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The challenges of growing renewable energy in Chile

Prepared for

IEEE PES Power & Energy Society®

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Outline

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Describe the evolution of Non Conventional Renewable Energy (NCRE) in Chile, the first actions to encourage NCRE generation, the successful growth without subsidies, and its impacts and the future challenges.

General market overview

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Main system in 2018

- Installed capacity: 24 GW
- Generation: 74,910 GWh
- Maximum demand: 10.8 GW
- Supplies 98.5% of population (other isolated systems: 1.5%)

Market overview – Spot energy market

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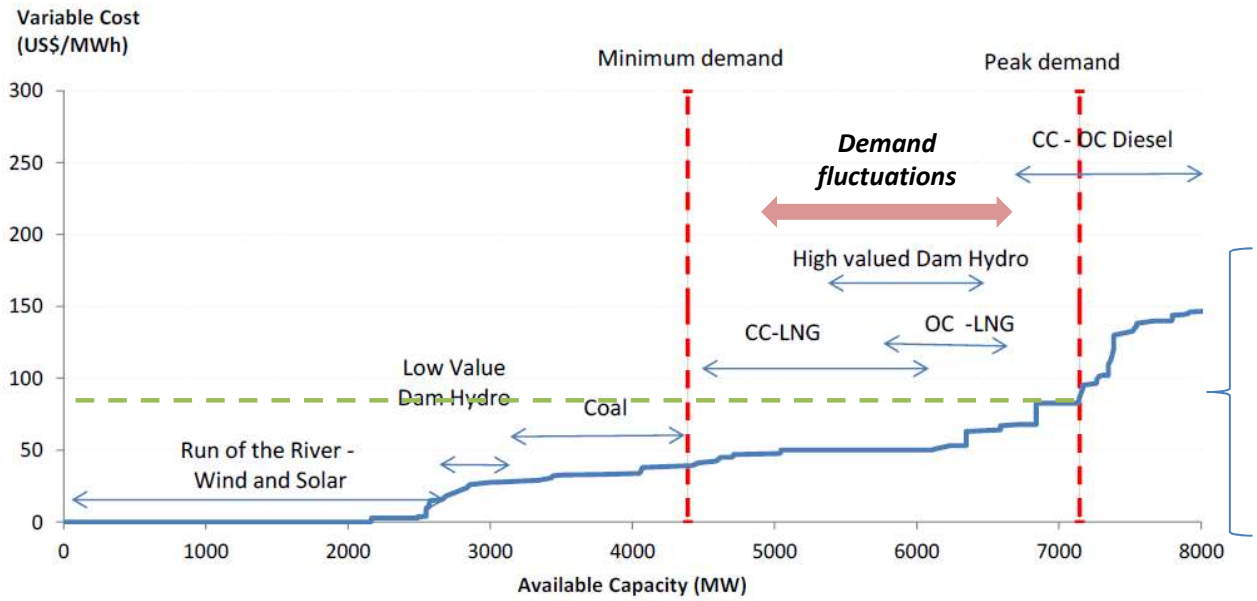
- System operation is **independent** of existing commercial agreements between generators/clients, i.e. physical operation is **independent** of commercial operation.

- Dispatch is performed by following the merit list**,** subject to transmission constraints and security standards. These **variable costs are audited** and **dispatch is decided centrally** by the CEN.

Merit order dispatch supply curve example for the SIC in September 2015



Energy spot price or marginal cost of the system clears at the variable production cost of the most expensive unit that can supply an additional MW at a particular time of day and at the non-fuel variable cost

Non Conventional Renewable Energy (NCRE)

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Law 20,257 of 2008 defines unconventional renewable energy:

Those resources that produce electrical energy through primary sources such as biomass, hydraulic energy (whose maximum power is less than 20 MW), geothermal, solar, wind and tidal energy or other generation that uses renewable energies, diversifies the matrix and causes a low environmental impact (determined by the National Energy Commission).

Chilean NCRE

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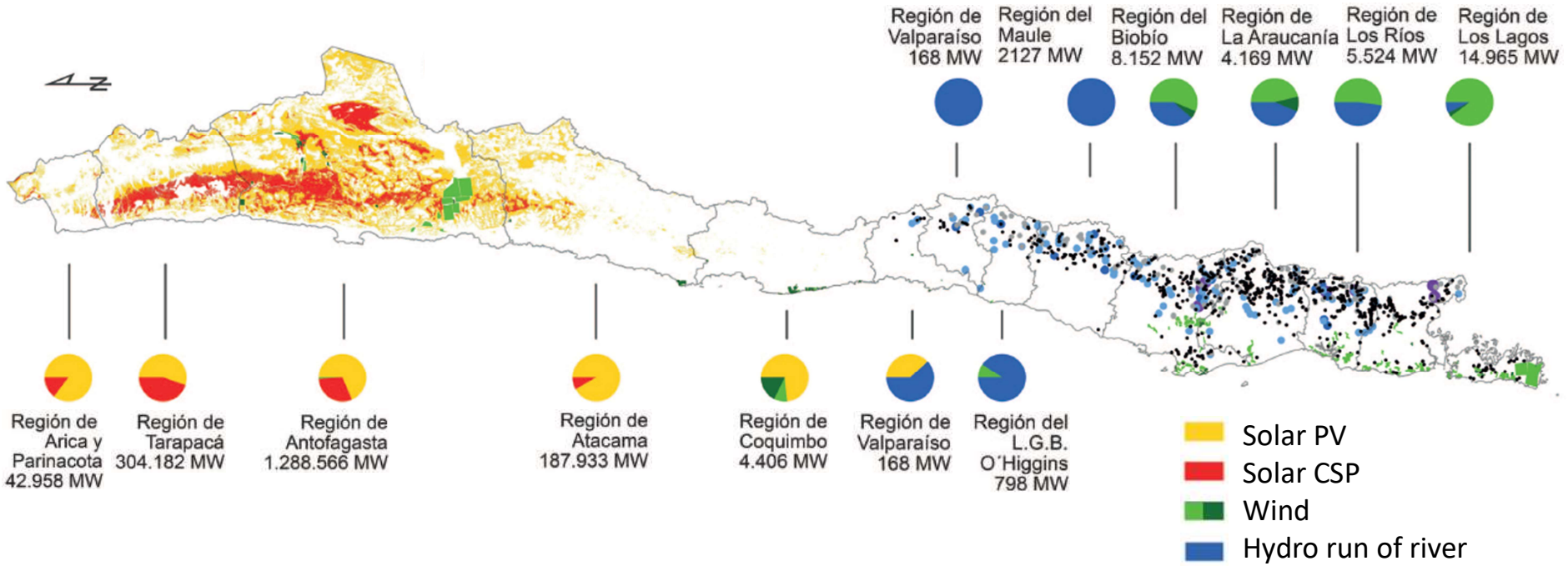
Chile has a huge potential of 1,827 GW of solar, 24 GW of wind and 14,6 GW MW of hydro energy, plus 2 GW geothermal plus 2 GW biomass.



Source: Mesa ERNC Energía 2050, Ministry of Energy, Chile

Chilean NCRE evolution

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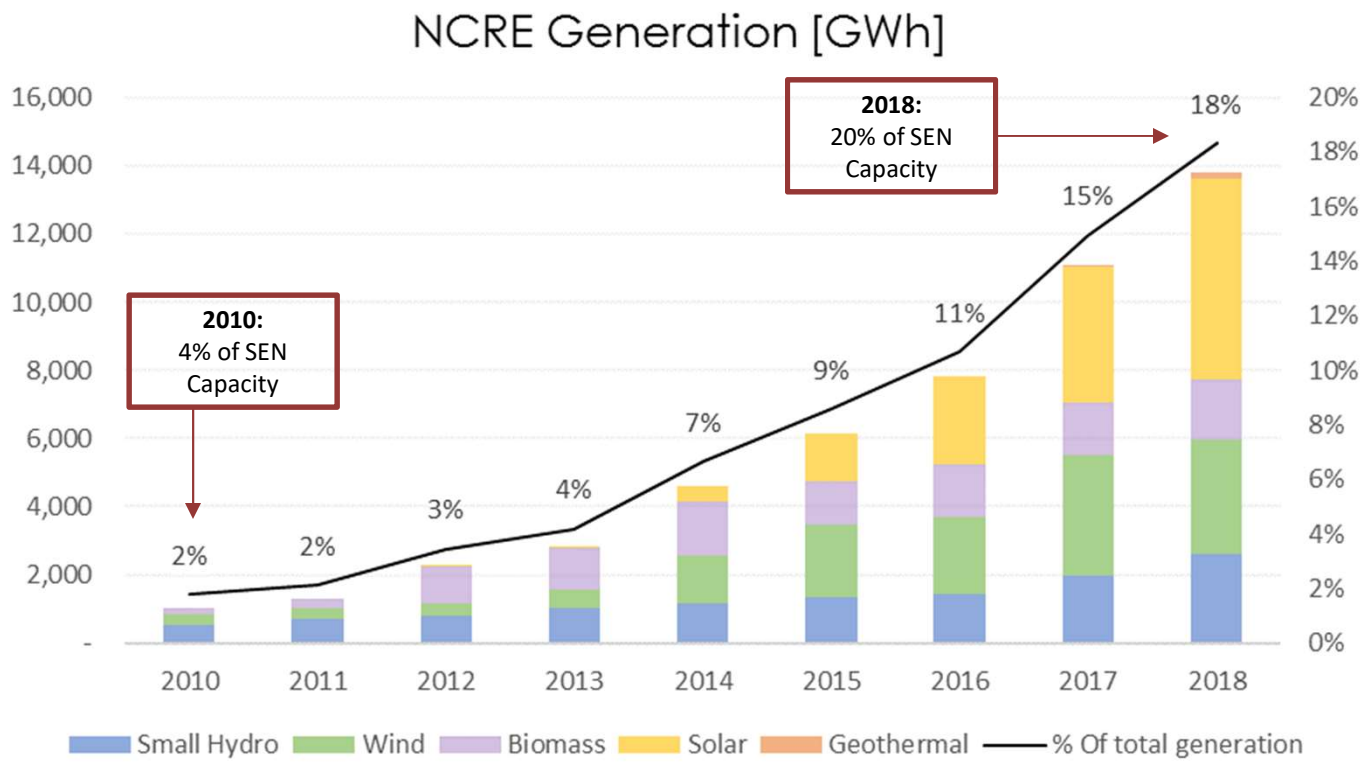
- Renewable power plants have increased their participation in the system in the last few years. They went from representing 2% of the total generation in 2010 to 18% in 2018.



Chilean NCRE - Injections June 2019

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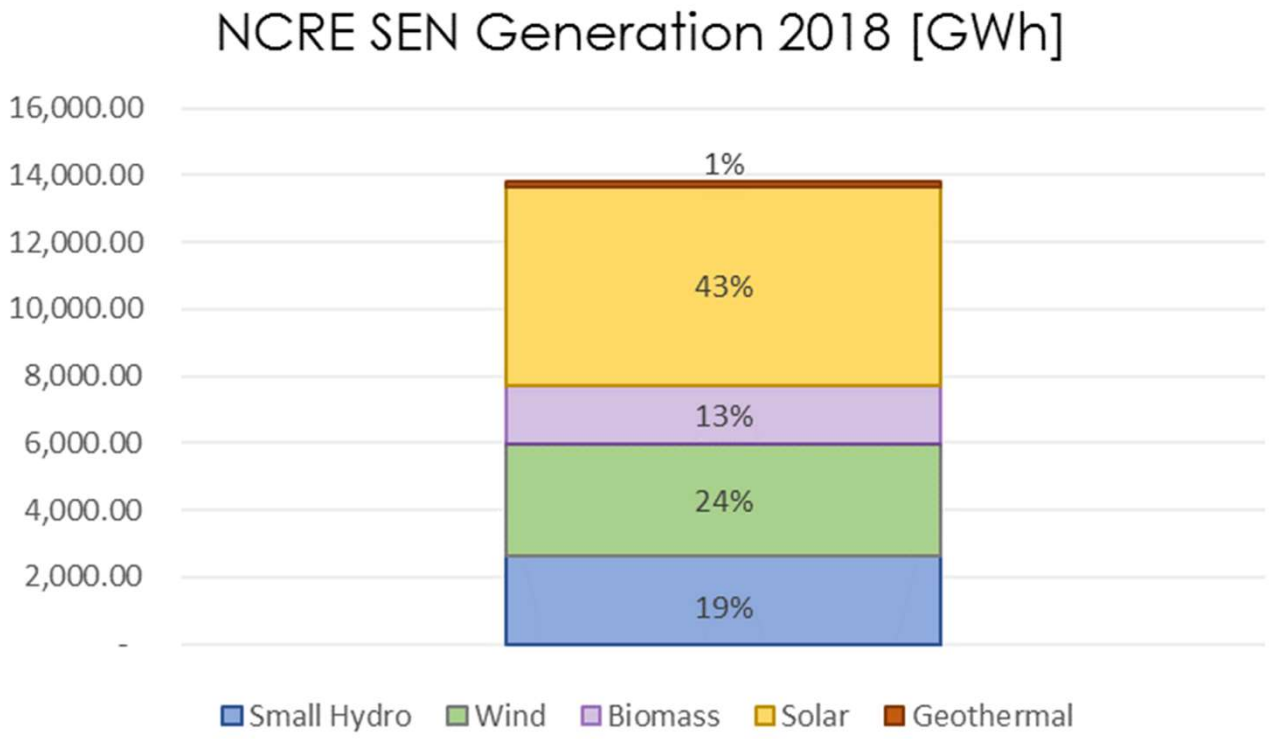
In 2018, 13,797 GWh of renewable energy were injected to the system. From it, 43% comes from solar sources (5,908 GWh) and 24% comes from wind sources (3,350 GWh).



Background - International interest in Chile

International interest in Chilean electricity market started for 3 main reasons:

1

The end of subsidies for renewable energy projects

- Almost all countries in the European Union started to cut or reduce the subsidies for renewable energy projects since 2012. Some countries, such as Spain, began cutting their renewable subsidies as early as 2010.

2

High marginal costs in the spot market in Chile (until 2014)

- At the beginning of this decade, most of the electricity in the northern part of the country was generated from fossil fuels.
- Due to a natural gas supply problem, originated by the cessation of supply from Argentina in 2002, many diesel generation units were often operated.
- This drove the spot market to present high marginal costs in the northern region. (A maximum average marginal cost during the month of August 2008, around 291USD/MWh)

3

Great conditions for solar and wind energy production

- 4,000 hours of sunshine per year in the northern regions.
- Highest levels of solar radiation found anywhere on the planet.
- Optimal wind energy potential may be found in the northern central region.

Background - International interest in Chile

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The New York Times

INTERNATIONAL EDITION | MONDAY, AUGUST 14, 2017

Workers installing pipe insulation at South America's first geothermal energy plant, located in Cerro Pabellón, Chile. The new plant will be able to power about 165,000 homes.

Chile's energy transformation

CERRO PABELLÓN, CHILE

Nation is a powerhouse for renewables thanks to wind, sun and volcanoes

BY ERNESTO LONDOÑO

It looks and functions much like an oil drilling rig. As it happens, several of the men in thick blue overalls and white helmets who operate the hulking machine once made a living pumping crude.

"war on coal" and take aim at American environmental regulations.

"It's irrational, like someone has been asleep for 10 years and refuses to wake up," said James Lee Stancampiano, the head of business development for South America at Enel Green Power, an Italian company that has played a leading role in overhauling Chile's energy sector. "We see renewables as a train that nobody can stop."

Even Argentina, something of a laggard in Latin America when it comes to clean energy, last year invited foreign companies to bid on renewable energy projects and declared 2017 to be the

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IEA Highlights Chile's Potential As Renewable Energy Behemoth

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January 23rd, 2018 by Joshua S Hill

The International Energy Agency has this week published a new report highlighting the emergence of Chile as one of the world's growing renewable energy destinations, thanks to second-to-none resources and increasingly forward-looking policies.

Bloomberg

Markets

Solar Sold in Chile at Lowest Ever, Half Price of Coal

By Vanessa Dezem

19 de agosto de 2016 12:53 GMT-3 *Corrected 22 de agosto de 2016 16:07 GMT-3*

- Solarpack won solar contracts for $29.10 a megawatt-hour
- Power prices declined 40% in Chile's largest-ever auction

Solar power just sold for the lowest price ever, in Chile

Chile's auction concludes with average price of $32.5/MWh

The Chilean government has allocated approximately 600 MW of renewable energy capacity in the auction.

NOVEMBER 3, 2017 EMILIANO BELLINI

MARKETS MARKETS & POLICY POLICY CHILE

'A SOLAR SAUDI ARABIA'

While Trump promotes coal, Chile and others are turning to cheap sun power

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Background – Decrease in investment costs

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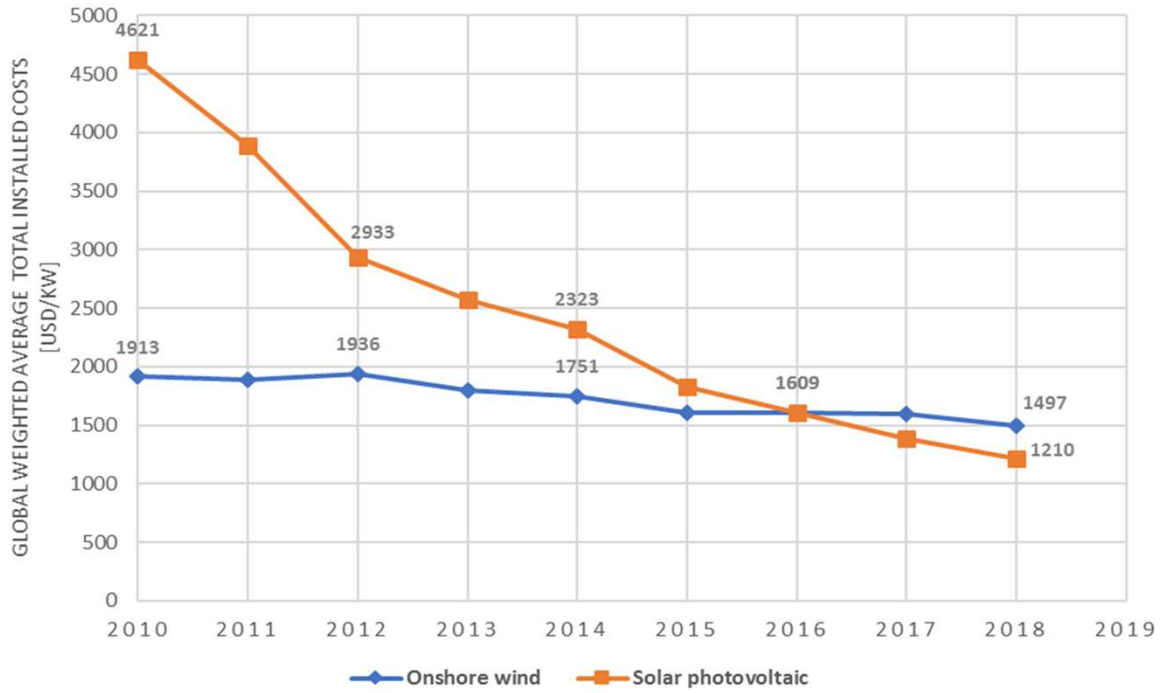
- Technological change and the accelerated decrease in investment costs

(since 2014) had made solar PV and wind very competitive technologies [1] .



*[1] Source: IRENA “Renewable Power Generation Costs in 2018”

NCRE definition and tolls

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Unlike in the international context, in Chile there were no specific subsidies for NCRE.

The appropriate way to encourage investment in them was through market mechanisms, to guide the development of the electricity sector towards clean energy.

Provisions of Law 19,940 (in 2004) grant an exemption in the payment of tolls for NCRE transmission.

In the particular scenario of hydroelectric power plants the exemption is total for plants less than 9MW and partial for those greater than 9MW and less than 20MW.

NCRE generation obligation

Government first policies aimed to encourage renewable generation.

2008: Law N° 20.257

Achieve in 2024 that 10% of system withdrawals are injected by renewable sources:

- As of 2010, electric companies that have supply contracts after August 1 2007, must prove to the Coodinator that an amount of energy equivalent to 5% of their withdrawals in each calendar year has been injected through non conventional renewable generation (own or contracted).
- This percentage should be increased by 0.5% every year from 2015 to 10% in 2024.

2013: Law N° 20.698

Achieve in 2025 that 20% of system withdrawals are injected by renewable sources:

- The article indicated above is amended in October 2013, establishing a new quota applicable to contracts after July 1 2013: 6% in 2014, increasing to 20% by 2025.

*It was established that if the obligation was not met, the company would be fined..

→ **New opportunity for contracts with those generators that do not have their own NCRE plants and that need to meet the established quota.**

Facilitating actions in power supply tenders

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The high prices achieved by the tenders of 2008 (USD 104) and 2013 (USD 129), product of the lack of competition in the process and the absence of new participants, made it necessary to modify the law governing the bidding system created in 2005.

In May 2014, a modification to the bidding system for electricity supply was made. This amendment sought to reduce the prices of the contracts resulting from the following tenders.

Tenders in a single process

The bidding conditions may group the supply requirements of different DSOs in the same process.
All distribution companies participate in just one public tender.

→ **It allows to increase competition.**

Supply start

The start of the supply is established 5 years after the award of the contract, i.e. power plants should not be under construction, or have the corresponding permits to support the offer.

→ **It allows renewable technologies to present a more competitive price given the decrease in investment costs and the shortest time required for their development and construction.**

Power hourly blocks

Change from standard 24-hour supply block to three time-blocks, which is a more suitable scheme for intermittent power generation from NCRE.

→ **Incorporates flexibility into the system.**

Long term contracts

Supply period set at 20 years (before max. 15 years).

→ **It facilitates access to projects finance.**

NCRE Growth -Quota exceeds 10%

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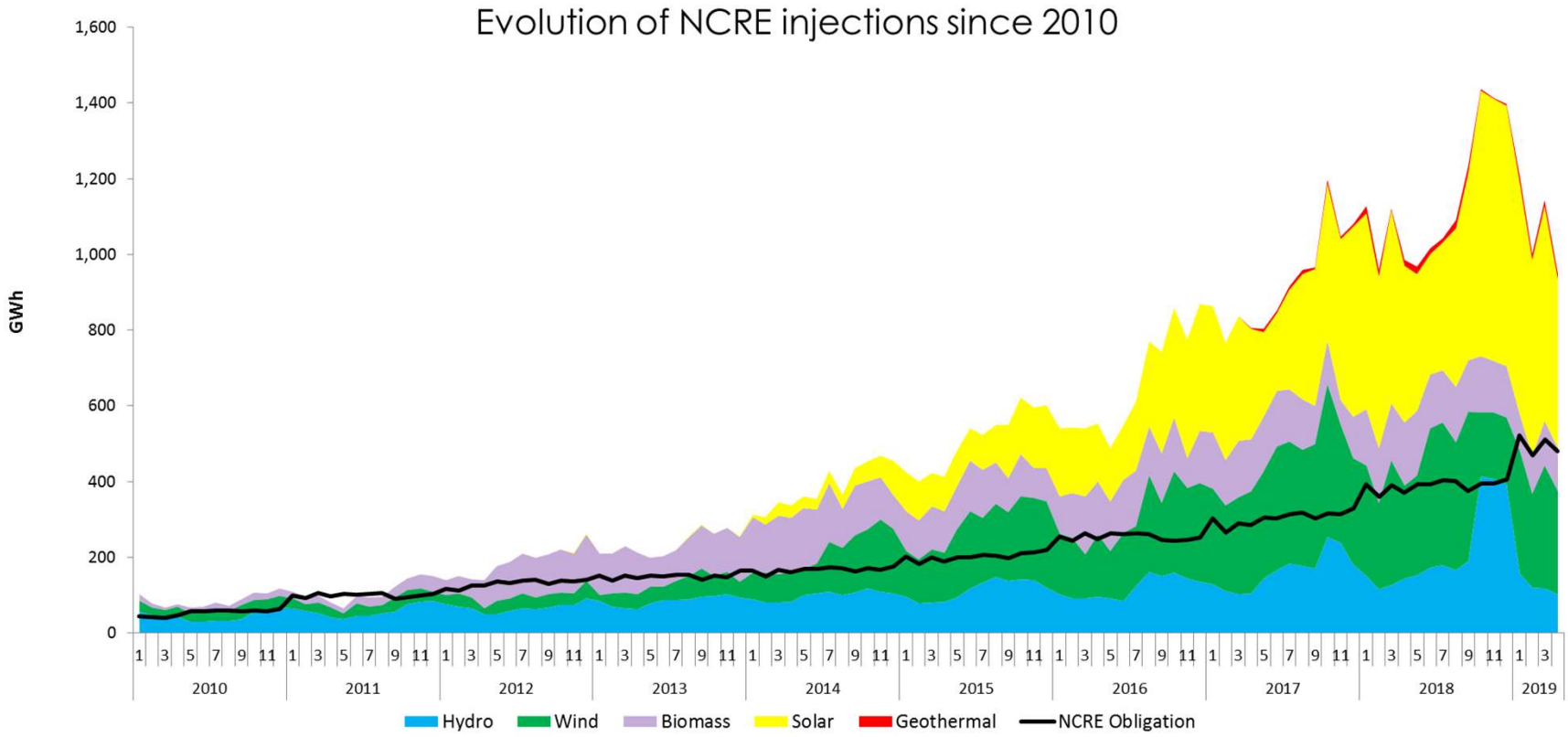
- The Chilean renewable energy market has grown so fast that the 10% quota imposed by the first law has been widely exceeded since September 2011.



Impacts of NCRE increase – PPA decrease

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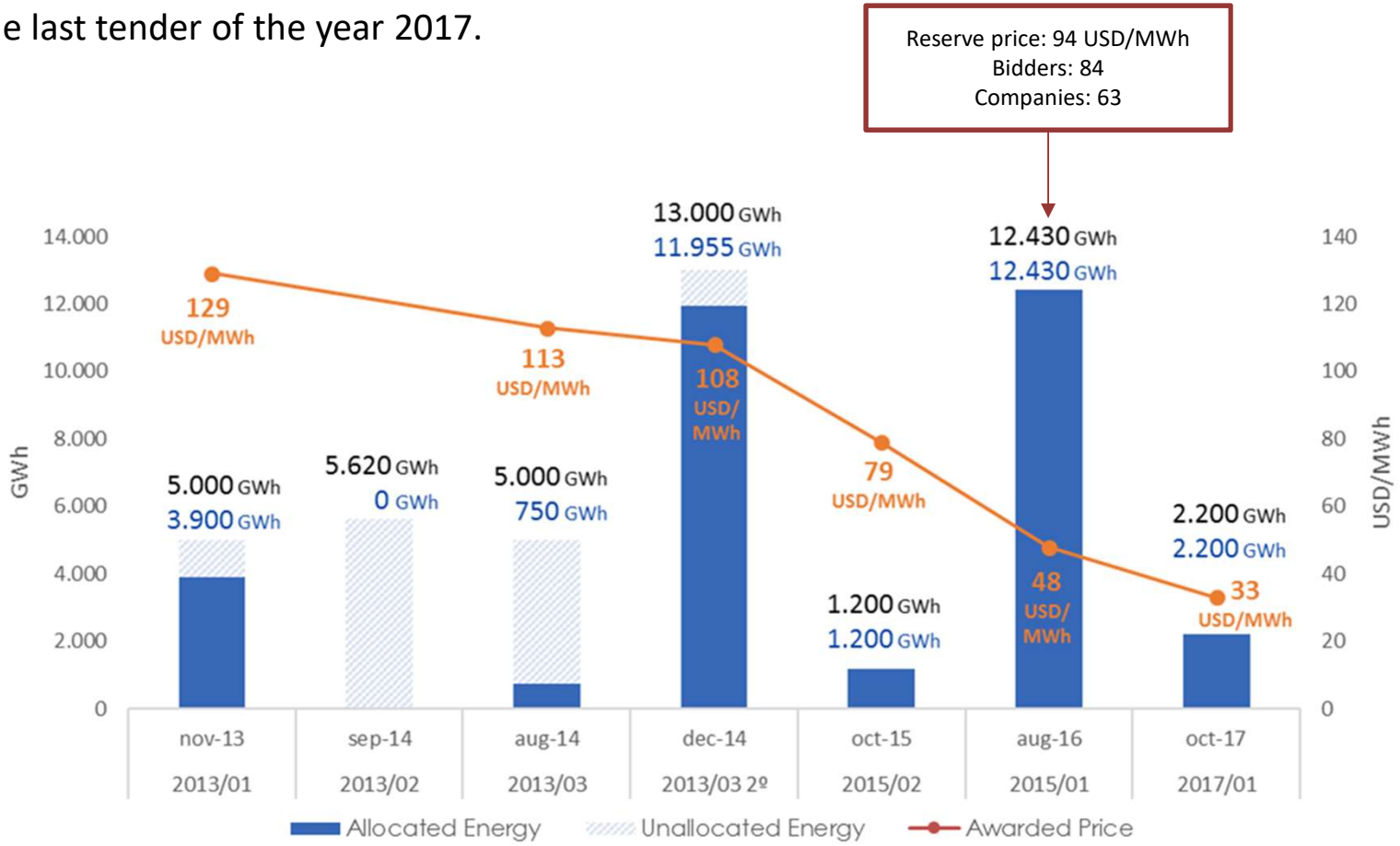
The average price reached in the tenders has decreased by 74% from the tender of the year 2013 to the last tender of the year 2017.



Impacts of NCRE increase- Reduction of marginal costs

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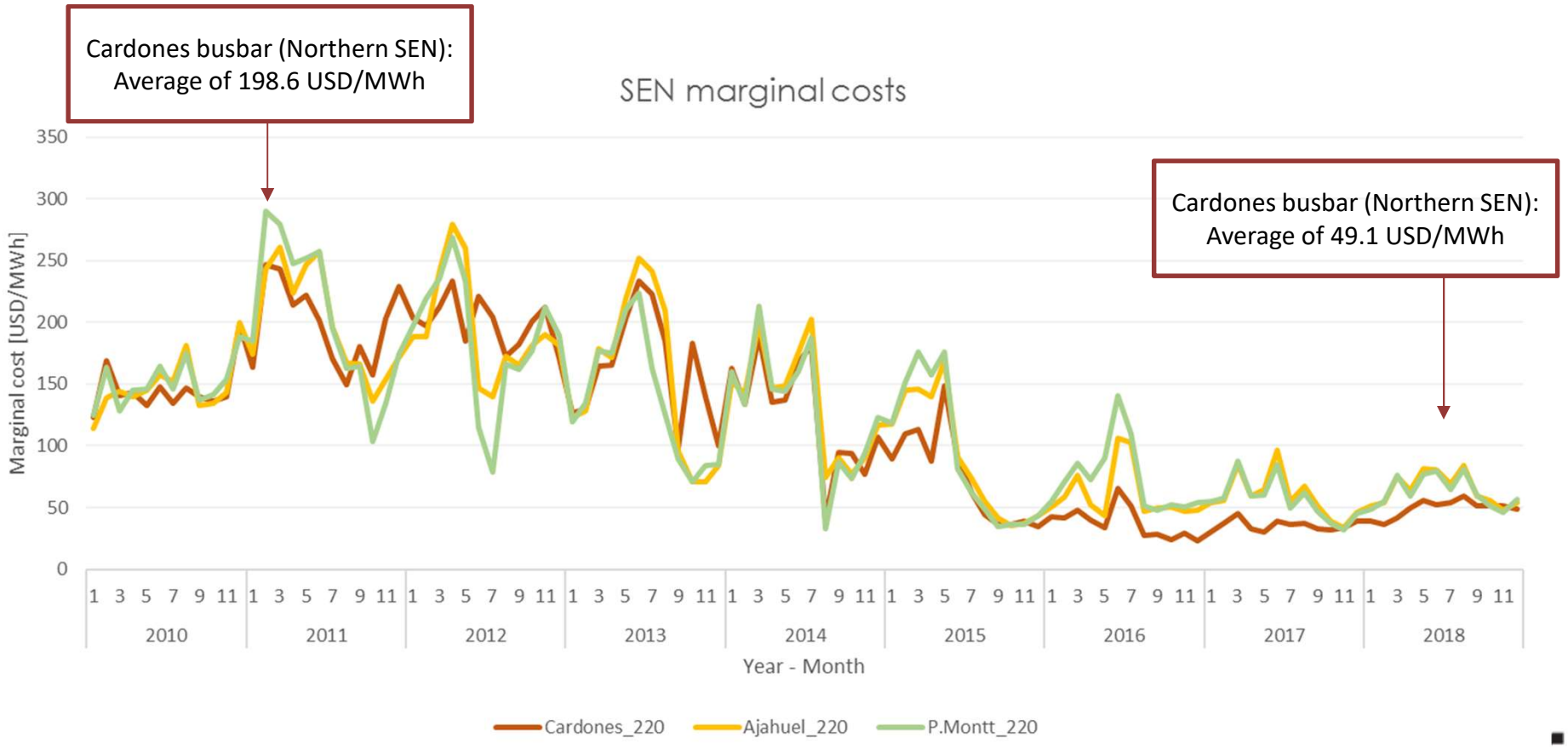
Monthly average marginal costs of different system busbars, belonging to the Northern, Central and Southern SEN.

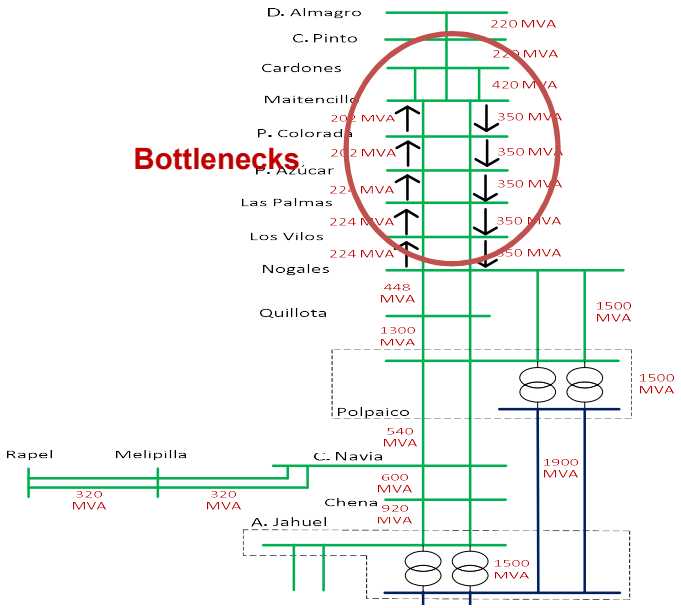


Challenges given the NCRE increase

Transmission development

- Transmission development conditions flow of renewable energy between systems.
- Restrictions may introduce considerable price decoupling risks on supplying PPAs in other nodes of the system.

The trunk transmission connecting the southern and northern SEN presented bottlenecks that when congested implied marginal cost decoupling and curtailments.



Challenges given the NCRE increase

Transmission development

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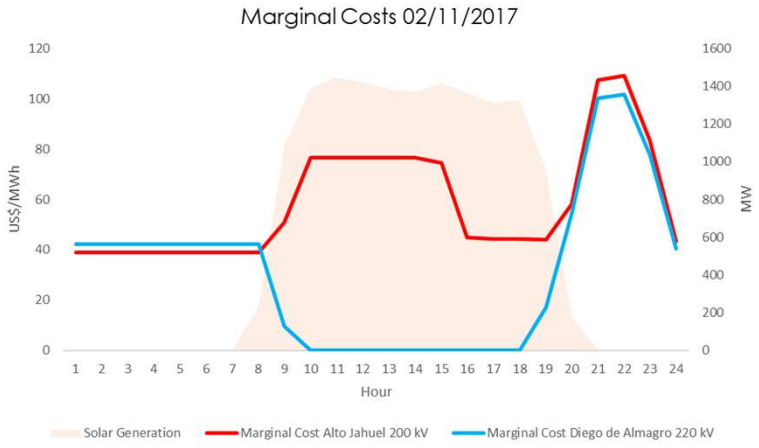
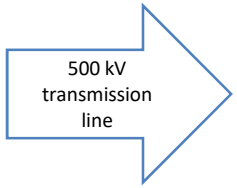
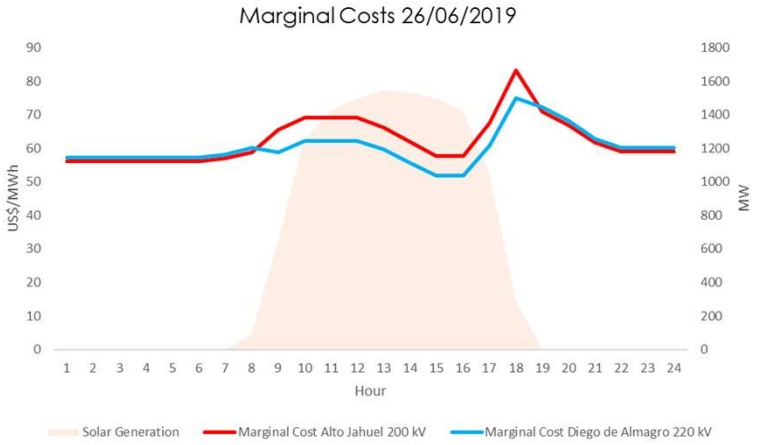
Differences in injection and withdrawal marginal costs ($MgC_A \neq MgC_B$):

- Transmission congestions produce price decoupling and in the case of Northern Chile, these decoupling make marginal costs reach zero, given the large penetration of renewables
- **A 500 kV transmission system intended to overcome this situation was commissioned on June 2019.**





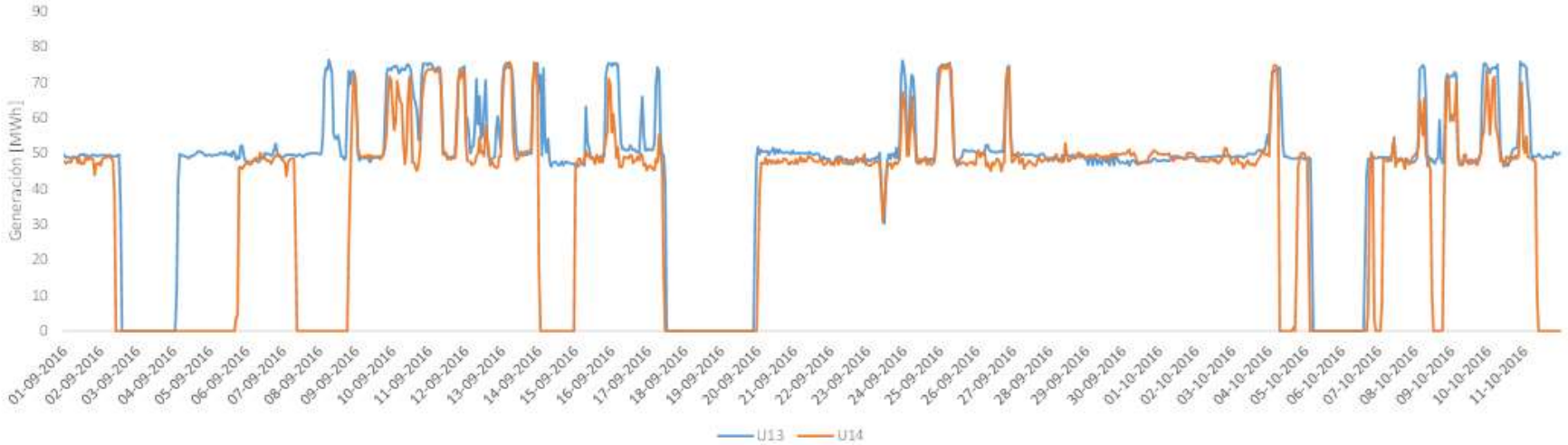


Challenges given the NCRE increase

Cycling

- With an **increasing penetration of photovoltaic and wind solar generation units**, characterized by their **intermittency** and variability, has led to the modification of the generation profiles of LNG and coal based plants: causing a **cycling type operation of conventional units.**

These modifications have even implied defining a daily profile of frequent switching on and off of certain thermoelectric generating units (cycling type operation) in order to have sufficient support at the time of the loss of the contributions of electrical energy from photovoltaic solar plants and wind.



→ **The cycling of thermal units implies an additional operation and maintenance cost of the units, compared to a base load operation.**

Challenges given Decarbonization Plan

Chile recently implemented a decarbonization plan whose main objetives are:

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Completely phase out coal plants by 2040

- **Chilean energy companies** that are included in the plan were not forced to participate in it, they **volunteered**.
- On its first stage, **the plan will close eight coal power plants over the next 5 years**, cutting coal-fired generation by 19% equivalent to 1,047 MW.
- The Government is actively negotiating with Chilean energy companies to agree on the schedule to phase out each of the remaining coal plants.

Achieve carbon neutrality by 2050

This requires to widely reduce Greenhouse Gas (GHG) emissions. **Phasing out coal plants is not enough for mainly two reasons:**

- Closing coal plants at first will increase capacity factor to the remaining coal power plants.
- Part of the national base generation change from coal to gas power plants.

→ Therefore, the decarbonization plan needs to also consider replacing outgoing plants for new NCRE.

Further reading

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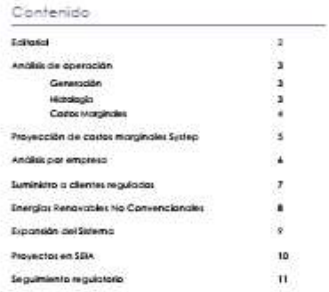
More information of the Chilean electricity market:

- Publications

  www.systep.cl/?page_id=23

- Monthly reports

  www.systep.cl/?page_id=21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