COMPLEX ENERGY SYSTEMS WORKSHOP

COORDINADOR ELÉCTRICO NACIONAL

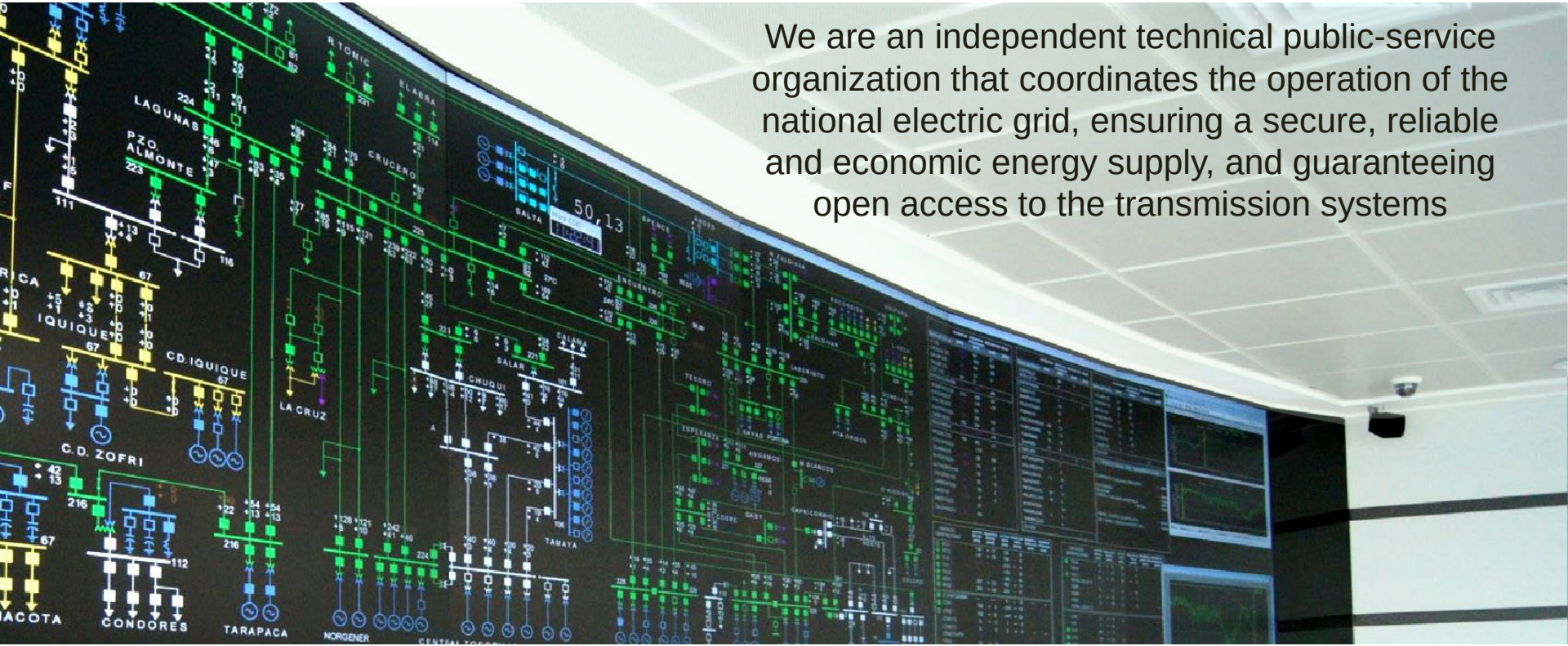
Flexible Transmission Expansion in the Chilean Electricity Market

Juan Carlos Araneda
Transmission Planning Manager

Agenda

- SIC-SING Interconnection and the National Power System
- Transmission Planning Process
- New Transmission Planning Criteria
- Flexibility in Transmission Expansion
- Long Term Vision in Transmission

Coordinador Eléctrico Nacional



We are an independent technical public-service organization that coordinates the operation of the national electric grid, ensuring a secure, reliable and economic energy supply, and guaranteeing open access to the transmission systems

SIC-SING INTERCONNECTION PROJECT

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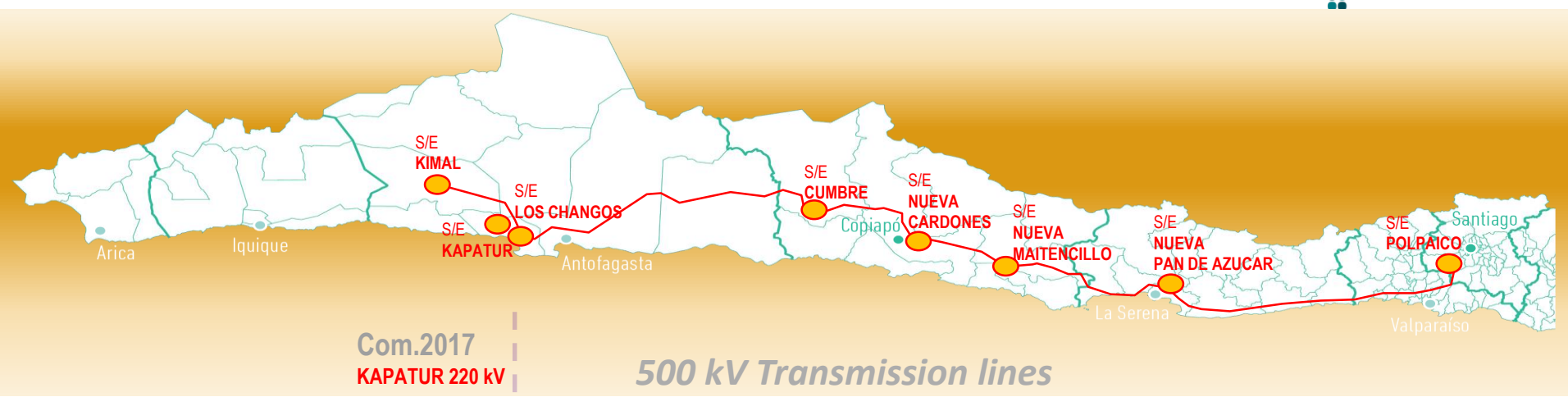


Com.2017
KAPATUR 220 kV

500 kV Transmission lines

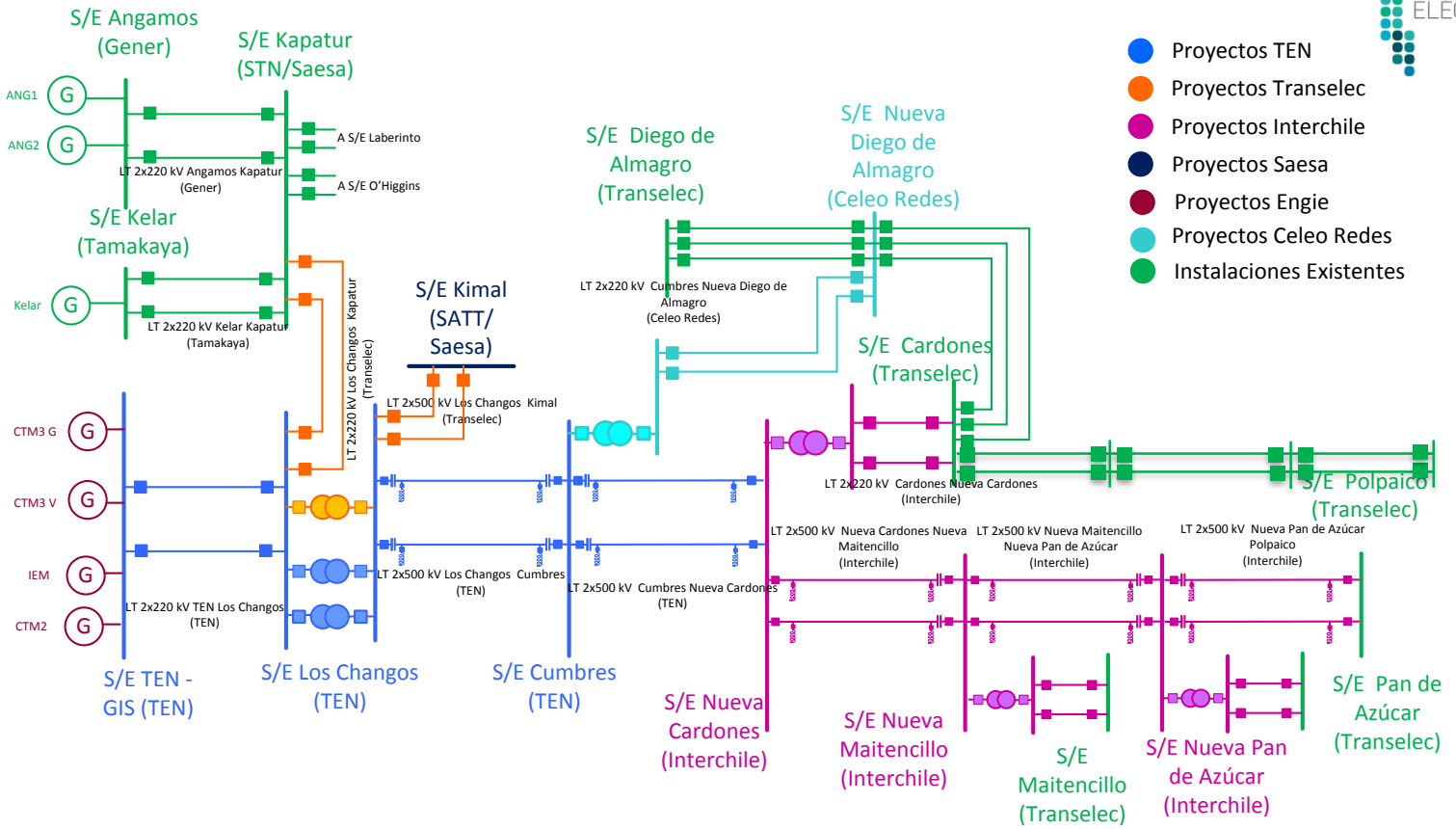
Com.2020 | Com.2017 | Com.2017-2018

140 km | 400 km | 189 km | 135 km | 212 km | 408 km

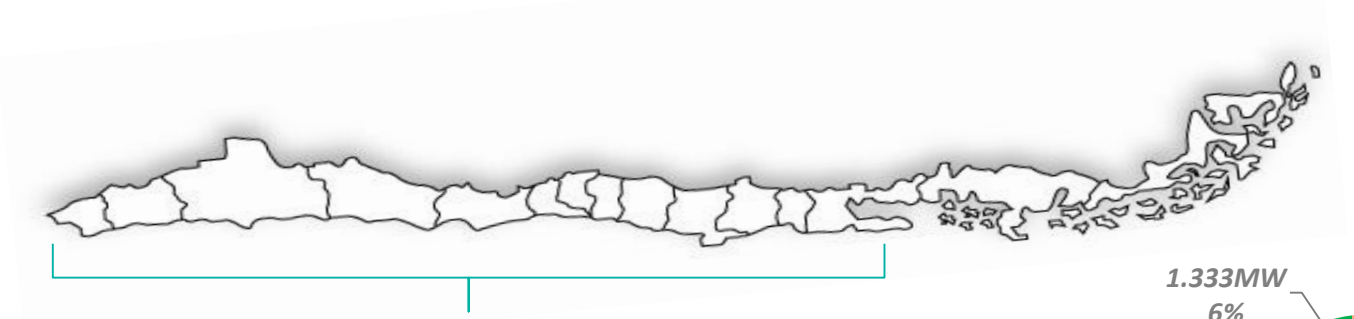
transelec | TEN | ISA INTERCHILE

SIC-SING INTERCONNECTION PROJECT

COORDINADOR ELÉCTRICO NACIONAL

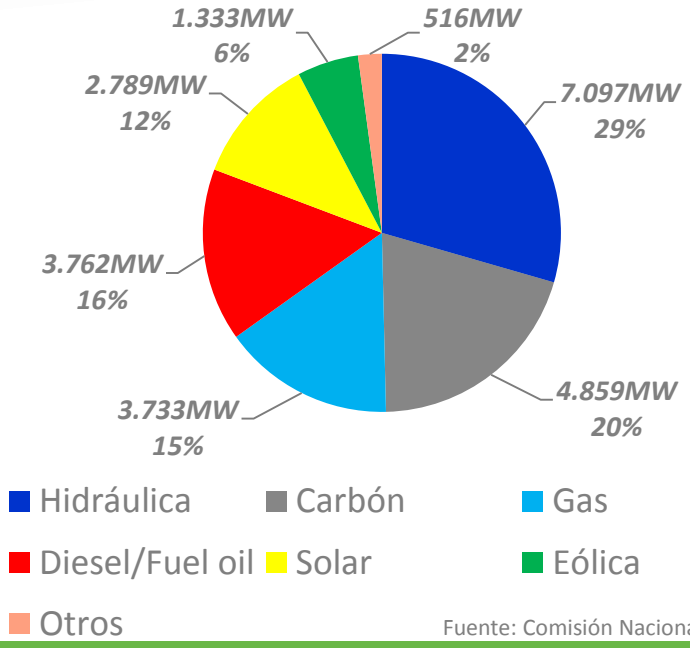


NATIONAL POWER SYSTEM in 2018



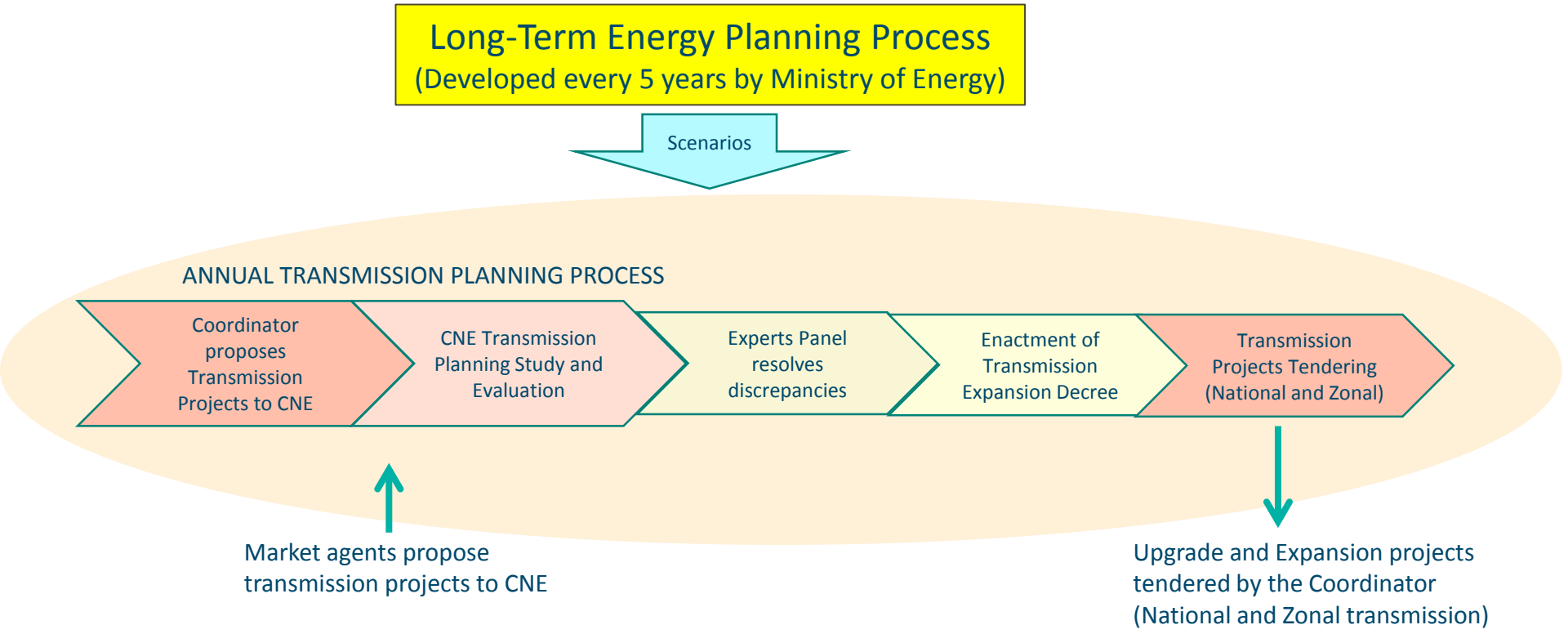
NPS
3,100 km

Installed Capacity: **24,000 MW**
Peak Demand: **11,000 MW**

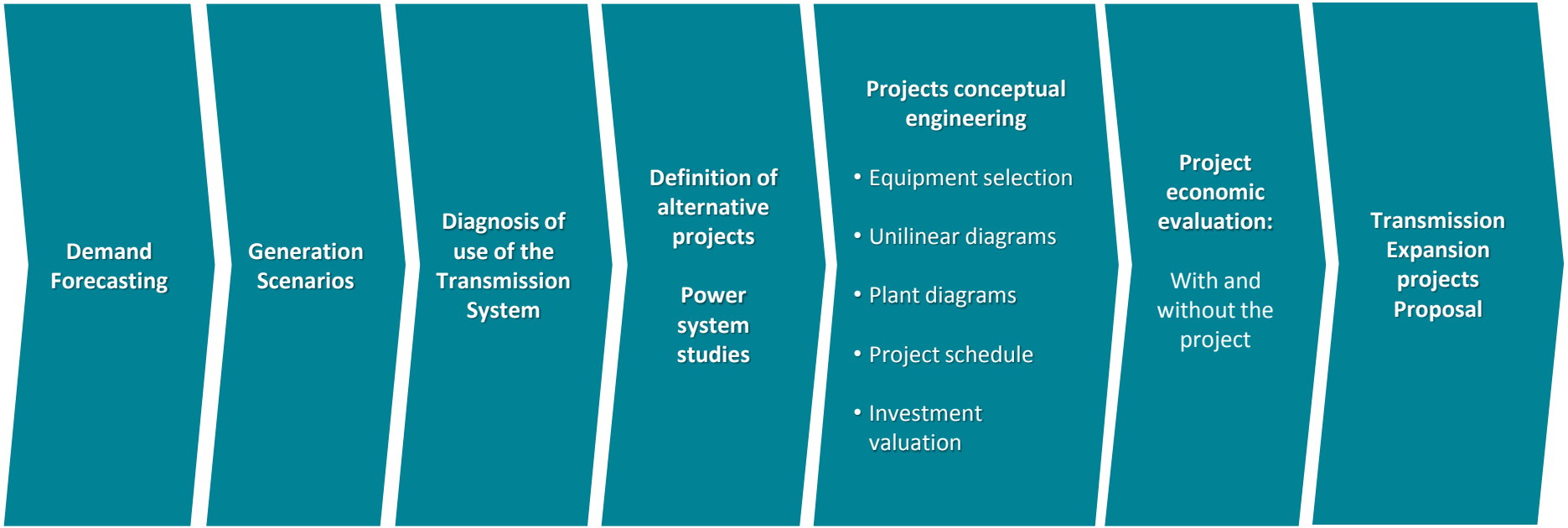


Fuente: Comisión Nacional de Energía

Transmission Planning and Delivery (from 2017 on)

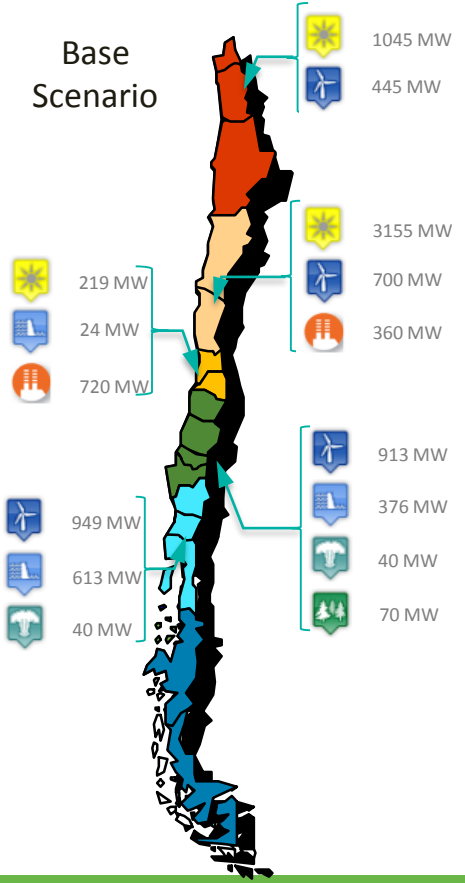


Transmission Planning Methodology

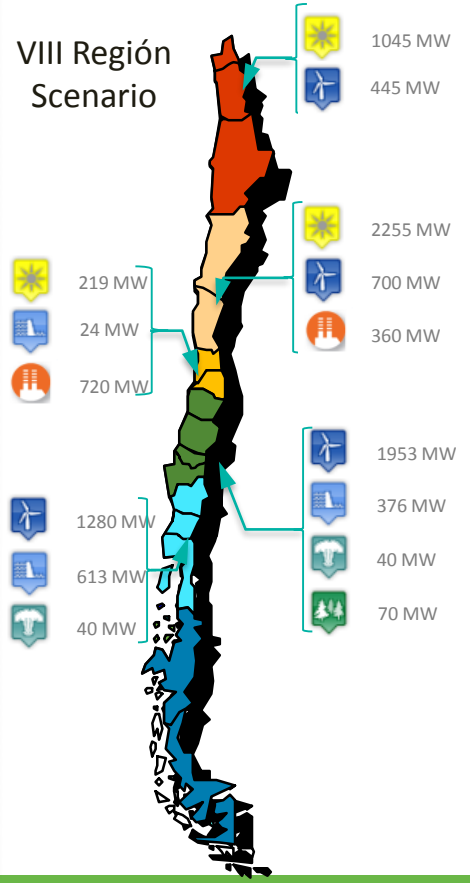


Generation Scenarios

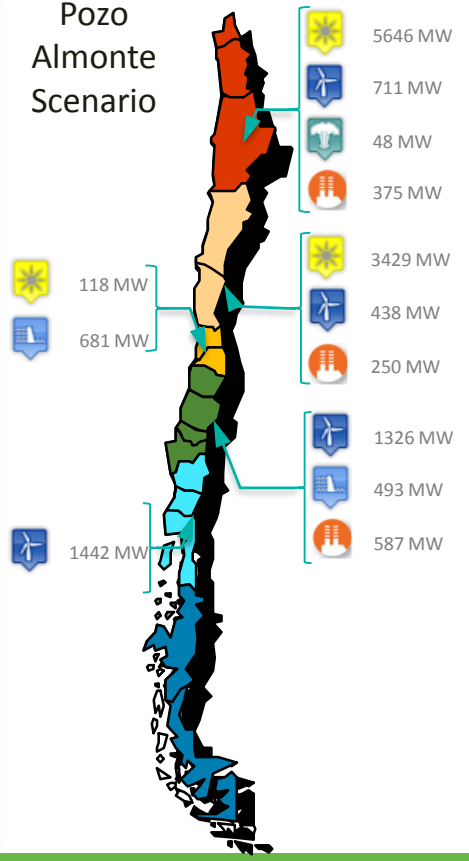
Base Scenario



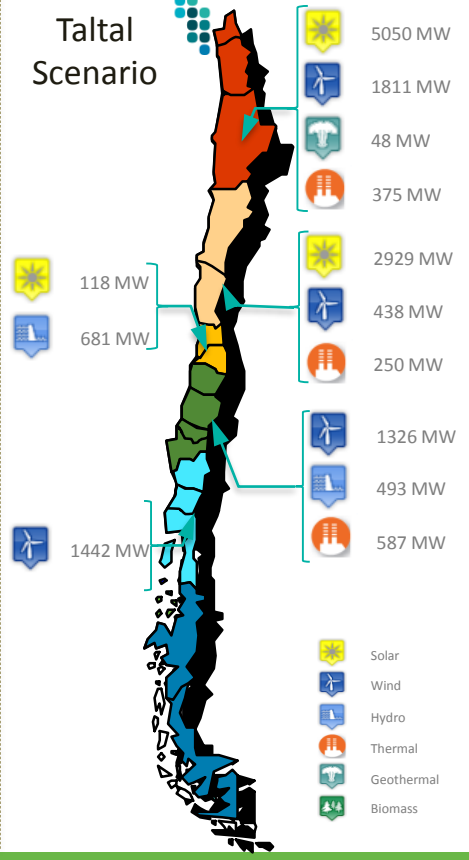
VIII Región Scenario



Pozo Almonte Scenario



Taltal Scenario



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New Transmission Planning Criteria

- 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

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Transmission planning must include **roominess** and **redundancies** in order to incorporate all previous criteria

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

Flexibility in Transmission Expansion

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

Flexible Transmission:

- ❑ **Robust Planning**
- ❑ **Technology**
- ❑ **Smart Grid**

Flexible Transmission: Robust Planning

- Anticipatory planning: make decisions under uncertainties
- Stripes for new transmission lines with Strategic Environmental Evaluation
- Roominess in the design of new transmission infrastructure
- Upgrade and uprate of existing lines and substations
- Zonal transmission:
  - Access to cities and towns
  - Shared services infrastructure
  - Distributed generation

Flexible Transmission: Technology

- Transmission support associated to Variable Renewable Energy:
  - Size and location of reserves
  - Inertia constraints
  - Battery Energy Storage Systems – BESS:
    - Expansion deferral
    - Congestion relief
- Flexible AC Transmission Systems: FACTS
- HVDC:
  - Long lines with LCC vs VSC
  - Multi-terminal option
  - Lines vs Cables
  - Back-to-Back Converters

FACTS: Reactive power compensation

Status: In operation

SVC Plus Diego de Almagro
–100 / +140 MVAr

SVC Maitencillo
–28 / +24 MVAr

SVC 1 Pan de Azúcar
–28 / +24 MVAr

SVC Polpaico
–65 / +100 MVAr

SVC Puerto Montt
–40 / +70 MVAr

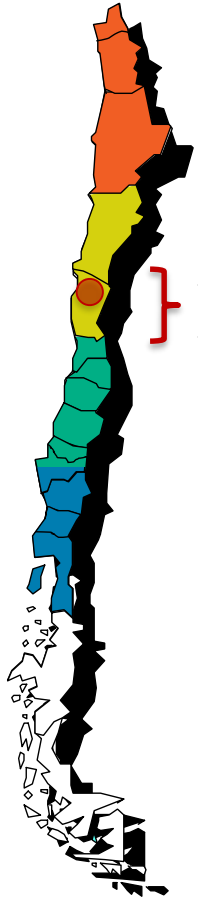
SVC Domeyko
–50 / +120 MVAr

SVC Cardones
–60 / +100 MVAr

SVC 2 Pan de Azúcar
–28 / +24 MVAr

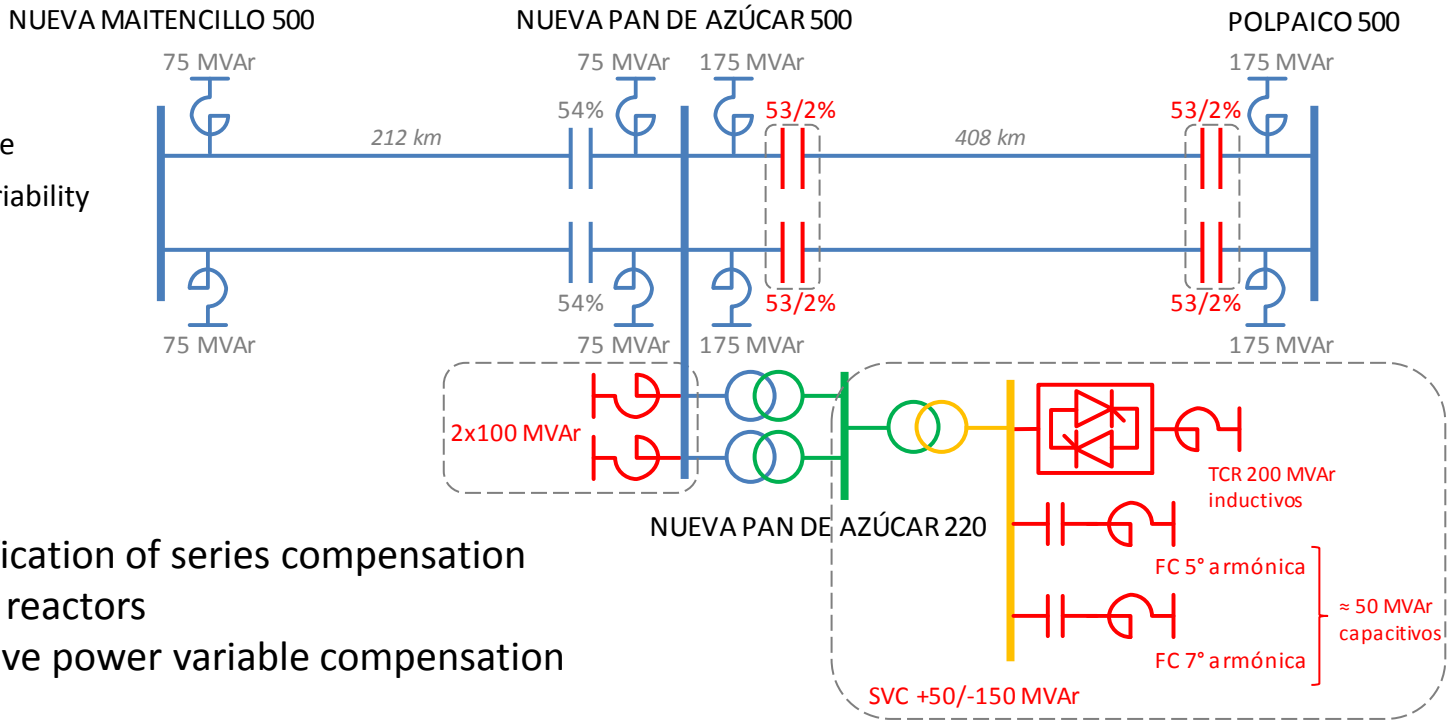
STATCOM Cerro Navia
–65 / +140 MVAr

FACTS: Reactive power compensation



- Overvoltage
- Voltage variability

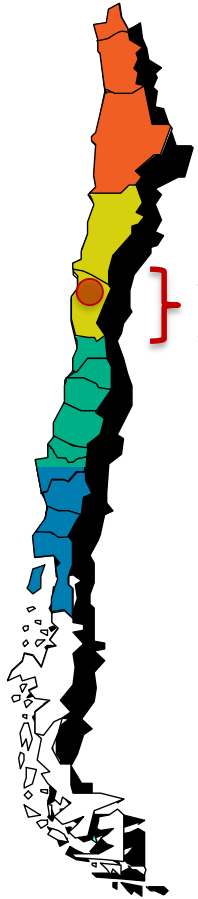
2017 Recommended project (under tendering)



Proposal:

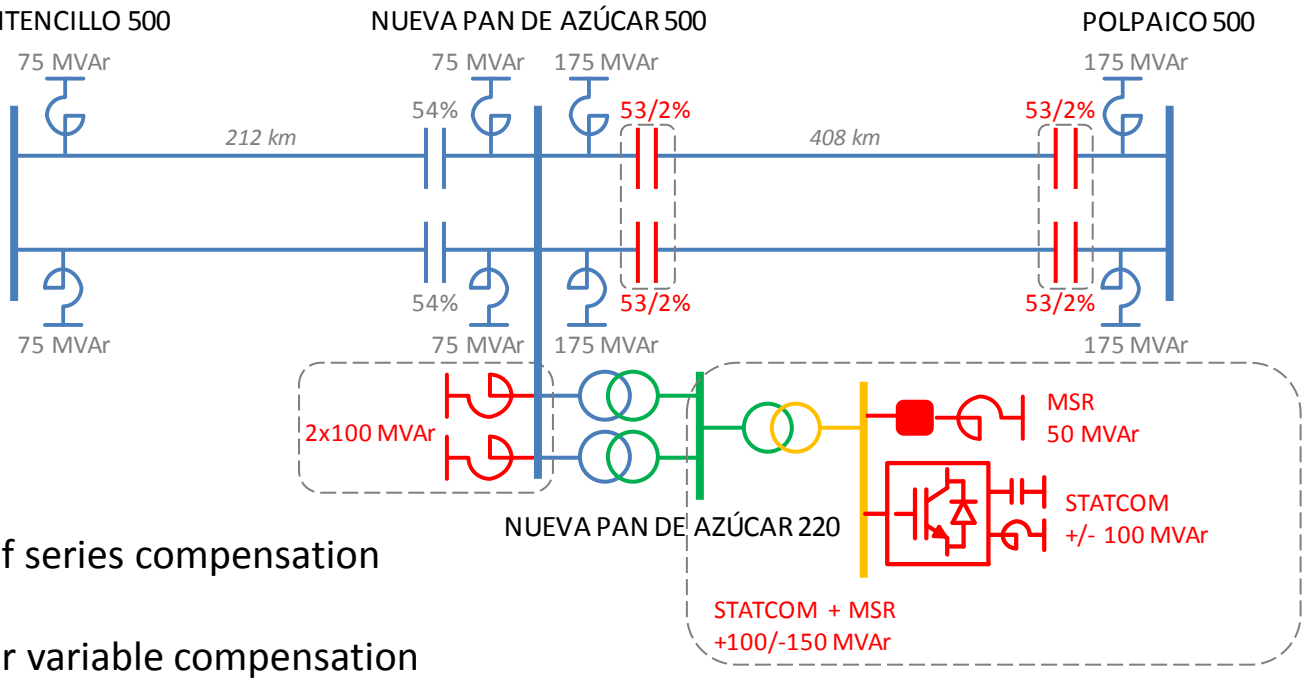
- Modification of series compensation
- Shunt reactors
- Reactive power variable compensation

FACTS: Reactive power compensation



- Overvoltage
- Voltage variability

Recommended project - ALTERNATIVE



Proposal:

- Modification of series compensation
- Shunt reactors
- Reactive power variable compensation

FACTS: Phase-Shifting Transformers

Tocopilla Substation
T1: 100 MVA – 110/110 kV
T2: 100 MVA – 110/110 kV

Objective: Control power flows in specific lines of the power system.

Cerro Navia Substation
T1: 350 MVA – 220/220 kV
T2: 350 MVA – 220/220 kV

FACTS: Fixed Series Compensation

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1x500 kV Ancoa-Alto Jahuel C1
Ancoa: 56% (241 km)

1x500 kV Ancoa-Alto Jahuel C2
Ancoa: 58% (257 km)

2x500 kV Ancoa-Alto Jahuel C3 and C4
Ancoa: 44% (256 km)

1x500 kV Charrúa-Ancoa C1
Ancoa: 50% (183 km)

1x500 kV Charrúa-Ancoa C2
Ancoa: 53% (196 km)

1x345 kV Andes-Salta
Andes: 36% (408 km)

2x500 kV Los Changos-Cumbre
Los Changos: 65/2% (400 km)
Cumbre: 65/2% (400 km)

2x500 kV Cumbre-Nueva Cardones
Cumbre: 55% (189 km)

2x500 kV Nueva Maitencillo-Nueva Pan de Azúcar
Nueva Pan de Azúcar: 55% (212 km)

2x500 kV Nueva Pan de Azúcar-Polpaico
Nueva Pan de Azúcar: 53% (408 km)

2x220 kV Colbún-La Candelaria
La Candelaria: 60% (214 km)

Flexible Transmission: Smart Grid

System Monitoring, Control and Protection – Conceptual View

Wide Area – WAMPAC: with PMU, DLR

Extended Control: WAC-SIPS-RAS with PMU, DLR, IED

Control and Protection: IED

Back up: PMU, IED

Local (logic)

Remote (Comm. aid)

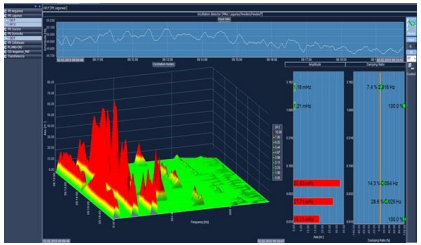
Local protection: IED

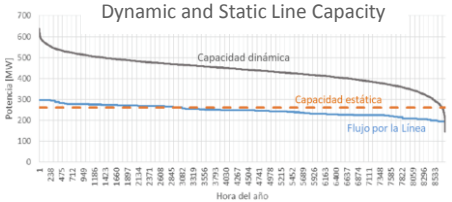
First adjacency: IED

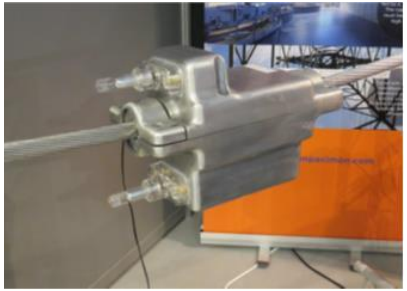
Principal (no delay)

Local backup (with delay)

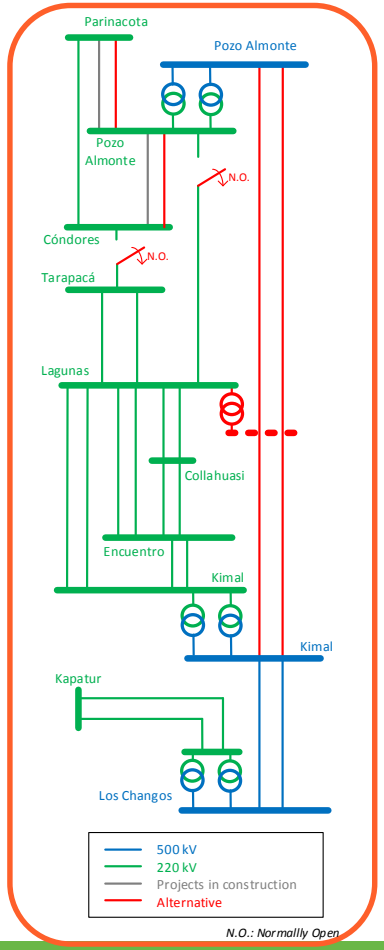
WAMPAC: Wide Area Monitoring, Protection and Control
DLR: Dynamic Line Rating / PMU: Phasor Measurement Unit
SIPS: System Integrity Protection Scheme / RAS: Remedial Action Scheme
IED: Intelligent Electronic Device

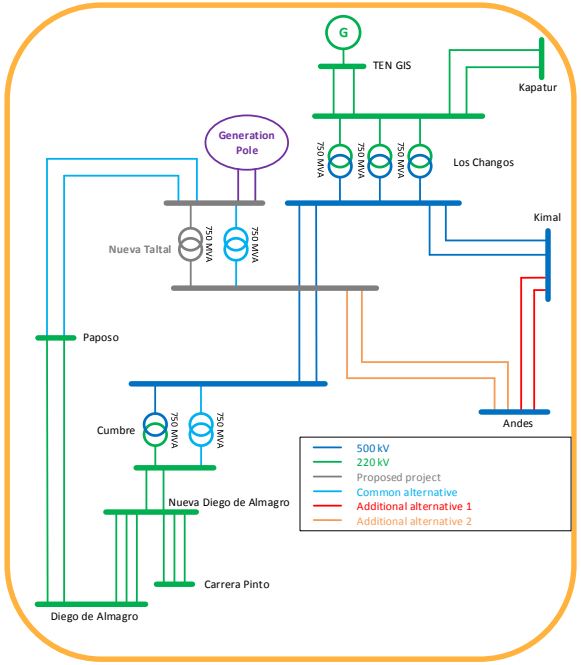


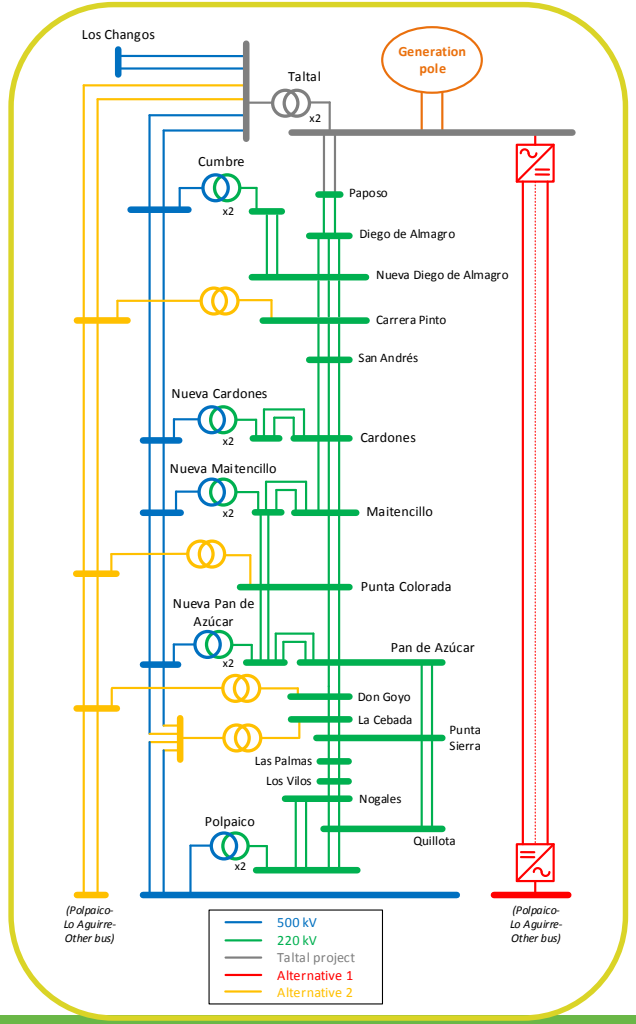




Long Term Vision in Transmission







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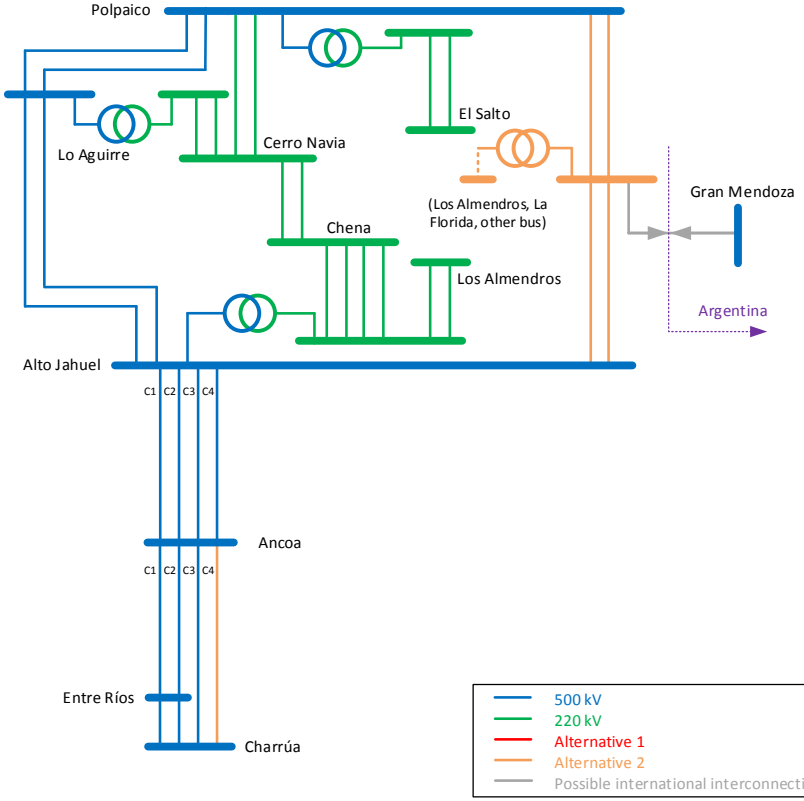

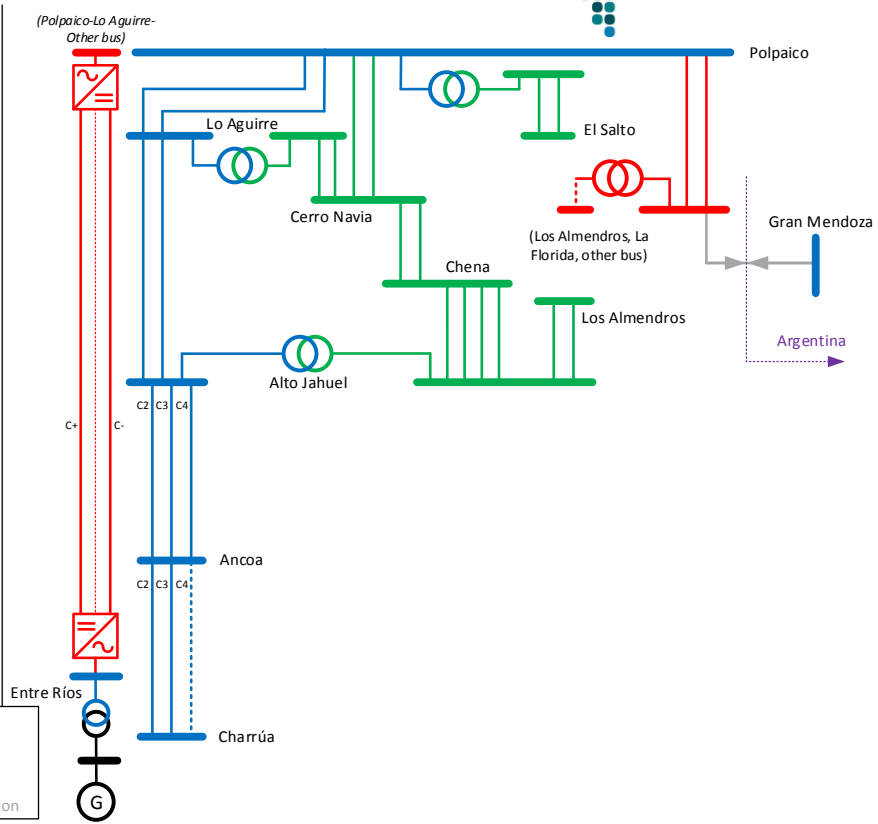

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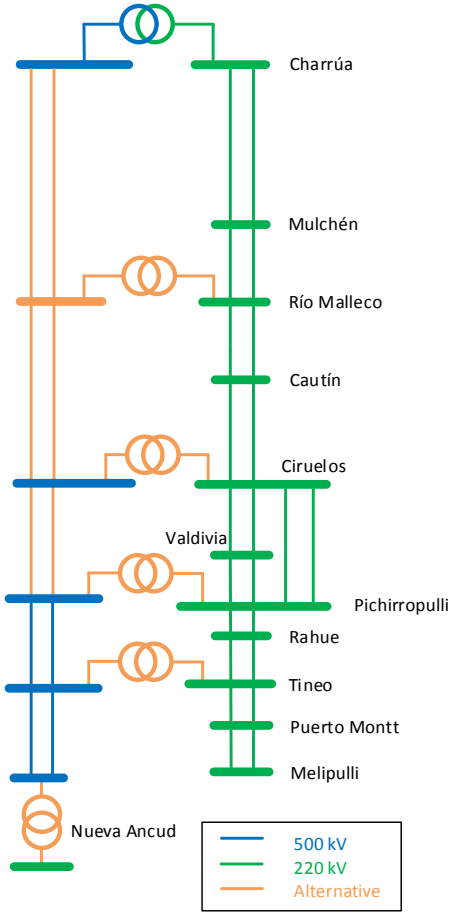

In Summary

- Coordinador face current challenges associated to:
  - the interconnection of SIC and SING to create a unique (long) national power system (3,100 km)
  - implementing the new transmission planning and delivery processes
  - developing and applying the new transmission planning criteria
- Flexibility in transmission expansion is reflected via robust planning, technologies and smart grids

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