uses (such as desalination and hydrogen production) and potential changes in hourly consumption (such as air conditioning) must be satisfied.
3. Implement policies, instruments and measures that reduce the pressure on the energy system derived from climate impacts. Changes in electrical consumption can increase pressure on the electricity system. Energy efficiency and demand management measures that include incentives and price signals reduce stress on the system during times of high demand. In the same way, distributed generation in homes and businesses increases the security of the system. In this sense, it is necessary to include technology and modernize the distribution segment.
4. Long-term planning with explicit considerations on climate change. Energy policy must consider changes in consumption levels and patterns derived from climate change. This allows to anticipate requirements and modifications to the infrastructure of energy systems as well as introducing regulatory modifications and/or incentives.
5. Effective coordination between sectoral ministries and regional authorities. Sectoral and regional coordination is necessary both for the planning of energy requirements and to assess how these requirements can stress energy systems; and to have adequate plans in case of emergencies.
6. Develop emergency plans that explicitly account for climate risks. An energy plan responds to unplanned events that trigger supply challenges. The motivations for having an emergency plan are related to reducing social - economic, environmental, and human costs - through adequate preparation to face emergency events and reduce the recovery time of supply systems. Requirements for successful implementation of such plans include effective communication systems, stakeholder engagement and coordination, and robust institutional capacities,

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