



# Challenges and opportunities in the development of networks in Latin America: national and international perspectives

Harvard Environmental Economics Program & The Enel Foundation  
Roundtable on Energy and Climate Change Policy  
Rio de Janeiro, 29-30 November 2018



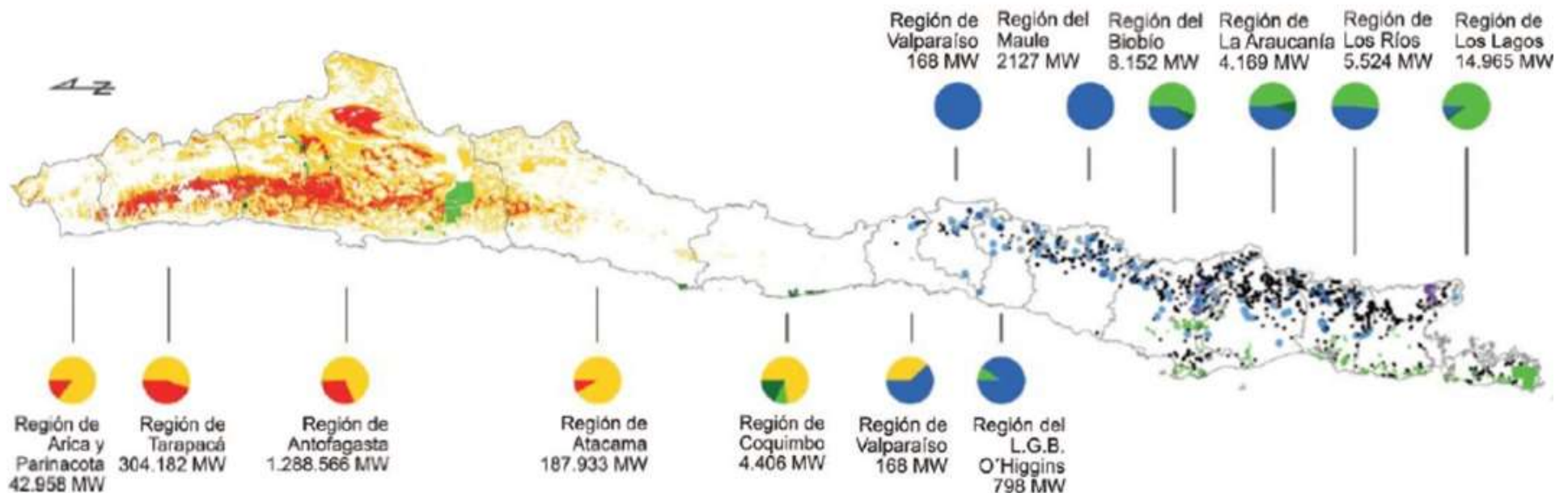
## **-Introduction**

- Assess Chilean future transmission capacities until 2035**
- Assess effects of energy exports to Peru and Argentina**
- Discuss regulatory changes for creation of common markets**
- Discuss regulatory conditions for transmission expansion**

# General overview – Chilean renewables



Chile has a huge potential of 1,850,00 MW of wind, solar and hydro energy, plus 2,000 geothermal plus 2,000 biomass



Mesa ERNC Energía 2050, Chile

# General overview – Chilean renewables



Chile has a huge potential of 1,850,00 MW of wind, solar and hydro energy, plus 2,000 geothermal plus 2,000 biomass

## 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 drilling machine once made a living pumping crude.



"near 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.

## 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

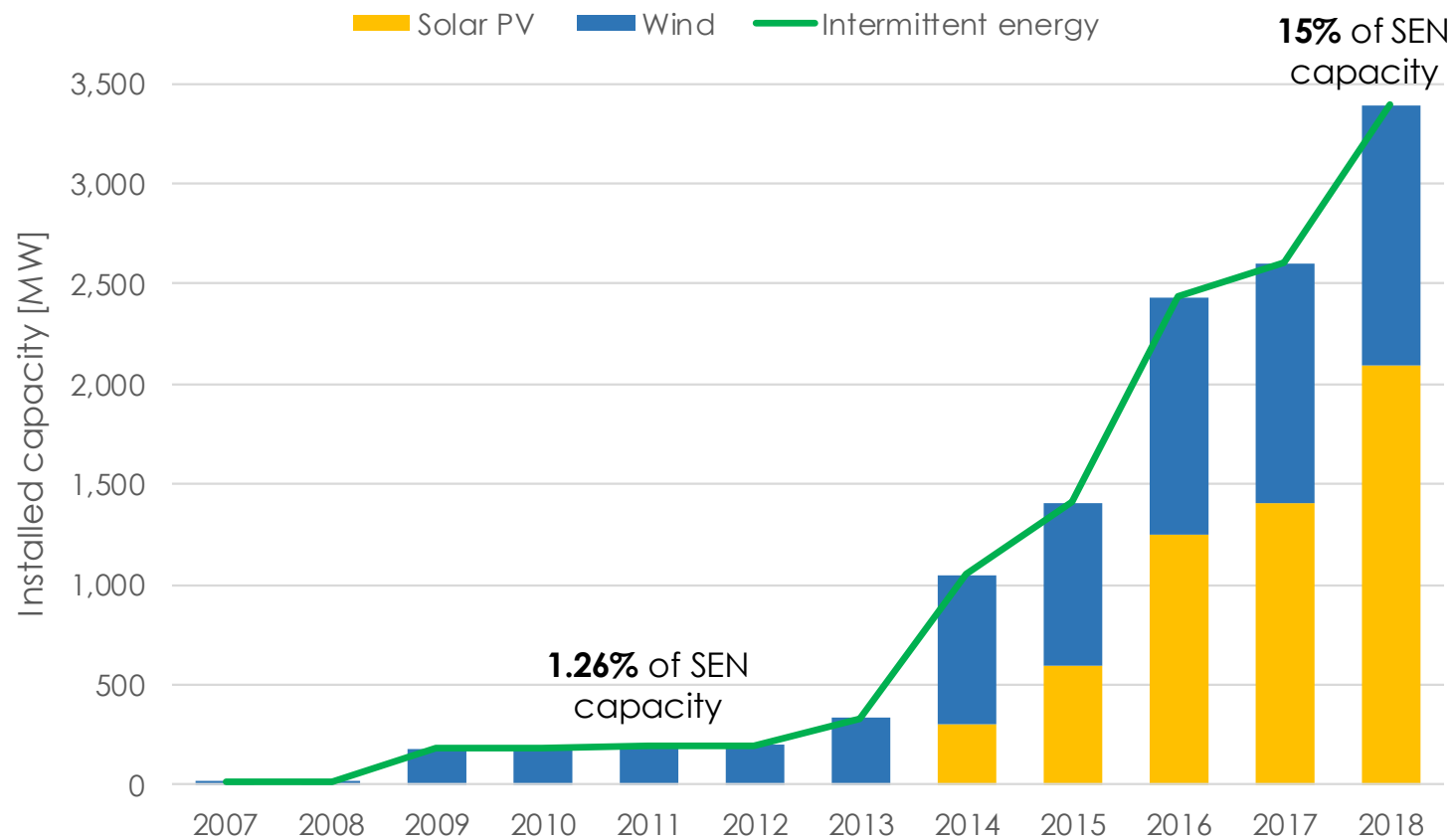
## 'A SOLAR SAUDI ARABIA'

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

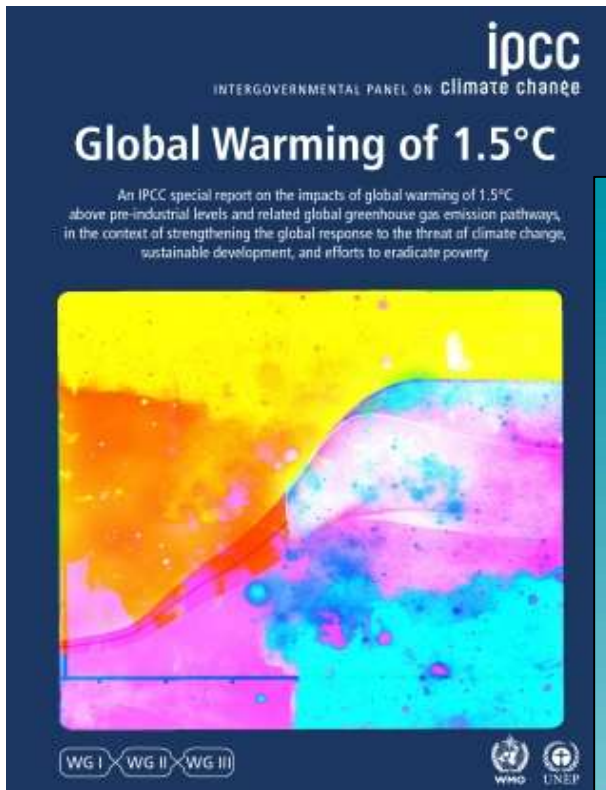
# General overview – Chilean renewables



Intermittent energies have increased their participation in the system in the last few years



# General overview – Renewable energy



Michelle Bachelet  
2014 - 2018



Sebastián Piñera  
2018 - 2022



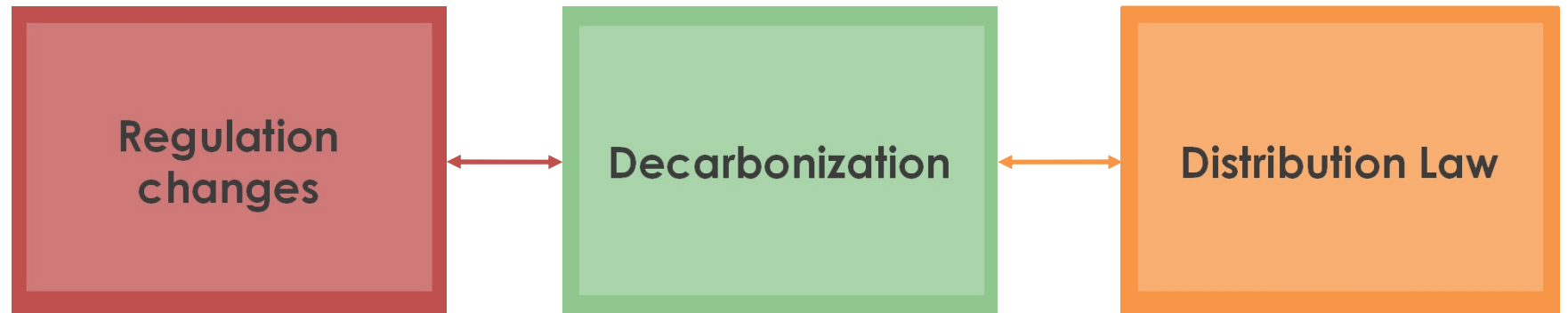
Government policies have had continuity in fostering the deployment of renewable energy to reduce carbon emissions



# General overview – Renewable energy



## Topics addressed during the first months of the current government



Efficient allocation of operating costs and benefits are needed, towards the **adequate recognition of sufficiency (capacity)** for each technology.

Government agrees a decarbonization plan with coal generation plants, withdrawing them in a programmed fashion.

Distributed generation needs **adequate and efficient price signals for all users**. Consumers should have signs of use and options to manage their demand.



## Transmission system development

- Transmission expansion conditions use of renewable energy along a country
- Regulation of transmission expansion may facilitate or delay transmission growth
- Transmission development conditions creation of energy markets and flow of renewable energy among systems
- Depending on transmission capacities, renewable shedding may take place, bringing marginal costs to zero





## Transmission system development

- Transmission expansion between regions, abundant of solar and wind energy, may provide opportunities for clean energy backup and complementation
- Social and community approval of transmission expansion is becoming a difficult process, restricting finding adequate transmission paths
- International interconnections provide further benefits for renewable exchange

# General overview – Electrical interconnections



## Gobierno promoverá 6 nuevas líneas eléctricas para conectar a Chile con Perú y Argentina

Autor: Francisco González G.

22/06/2017 | 04:29 AM



Ministro de Energía viaja hoy a Perú a firmar acuerdos para iniciar los estudios de la interconexión. Autoridad estableció un calendario tentativo para que los tendidos estén en funcionamiento.



[caf.com / argentina / comienzan los estudios de alternativas de interconexión entre chile - argentina](http://caf.com/argentina/comienzan-los-estudios-de-alternativas-de-interconexión-entre-chile-argentina)

argentina

13 de junio de 2018

### Comienzan los estudios de alternativas de interconexión entre Chile - Argentina

El Estudio que se inicia analizará los beneficios económicos de las interconexiones eléctricas entre los sistemas chileno y argentino, así como el estudio de los aspectos regulatorios para diferentes formas de intercambio energético

## Chile aguarda estudios para interconexión eléctrica con Perú

Ministra de Energía de Chile espera resultados de factibilidad para la construcción línea de transmisión entre Arica y Tacna



### Los avances de la interconexión eléctrica regional

A inicios de 2019 el Ministerio de Energía espera que estén listos los estudios de factibilidad técnica y económica con Perú y Argentina, para avanzar en opciones de intercambio de energía eléctrica, lo que permitirá aprovechar el desarrollo de energías renovables disponibles en el sistema eléctrico nacional.



# General overview – Gas exchanges



## ■ Gas integration with Argentina

- On October 30, the **first shipment of natural gas to the central zone of Chile** was carried out for the first time in a decade.
- According to Minister Jiménez, **there are at least ten companies that have already requested an exchange with Argentine suppliers** and five of them have already been authorized, which are four for the company Methanex de Magallanes and **one for Colbún, for electric generation**.
- There are also five other applications already in progress and it is believed that **it will increase, as long as benefits are seen in the country**.

### Diez empresas en Chile han solicitado comprar gas natural de Argentina

Así lo informó la ministra de Energía, Susana Jiménez, tras el reinicio del envío de gas tras al país después de diez años, en una ceremonia que fue encabezada por el Presidente Sebastián Piñera, quien sostuvo que estos intercambios deberían bajar los precios del combustible en el mercado local.



Negocios e industria  
LA CEREMONIA DE REINICIO DE IMPORTACIONES DE GAS ARGENTINO A CHILE SE REALIZÓ EN LAS INSTALACIONES DE GAS ANDÉS EN LA COMUNA DE SAN BERNARDO.

### Argentina autoriza a Pan American Energy exportar gas natural a chilena Agesa hasta octubre 2019

La decisión fue oficializada a través de la Resolución 86/2018 publicada en el Boletín Oficial con la firma del secretario de Energía, Javier Iguacel.



Negocios e industria

Publicado el 13 de noviembre del 2018

EL MERCURIO  
MARTES 13 DE NOVIEMBRE DE 2018

ECONOMÍA Y NEGOCIOS

Tras once años, el suministro se retomó hace solo dos semanas:

## Gobierno trasandino aprueba ampliar permisos de exportación de gas a Chile

El excedente de producción del hidrocarburo en la cuenca de Vaca Muerta está impulsando los envíos a nuestro país y ya van once contratos.

TOMÁS VERGARA P.

Mucho más rápido de lo esperado está creciendo la exportación de gas argentino al mercado local, suministro que fue retomado recién hace dos semanas, luego de que pasarán más de once años en los que se mantuvo suspendido. Ayer, el gobierno argentino dio un nuevo paso al ampliar uno de los contratos mediante los que se está exportando el gas a Chile, el cual corresponde a la firma Pan American Energy (PAE), que ya contaba con una autorización para exportar del



Miércoles, 24 de octubre de 2018 | 9:00

## Argentina visa primer envío de gas desde Vaca Muerta a Chile

Valor de exportaciones correspondería a la mitad del que se paga por el gas natural licuado (GNL).

## ARGENTINA REINICIA ENVÍO DE GAS NATURAL A CHILE POR PRIMERA VEZ EN UNA DÉCADA

El combustible llegó a través del Gasoducto GasAndes, de 463 kilómetros de extensión entre la localidad La Mora, en la provincia de Mendoza, Argentina, y San Bernardo, Región Metropolitana, gracias a un contrato interrumpible para ambas partes, entre las empresas Compañía General de Combustibles, de Argentina, y la chilena Colbún S.A., por hasta 1,3 millones diarios de m<sup>3</sup> de gas.

por Patricia Schüller Gamboa - Martes, 30 de Octubre de 2018



f t G+ in Compartir

Economía y Negocios  
El Mercurio

El gobierno argentino aprobó a la al empresario trasandino Eduard convencional) proveniente desde enviado a la generadora controlada por la familia Matte, Colbún.

<http://www.elmercurio.com/Inversiones/Noticias/Analisis/2018/10/24/Argentina-visa-primer-envio-de-gas-desde-Vaca-Muerta-a-Chile.aspx>



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- Assess Chilean future transmission capacities until 2035**
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## Objectives of our analysis

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- Assess the power flows in 2035 of the main transmission lines of the National Electrical System (SEN) and their composition.
- Analyze the requirements of transmission capacity expansion in these lines.
- Assess the effects of energy exports to Peru and Argentina.
  - Additional required installed capacity.
  - Exported energy composition by technology.

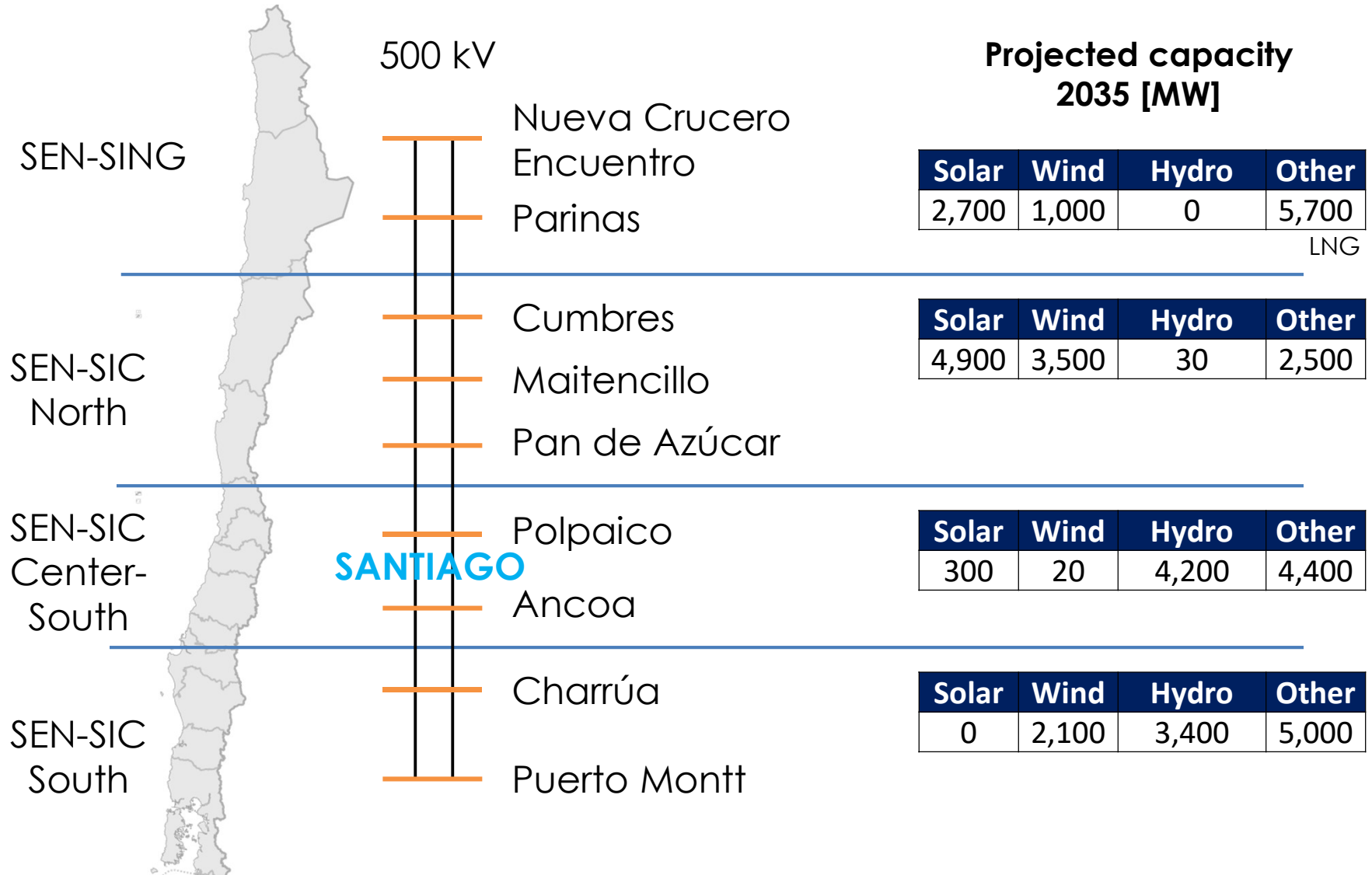




- The operation of the SEN in 2035 was simulated under two different scenarios.
- In each scenario, long term spot prices are defined by the balance of supply and demand.
- Base Case
  - Solar + Gas mix drives generation expansion.
  - SEN demand in 2035: 121,000 GWh (reference: ~68,000 GWh in 2017)
- Exports Case
  - Solar + Gas mix drives generation expansion.
  - Exports to Perú in 2035: 5,600 GWh.
  - Exports to Argentina in 2035: 5,600 GWh.

# Installed generation capacity by zone by 2035

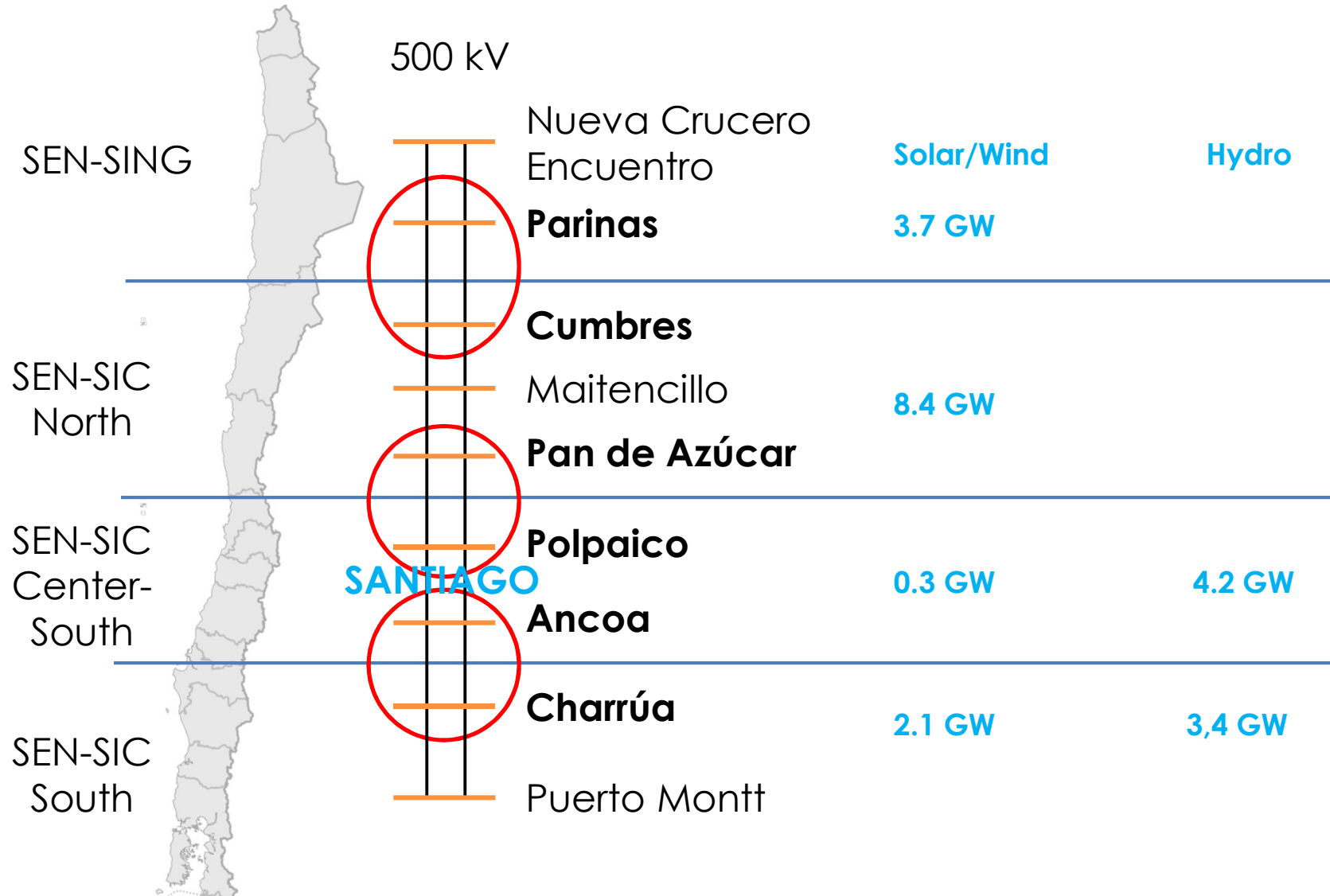
## Base Case





# Transmission flows through the country

## Base Case

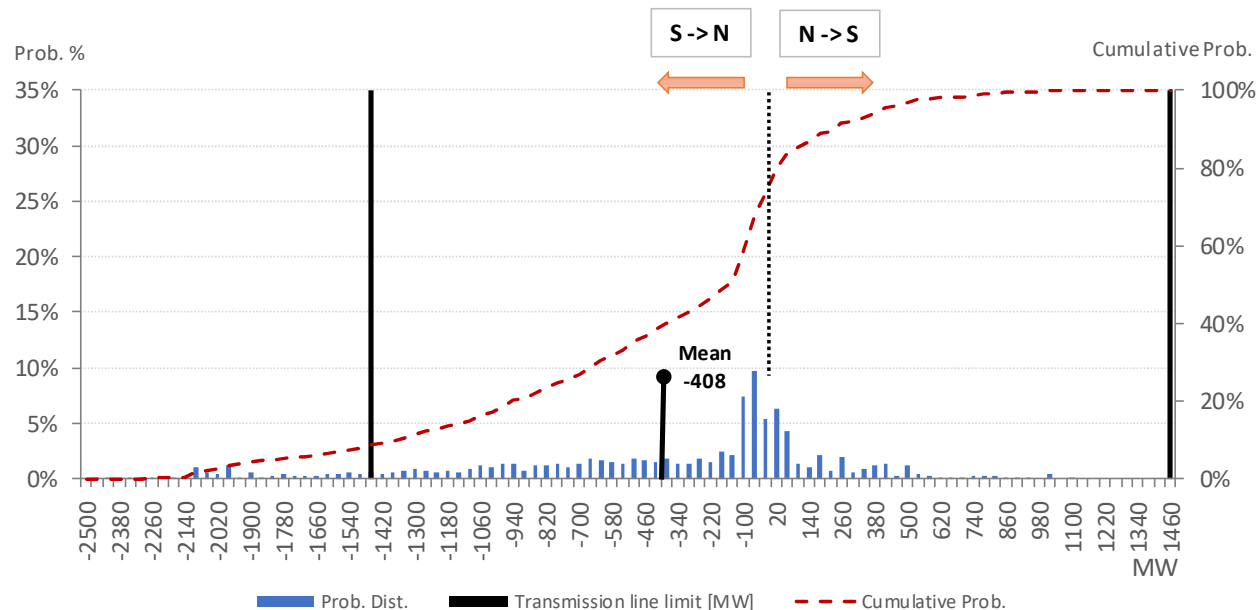


# Transmission flows projected by 2035

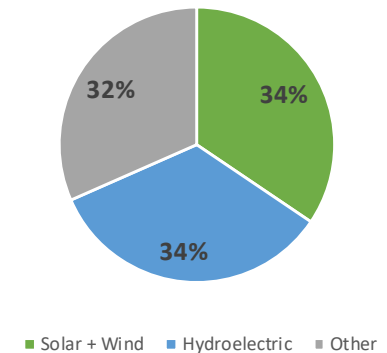
## Base Case



Projected power flow for **Parinas - Cumbres 500 kV** line, year 2035 [MW]



Annual participation in  
Parinas - Cumbres 500 kV (2035)



If there were no expansion of the **Parinas – Cumbres** line by 2035, congestion would occur about 10% of the year, that would not allow exports from the northern SEN-SIC to the SEN-SING.

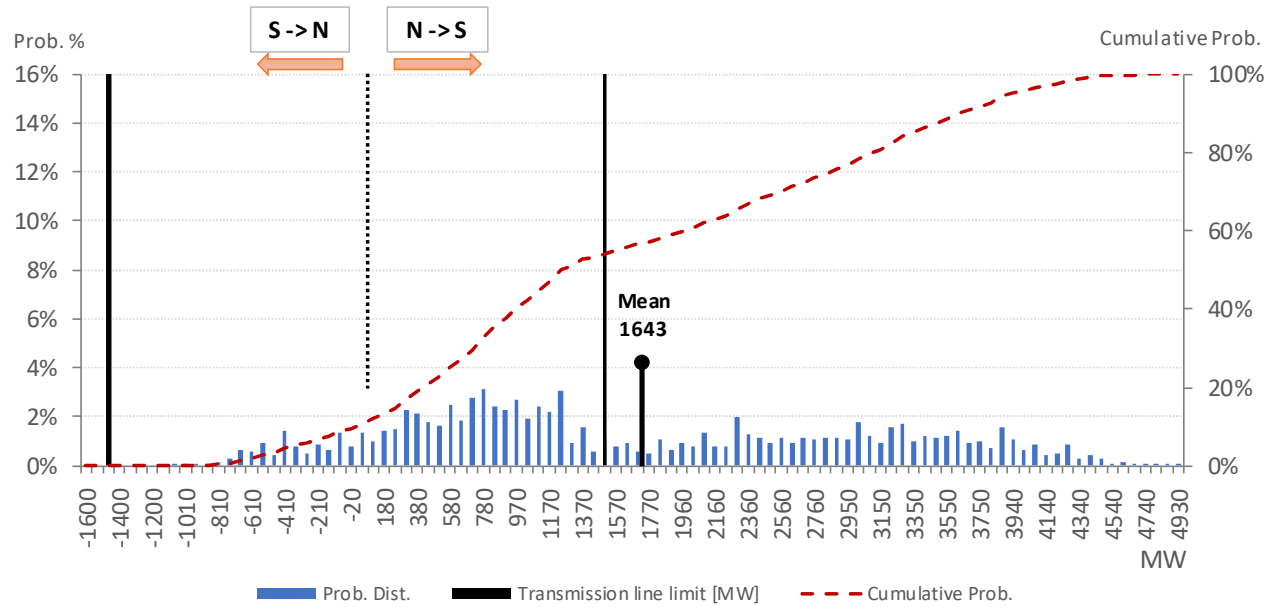
Could need expansion, subject to economic analysis

# Transmission flows projected by 2035

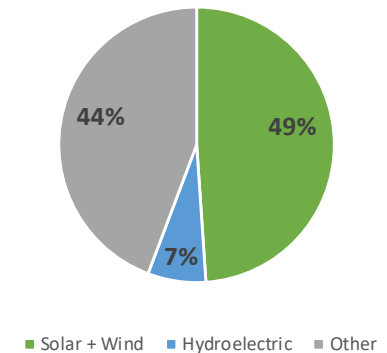
## Base Case



Projected power flow for **Pan de Azúcar - Polpaico 500 kV** line, year 2035 [MW]



Annual participation in  
**Pan de Azúcar - Polpaico 500 kV** (2035)



If there were no expansion of the **Pan de Azúcar - Polpaico** line by 2035, congestion would occur about 50% of the year, that would not allow exports to the center of the country.

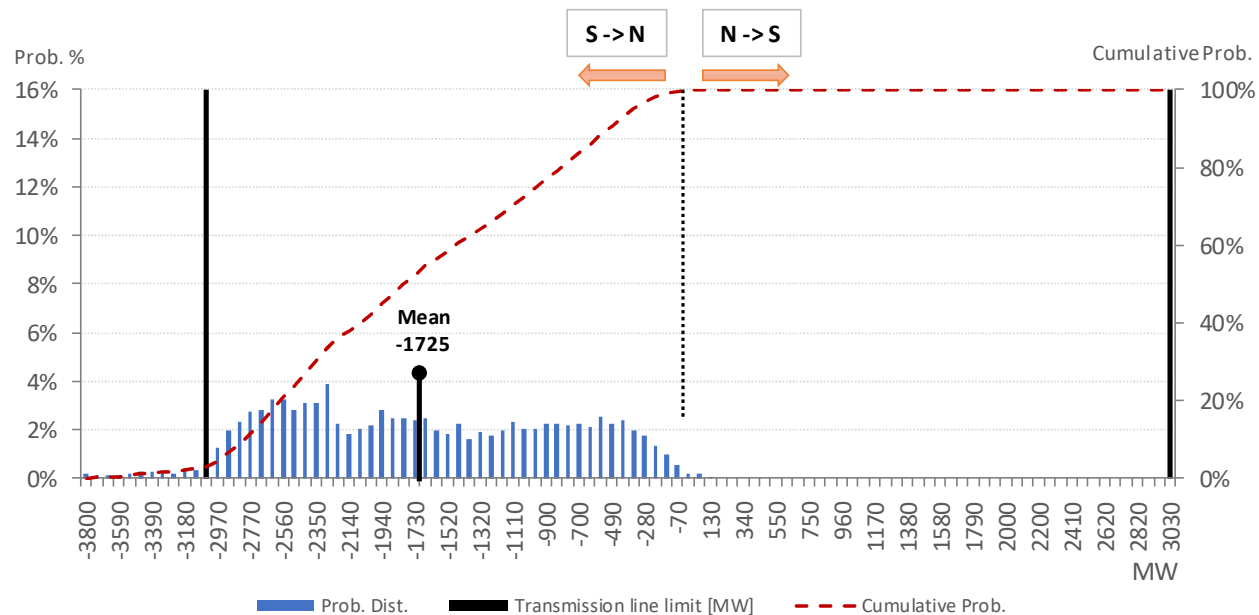
Need for expansion

# Transmission flows projected by 2035

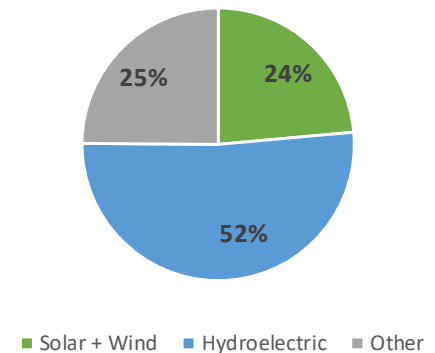
## Base Case



Projected power flow for **Ancoa - Charrúa 500 kV** line, year 2035 [MW]



Annual participation  
in Ancoa - Charrúa 500 kV (2035)



The expansion of the **Ancoa - Charrúa** line by 2035 would only help to resolve a congestion that would occur around 3% of the year.

No need for expansion



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## General overview – Interconnections

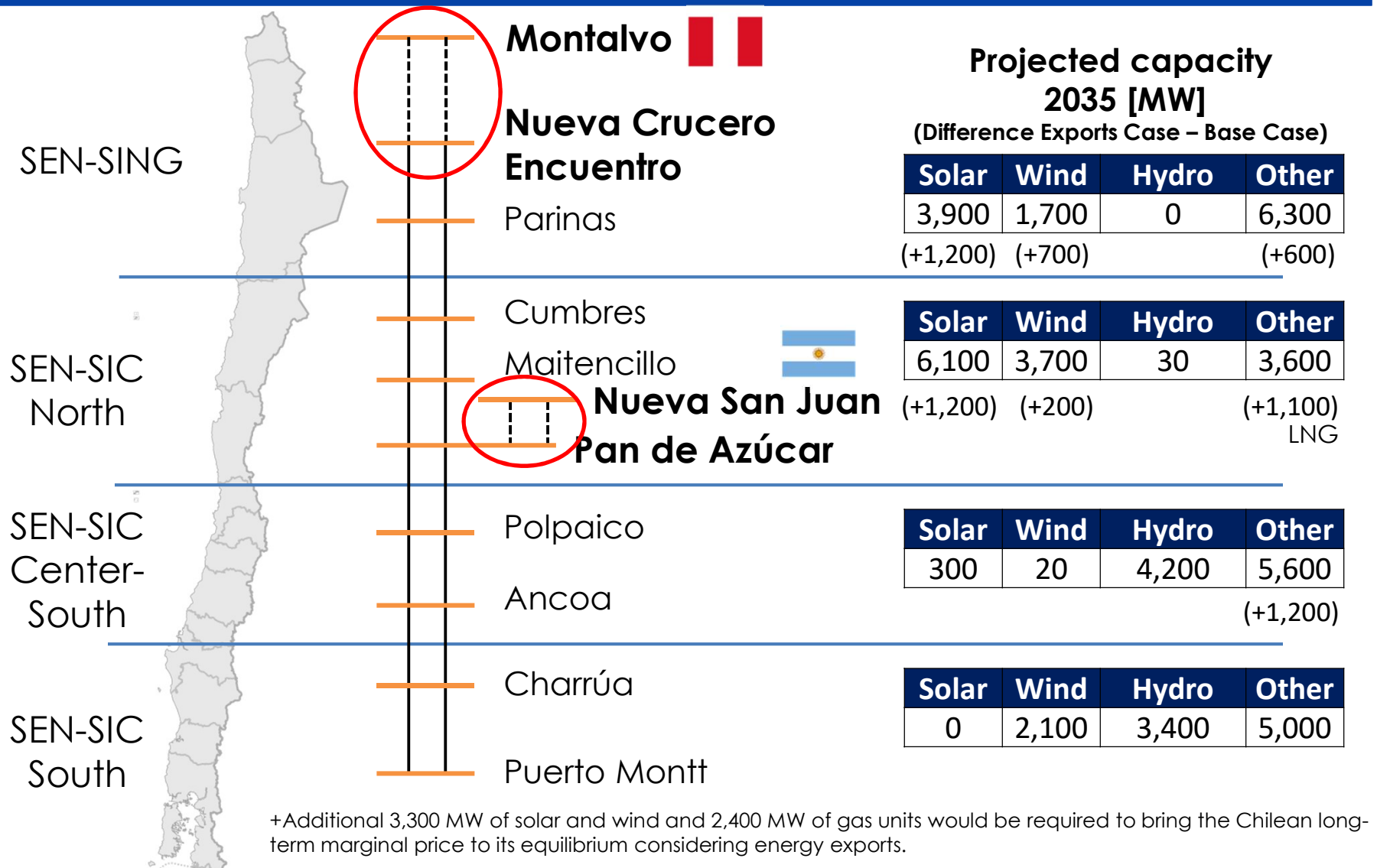
International transmission lines considered by the Ministry of Energy in the Long-term Energy Planning (PELP) study of 2017.

Busbar in Chile	Busbar abroad	Transmission capacity [MW]	PELP estimated commissioning date
Parinacota	Los Héroes (Perú)	200	2023
Kimal	Montalvo (Perú)	1,000	2028
Andes	Cobos (Argentina)	600	In operation
Pan de Azúcar	Nueva San Juan (Argentina)	1,000	2027
Punta Colorada (Coquimbo)	Argentina bus bar	1,000	2025
Los Almendros (Santiago)	Argentina bus bar	1,000	2040



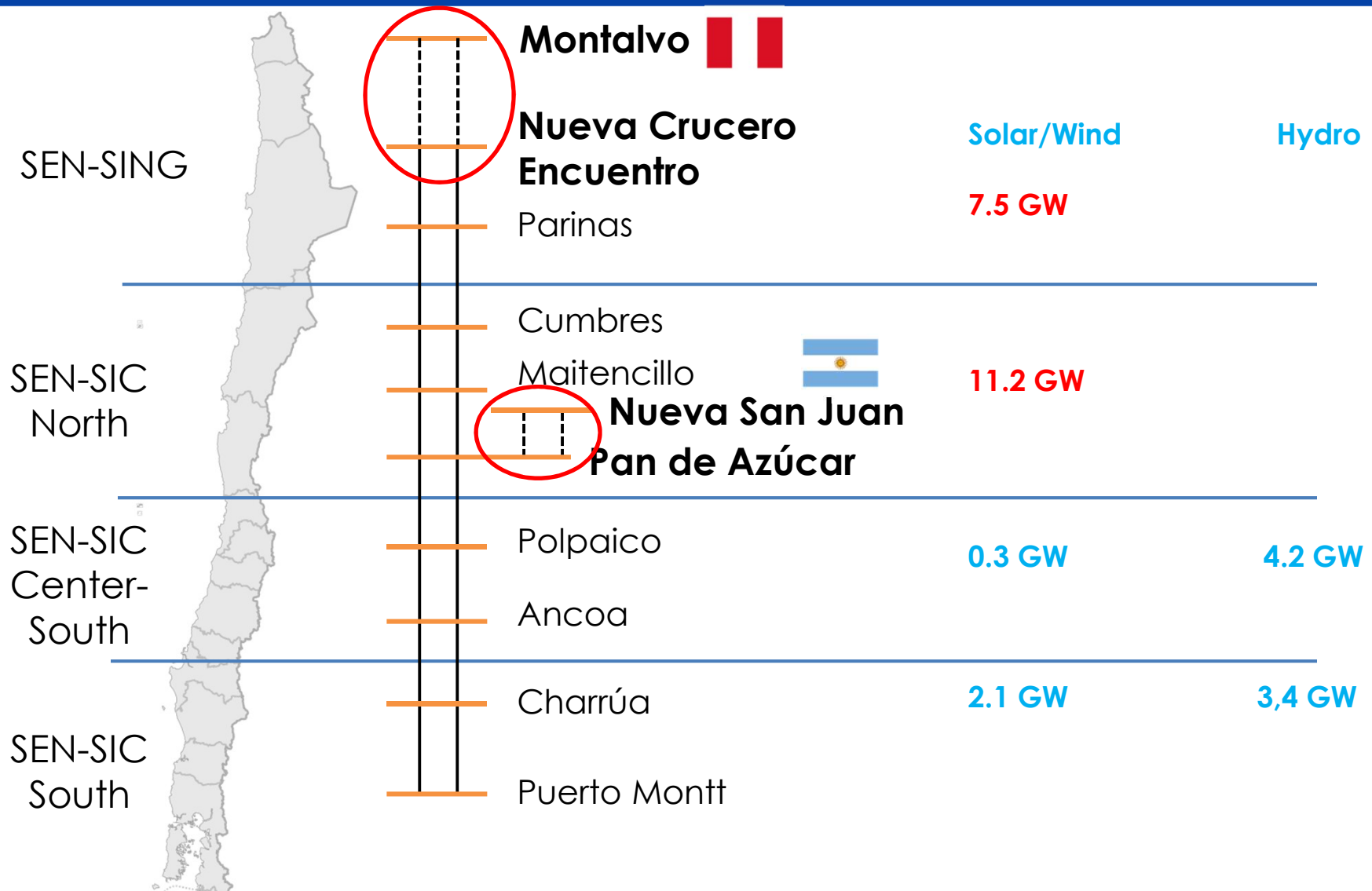
# Transmission flows through the country and exports

## Exports Case

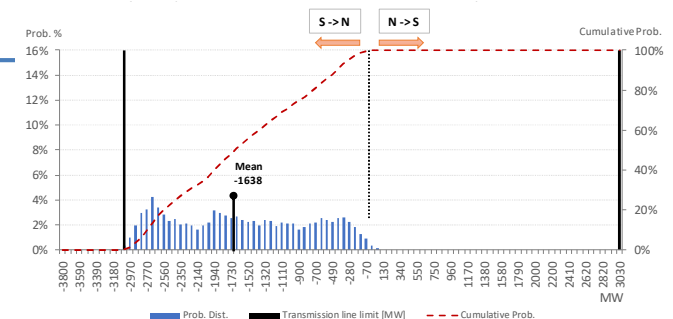
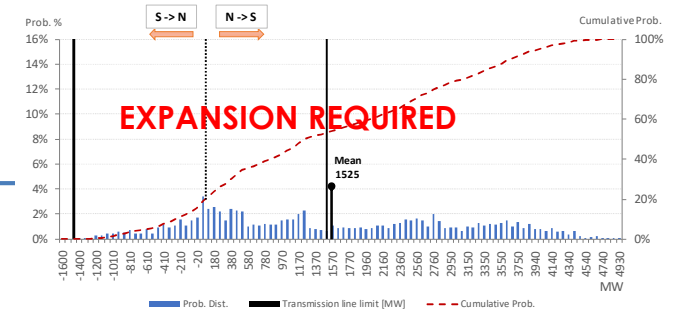
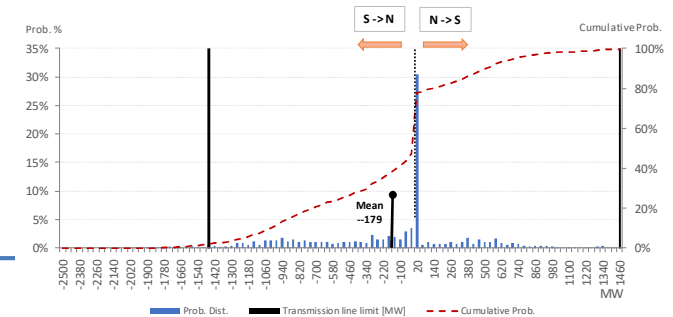
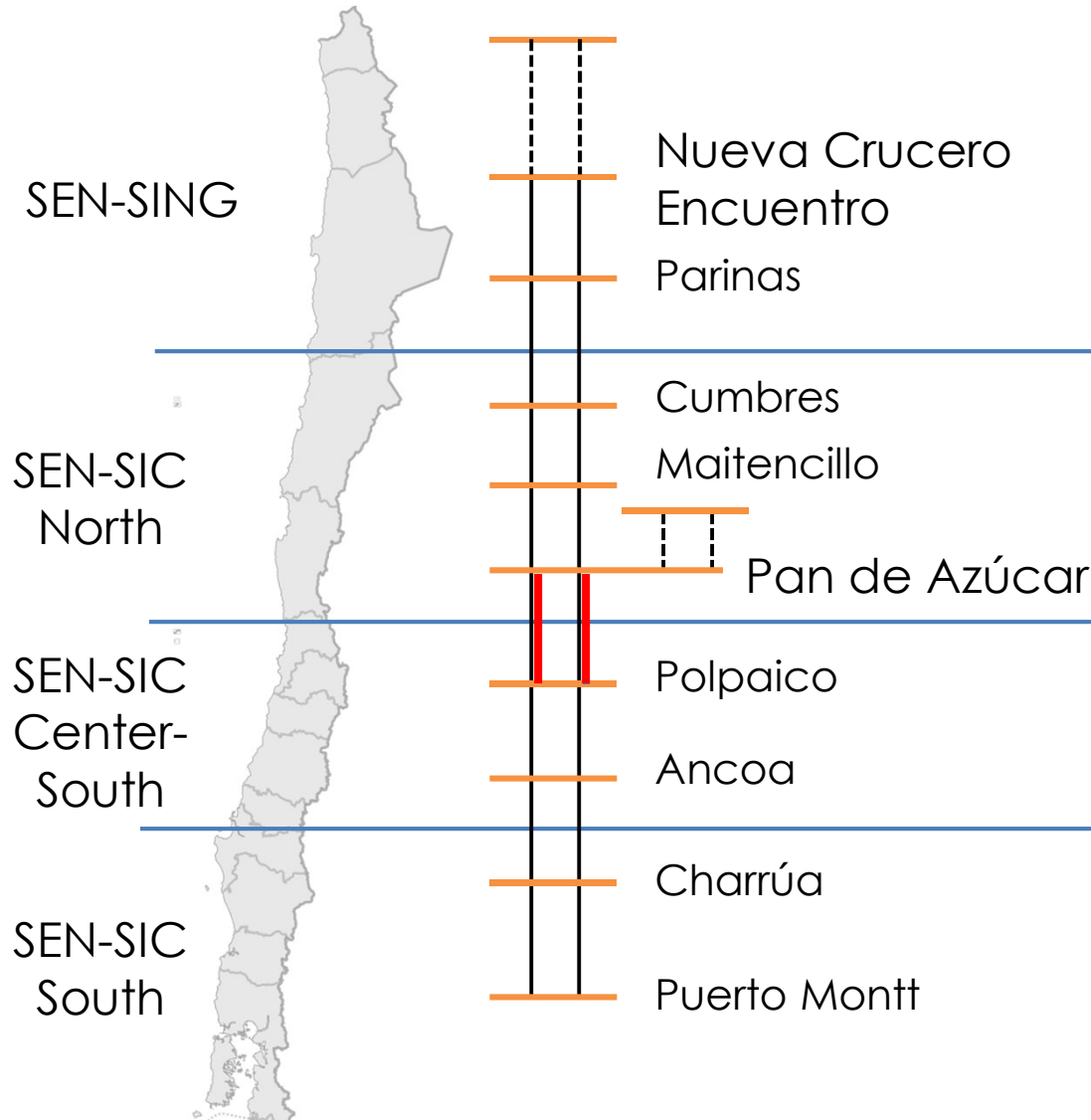


# Transmission flows through the country and exports

## Exports Case



# Transmission flows projected by 2035 Exports Case

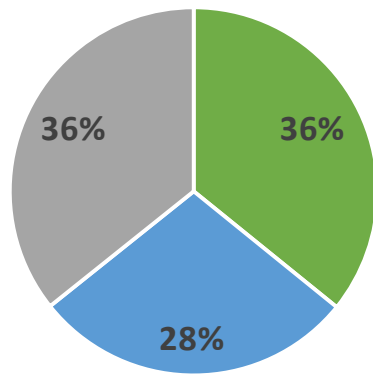


# Transmission flows projected by 2035

## Exports Case

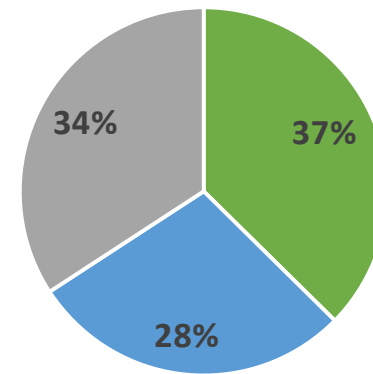


Annual participation in Nueva Encuentro  
Crucero - Montalvo 500 kV (2035)



■ Solar + Wind ■ Hydroelectric ■ Other

Annual participation in Pan de Azúcar -  
Nueva San Juan 500 kV (2035)



■ Solar + Wind ■ Hydroelectric ■ Other

Solar and wind accounts for 36% to 37% of energy exports **to Peru and Argentina**, reflecting the Chilean energy mix in 2035.



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## Regulatory framework for international interconnections

- **There could be both public service and private interest interconnection systems.** Public service interconnection systems facilitate the formation or development of an international electric market.
- The **Ministry of Energy** may instruct a proposal for the expansion of international public service interconnection in agreements, treaties, international protocols or other international instruments.
- The **payment is charged to final customers.** However, when these facilities are used for exporting energy, the supplier (s) responsible for exports will pay the corresponding proportion of their use. This amount is deducted from the charge to the final customers.

# Chilean regulatory framework for international interconnection systems



## Energy exchange regulation

- The Law in Chile **does not have a defined regulatory framework for the exchange of energy between countries**. Except the fact that Ministry of Energy is given the responsibility of authorizing such exchanges.

## What has happened in practice?

- The Ministry authorized AES Gener to export electricity to Argentina, **exporting electricity from solar curtailments and from units at technical minimum** (out of dispatch).
- We thus only have **opportunity exchanges** that have to be authorized by government.
- Also, it is not defined if a generator (e.g. solar) can be authorized to export energy (not curtailments) to another country if it participates in the marginal market.



# Chilean regulatory framework for international interconnection systems



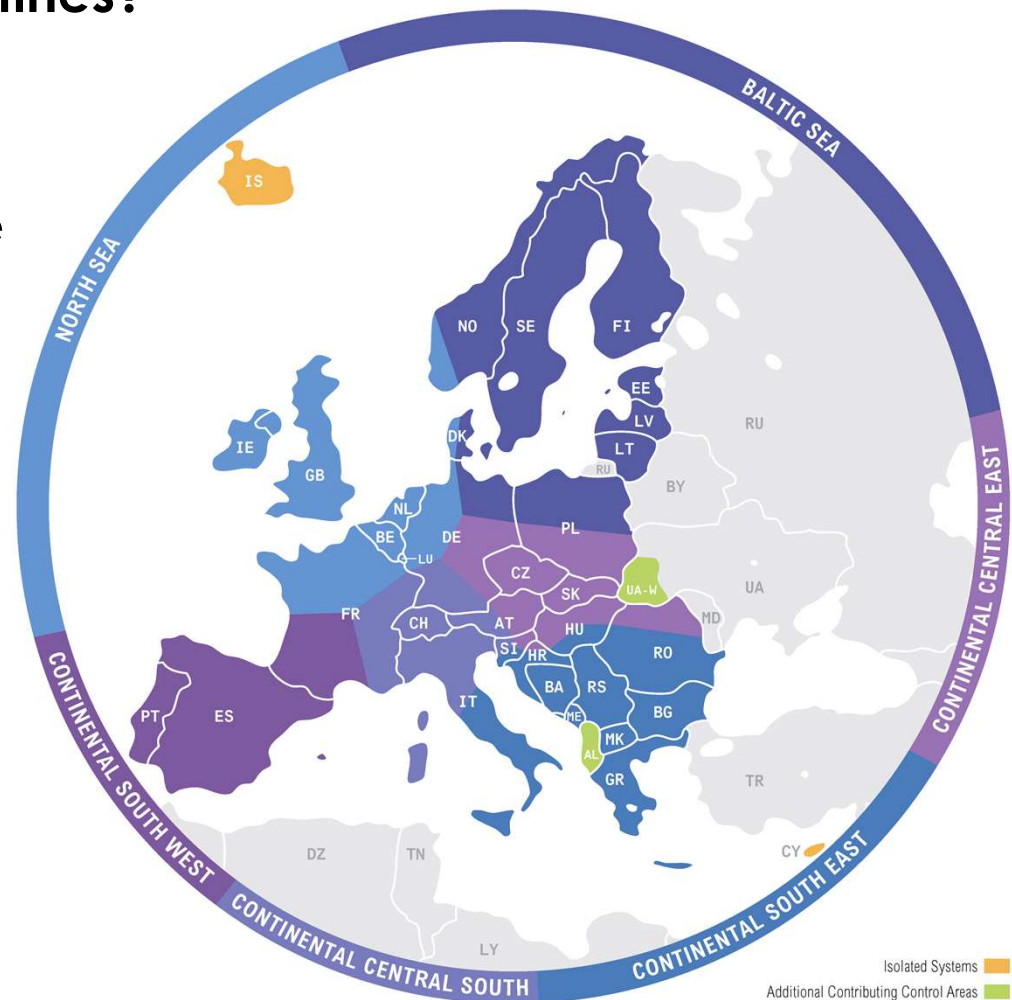
## What should be done to foster international interconnections?

- **Marginalist system makes noise** in terms of obtaining the correct incentives to deploy international interconnections.
  - With the massive deployment of solar energy in SEN North, the marginal cost will be  $\approx 0$ . How do we pay infrastructure?
  - Supramarginalist generators can export energy?
- An **integrated market** (regional) could be **beneficial if there was a centralized planner entity between nations**.
  - Deferral of solar energy investment in Argentina while using solar plants from Chile to supply demand (Chile has the know-how of solar energy)
  - Argentina has wind energy potential and inexpensive gas.



## What happens in other countries? Case of Europe...

- European countries have been interconnected for decades and regional TSOs have been working since the 1950s.

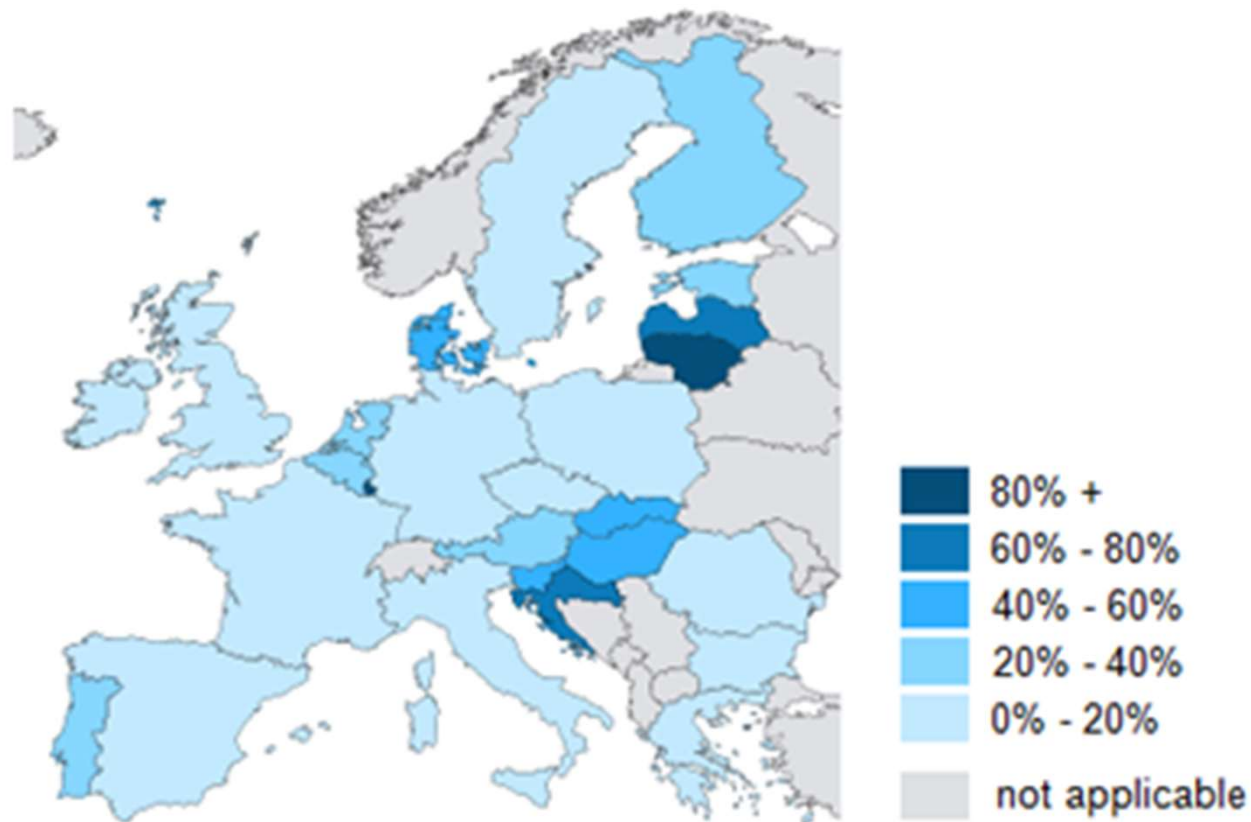


Source: ENTSO

# International interconnection systems



Electricity imports as a share of total consumption in the European Union (2012)

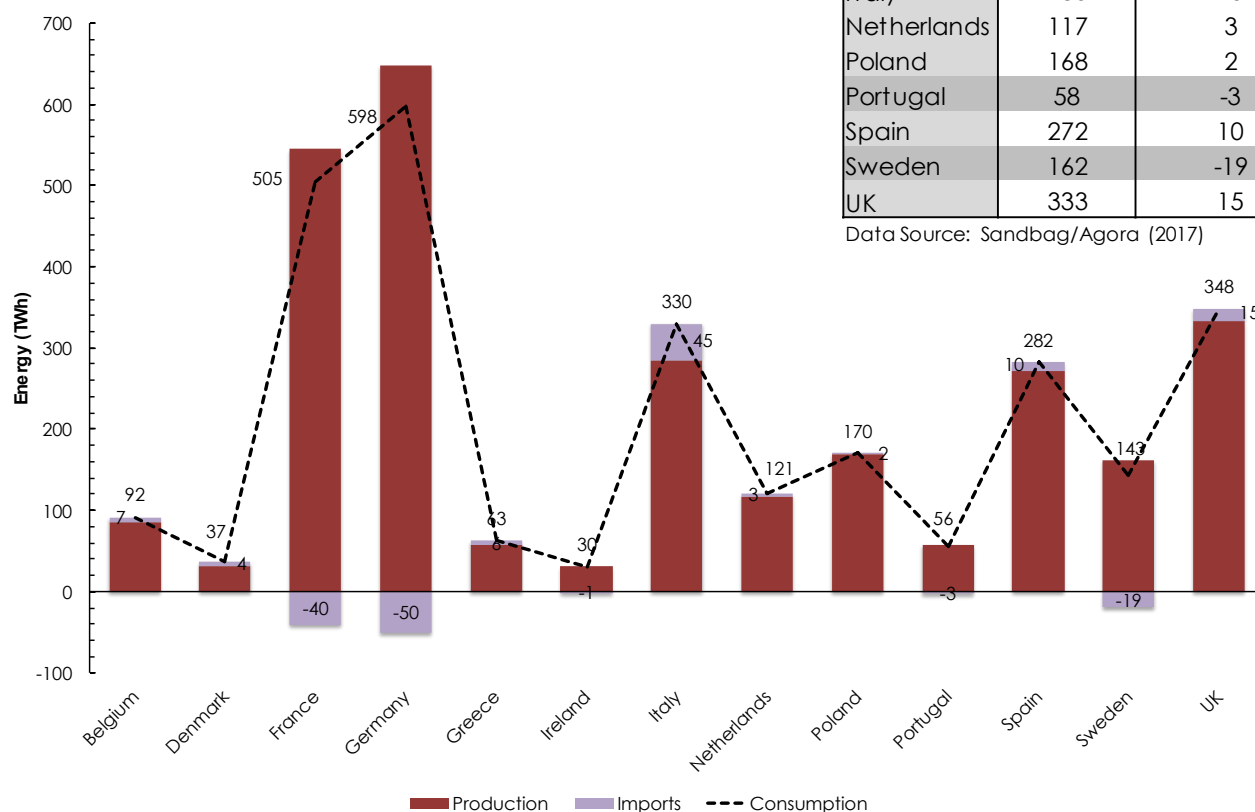


Source: EIA



# International interconnection systems

In 2017, EU imports/exports range between 1% to 14%.



TWh	Production	Imports/Exports	Consumption	%Imp/Cons.	%Exp/Prod.
Belgium	85	7	92	7%	
Denmark	32	4	37	12%	
France	545	-40	505		7%
Germany	648	-50	598		8%
Greece	57	6	63	10%	
Ireland	31	-1	30		4%
Italy	285	45	330	14%	
Netherlands	117	3	121	3%	
Poland	168	2	170	1%	
Portugal	58	-3	56		5%
Spain	272	10	282	3%	
Sweden	162	-19	143		12%
UK	333	15	348	4%	

Data Source: Sandbag/Agora (2017)



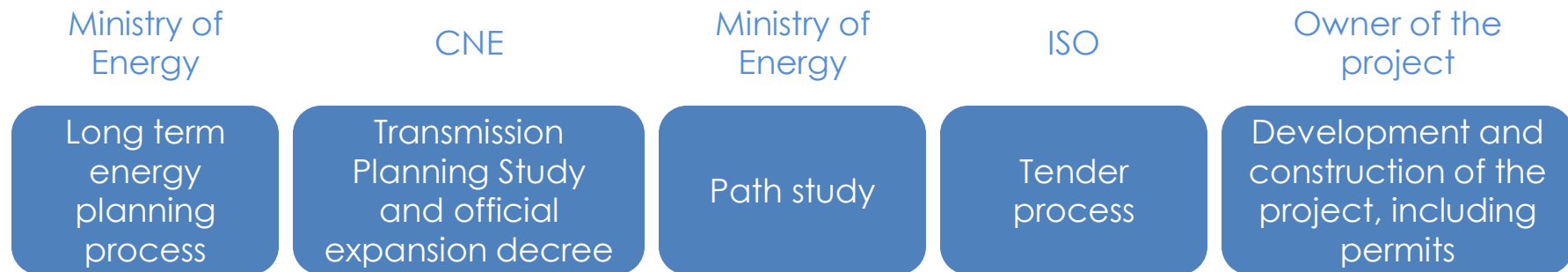


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# Transmission Expansion



## Expansion scheme according to Transmission Law of 2016



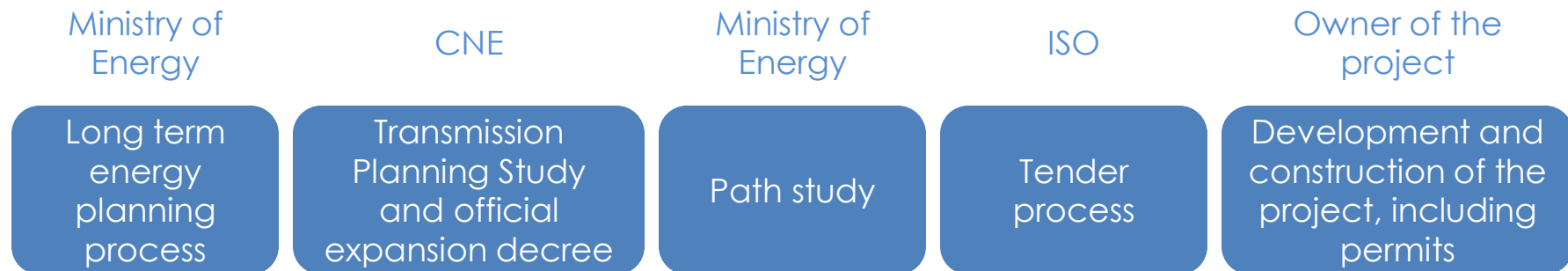
Chile instituted a formal transmission expansion procedure, directed by the National Energy Commission (CNE)

Centralized planning process facilitates adequate inclusion of renewables, given uncertainties present in their expansion

# Transmission Expansion



## Expansion scheme according to Transmission Law of 2016

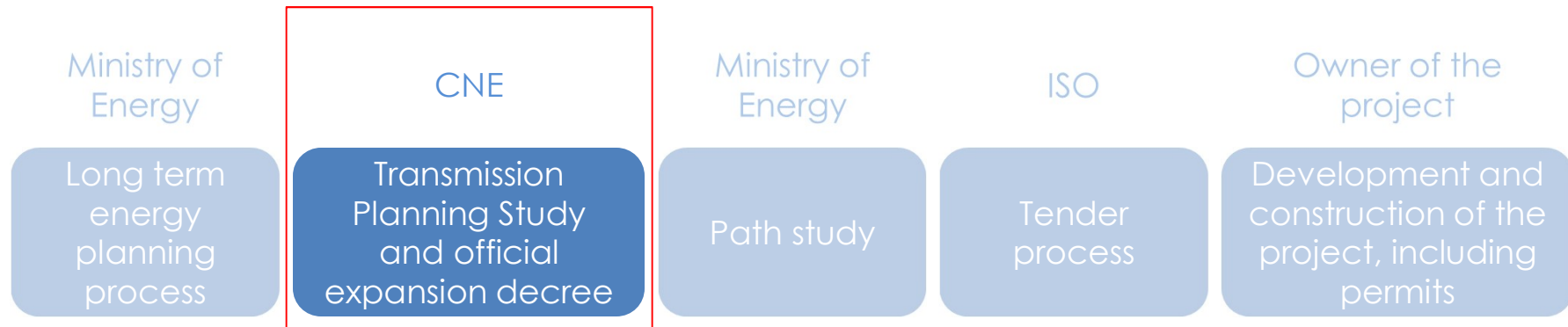


- **Long term energy planning process** every five-years defining long-term (at least 30 years) energy scenarios.
- Development of the **Transmission Planning Study** on an annual basis, defining a mandatory expansion plan for lines and facilities.
- Agents can present discrepancies to the **Experts Panel**.
- **Path study**: analysis for layout for some new transmission lines aiming to detect, in an early stage, possible problems that the project may face (local communities, environmental issues, etc.).
- ISO calls for an **international open tender** and then the awarded company develops and constructs the project

# Transmission Expansion



## Current discussions related to Transmission Expansion



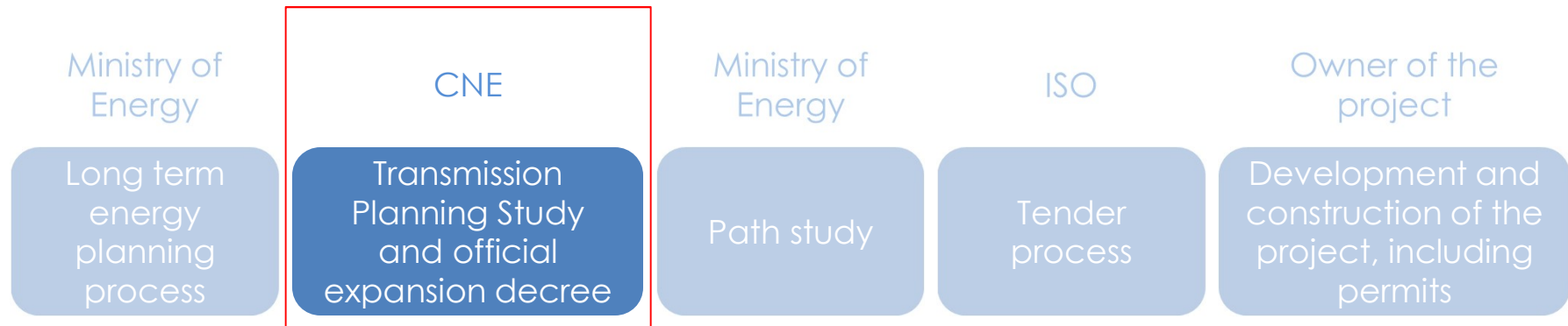
- Preliminary Transmission Planning Study of 2017 included two novel projects:
  - 3,000 MW HVDC transmission line of 1,500 km, between Antofagasta and Santiago
  - Energy storage system
- Market agents presented discrepancies to the Experts Panel, which finally decided to withdraw both projects from the Expansion Decree.
- Energy storage discussion arises, questioning its use as transmission asset.



# Transmission Expansion



## Current discussions related to Transmission Expansion

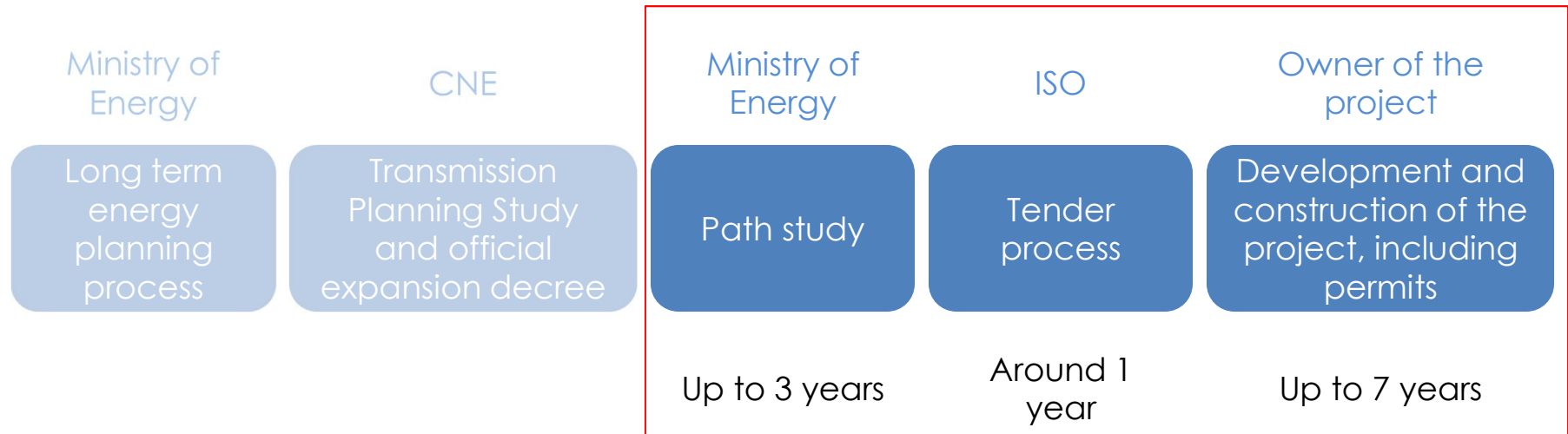


- Preliminary Transmission Planning Study of 2018 included the HVDC transmission line once again with some changes:
  - Capacity was reduced to 2,000 MW
  - Investment costs decreased from 1,788 to 1,176 billion USD.
- Some market agents question the need of this project due to its size, cost and the assumptions made to assess it.

# Transmission Expansion



## Current discussions related to Transmission Expansion



- Complex projects may take up to **11 years!**

# Conclusions



- Transmission expansion conditions use of renewable energy along Chile. Expansion procedures matter!!
- Electricity renewable exchanges are in need for a regulation, if other than opportunity exchanges are searched for.
- Depending on transmission capacities, renewable shedding may take place in the northern part of the country, which would bring marginal costs to zero.
- 36% to 37% energy exports to neighboring countries would be composed of solar and wind energy, under simulated scenarios.
- Additional cases where Chile imports energy from Argentina and Peru are required to assess other important long-term scenarios.



# Challenges and opportunities in the development of networks in Latin America: national and international perspectives

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