

**Conference on the International Experience in Transmission
Planning and Delivery**

Imperial College London, 11-12th January 2013

**COMPETITIVE TRANSMISSION PLANNING AND DELIVERY
IN CHILE: AN EXAMPLE**

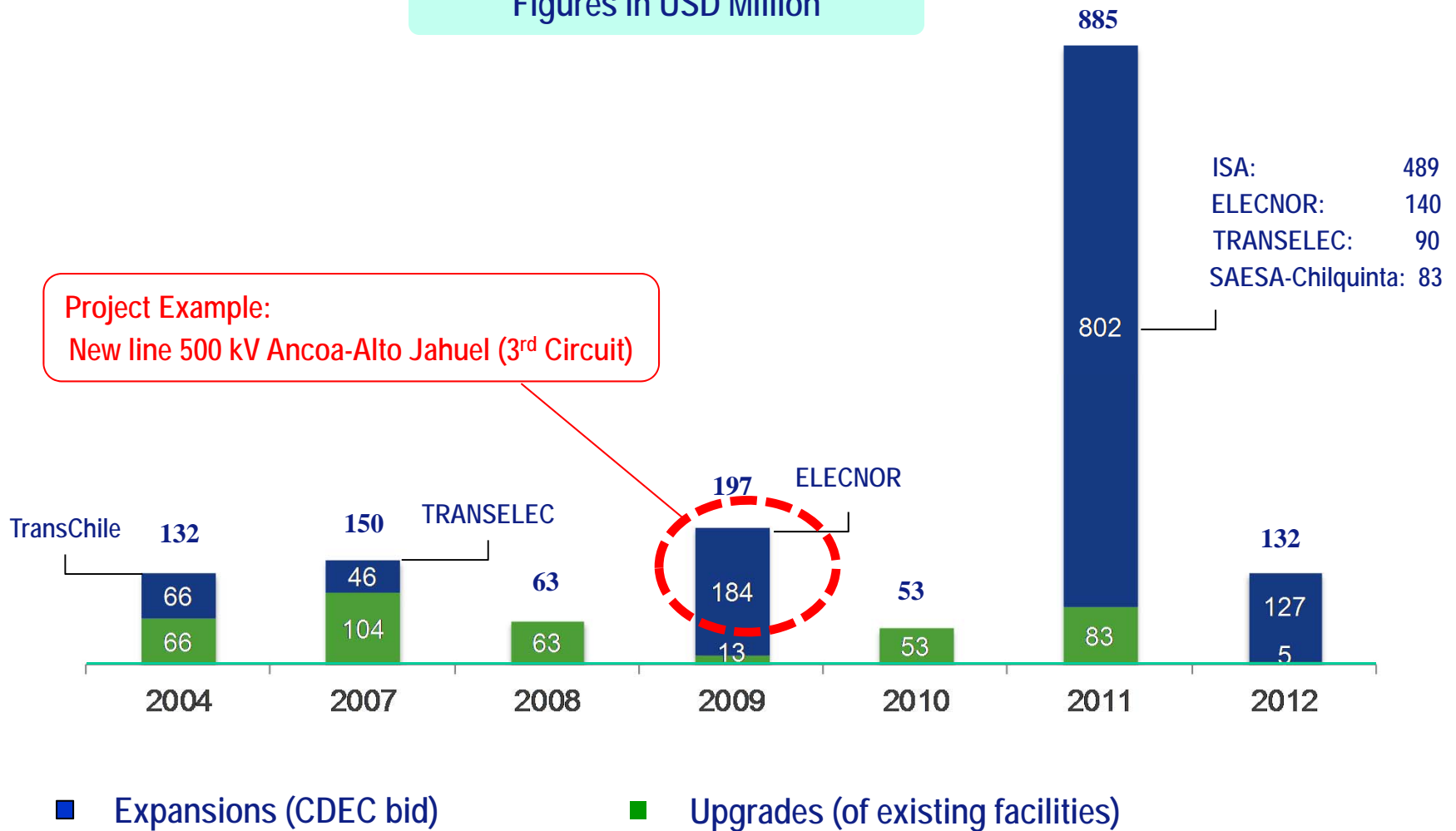
Juan Carlos Araneda
System Development Manager



- An actual example of planning and delivery of new 500 kV transmission line:
 - planning (decision to reinforce the network)
 - steps on the approval
 - actions taken by market agents
 - auction process
 - level of design details specified
 - scope for innovation in delivery
 - construction and delivery time

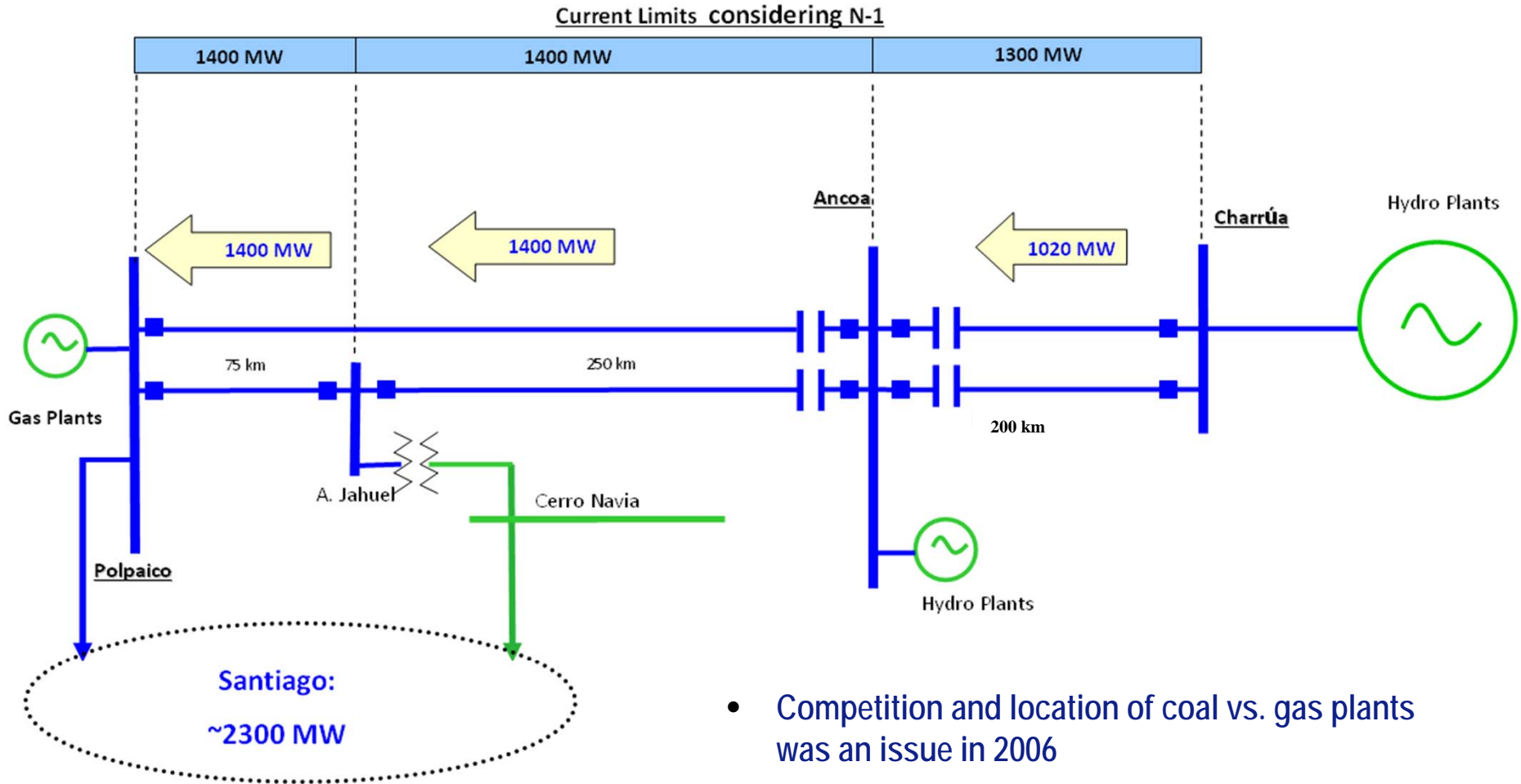
Trunk Expansion Plan Annual Investments Approved

Figures in USD Million



500 kV Trunk System in 2008

The project was not identified in the Trunk Study 2006

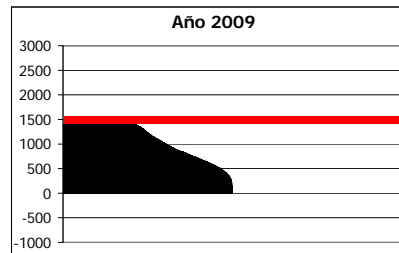


- Competition and location of coal vs. gas plants was an issue in 2006
- The 500 kV network was extended to Polpaico in 2008, upgrading an existing 220 kV line

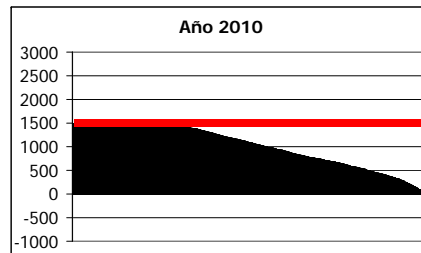
500 kV Ancoa-Alto Jahuel lines

Expected power flows (duration curve)

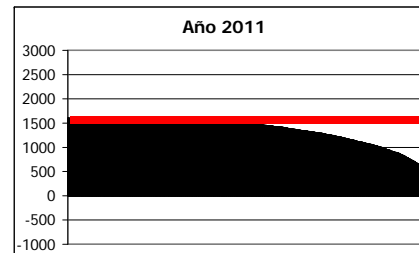
Ancoa_500->AJahuel_500



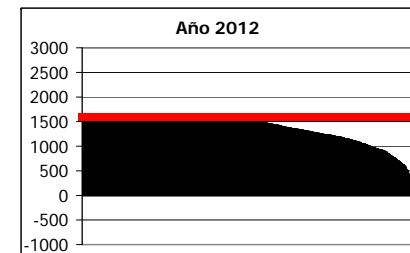
Máxima [MW]	Media [MW]	Minima [MW]	Factor Carga [%]
1,481.9	1,102.6	151.0	37.2



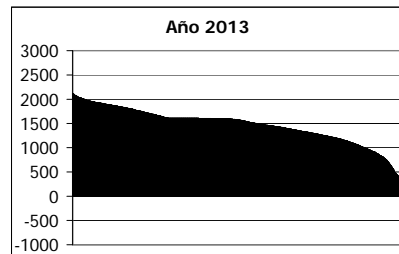
Máxima [MW]	Media [MW]	Minima [MW]	Factor Carga [%]
1,481.9	989.9	-390.9	67.0



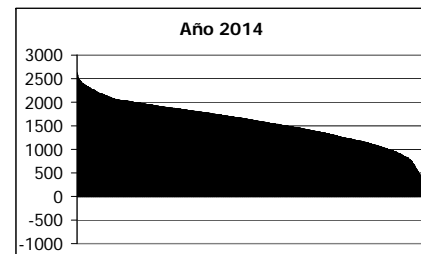
Máxima [MW]	Media [MW]	Minima [MW]	Factor Carga [%]
1,599.6	1,335.8	-101.9	83.5



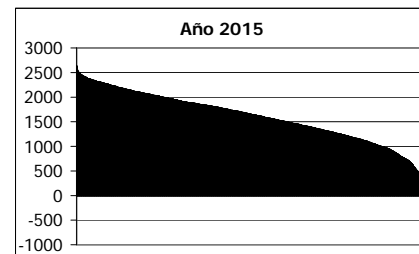
Máxima [MW]	Media [MW]	Minima [MW]	Factor Carga [%]
1,600.1	1,371.6	-2.6	85.7



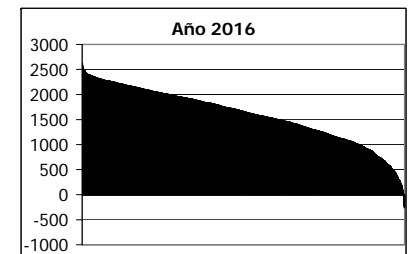
Máxima [MW]	Media [MW]	Minima [MW]	Factor Carga [%]
2,113.1	1,460.2	-83.3	69.1



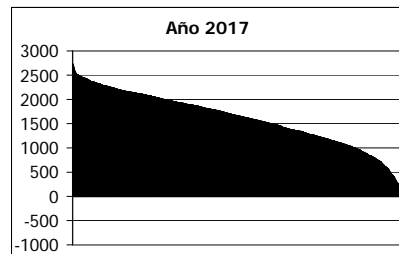
Máxima [MW]	Media [MW]	Minima [MW]	Factor Carga [%]
2,617.3	1,566.5	-185.8	59.9



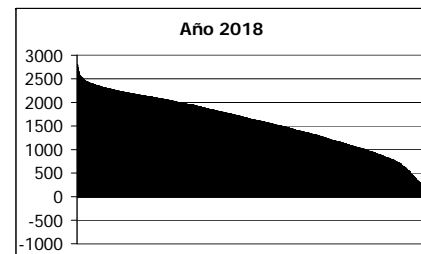
Máxima [MW]	Media [MW]	Minima [MW]	Factor Carga [%]
2,633.4	1,589.9	-96.2	60.4



Máxima [MW]	Media [MW]	Minima [MW]	Factor Carga [%]
2,614.9	1,591.8	-261.8	60.9



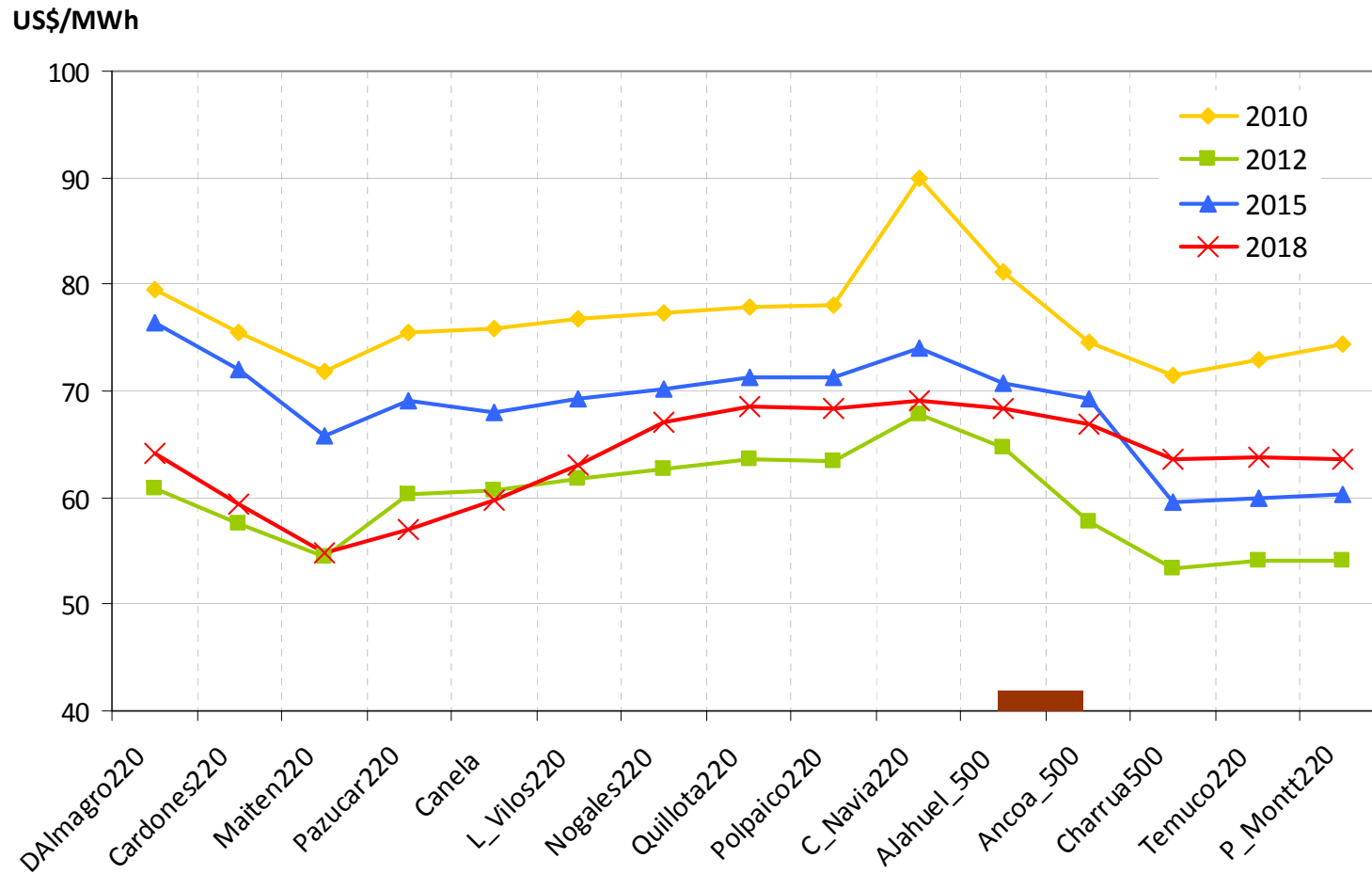
Máxima [MW]	Media [MW]	Minima [MW]	Factor Carga [%]
2,729.4	1,603.0	-286.6	58.7



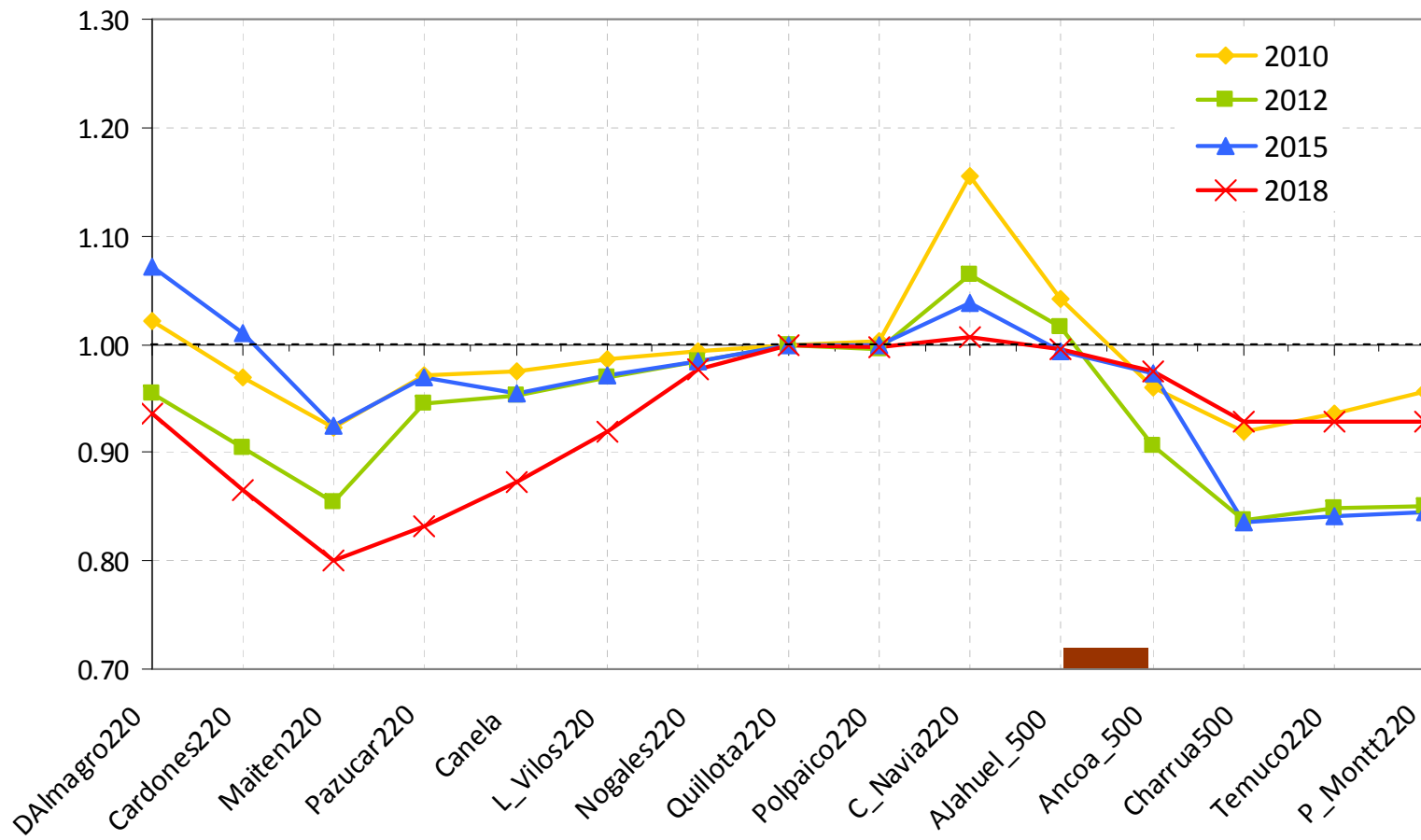
Máxima [MW]	Media [MW]	Minima [MW]	Factor Carga [%]
2,804.3	1,570.2	-355.2	56.0

- Coal wins the competition against LNG in 2007
- Two 350 MW coal fired power plants were decided in the south (Charrua area)

Trunk Network Expected LMP 2010-2018



Trunk Network LMP (as Penalty Factors) 2010-2018



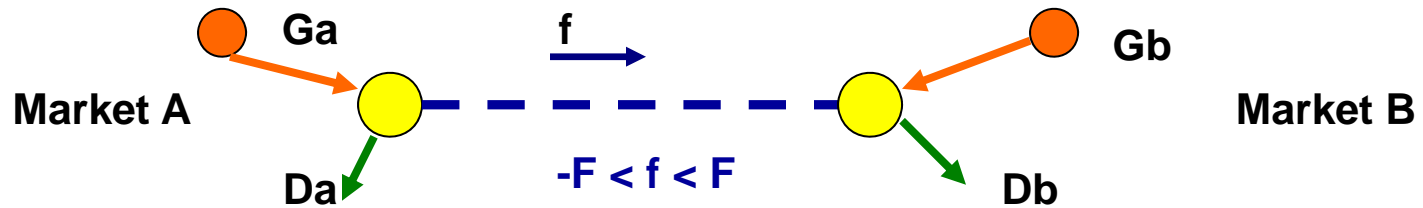
Planning Process and Tools

- The sources of key data are the CNE demand forecast and fuel costs projections for the next 15 years, transmission capacity per corridor defined by CDEC-SIC and future generation expansion plan based on an indicative plan elaborated by CNE for the semester nodal prices calculations. A sensibility analysis on the main new plants that drive the project was performed.
- CDEC-SIC uses the PLP model to simulate the SIC future operation, same as Transelec. PLP used the Stochastic Dynamic Dual Programming (SDDP) methodology to solve the minimum cost operation of the system considering multi-reservoirs (with 40 hydrological conditions) and multi-nodal representation of the transmission network. The power system studies are performed with DigSilent, under normal and contingency states, to confirm that the solution meets the quality and security of service standards.
- CNE uses the OSE2000 model to revise the project evaluation and confirm or modify CDEC-SIC proposal. That model uses the same SDDP technique of PLP.

Planning Process of the Project

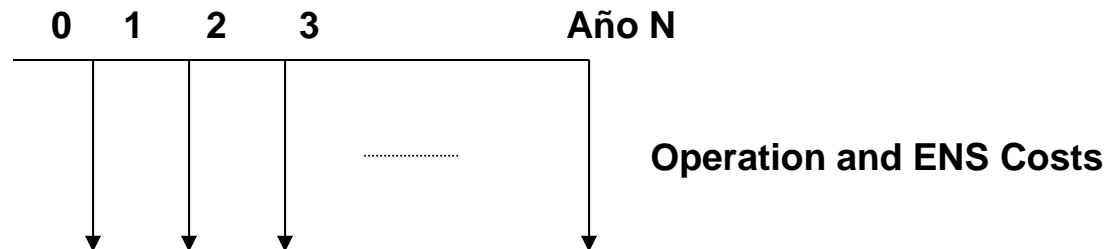
- After planning studies that identified an important congestion on the main 500 kV corridor of the Central Interconnected System (SIC), the construction of a new 500 kV transmission line between Ancoa and Alto Jahuel substations, with a length of 258 km, was proposed. There are two existing 500 kV circuits between those substations, therefore the new circuit should have a rating similar to the existing lines.
- The project was proposed by Transelec to CDEC-SIC in April 2008, with a single circuit 500 kV on a double circuit tower, with an estimated value of investment of US\$ 213 million.
- In October 2008 CDEC-SIC recommended to CNE the project (among other projects in the annual revision of the trunk expansion plan) with a single circuit on a single tower with a value of investment of US\$ 140 million.

Economic Evaluation of the Project



WITHOUT LINE:

System View:

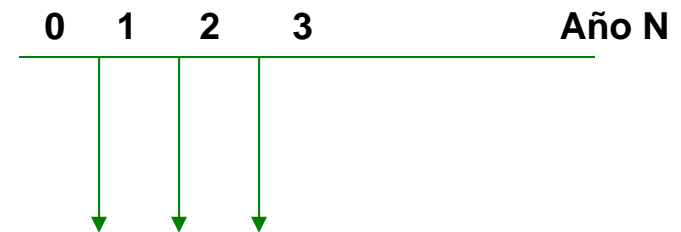


Agents view:

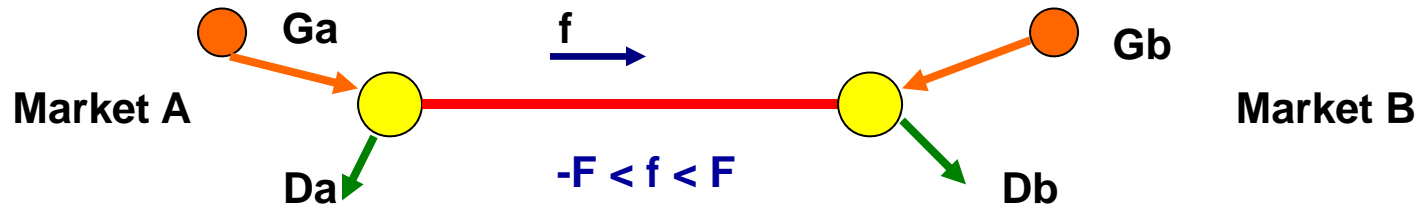
Generators at A (margin)



Demand at B (costs)

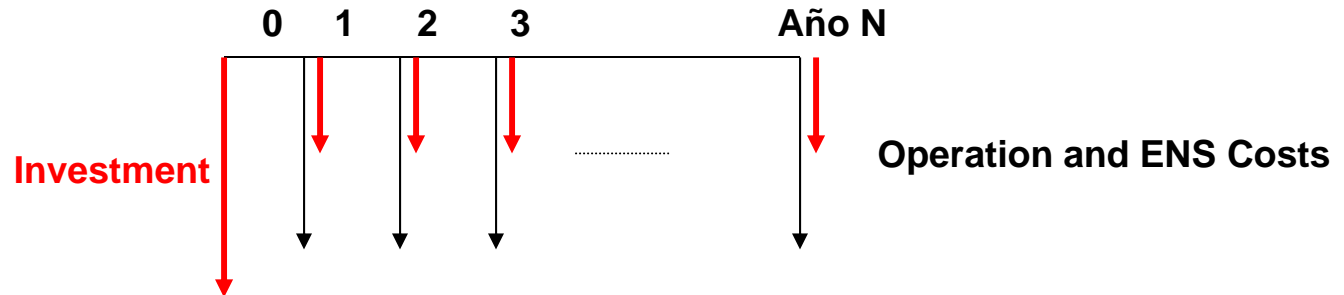


Economic Evaluation of the Project



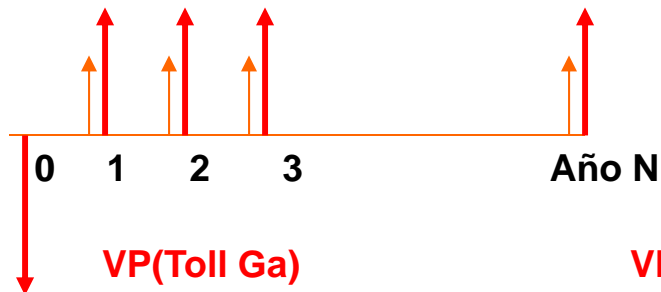
WITH LINE:

System view:

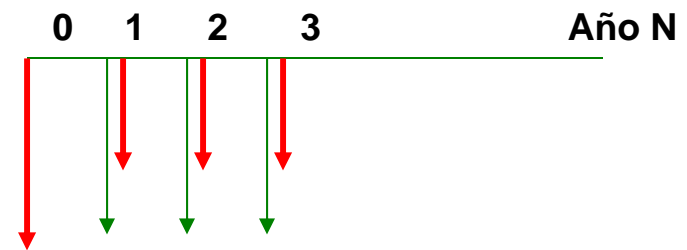


Agents view:

Generators at A (margin)



Demand at B (costs)

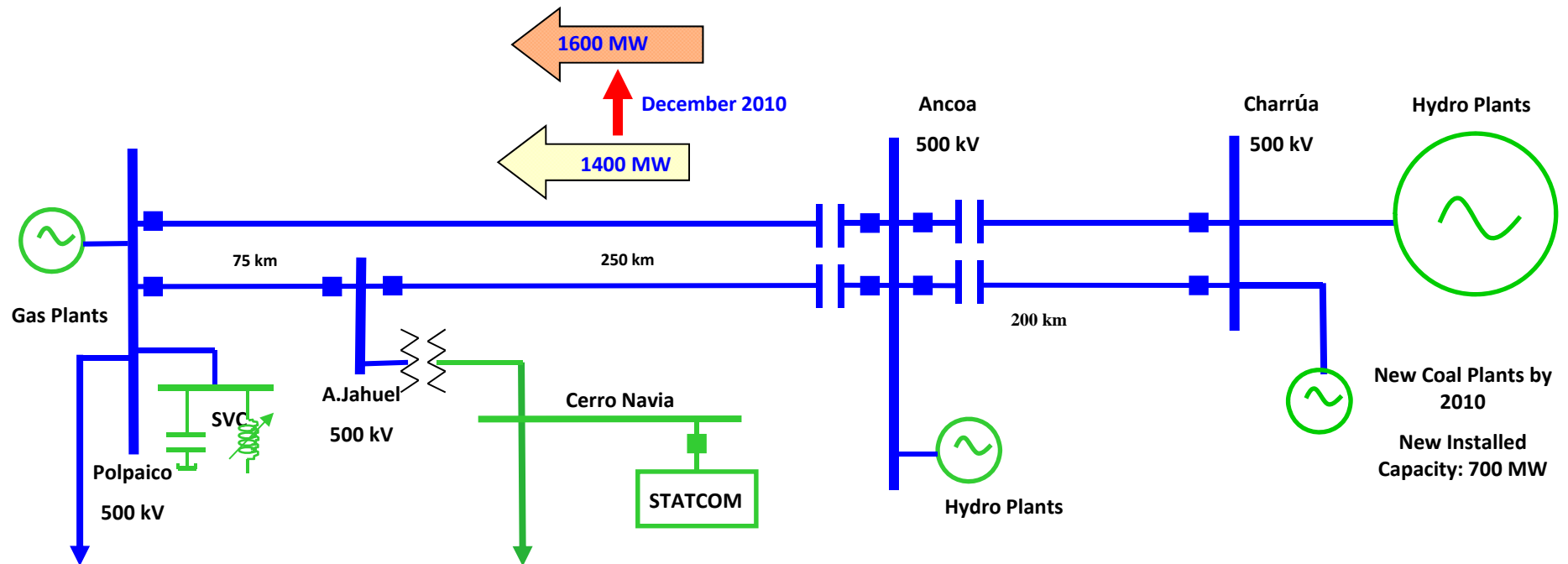


Economic Evaluation of the Project

- The benefits of the project were assessed comparing the system operational costs (total generation costs and not supplied energy) based on a forecast simulation of the SIC, with and without the project, over an 8-year horizon.
- CNE performed its own economic evaluation of the project, using the discounted cash flow method, with a 10% annual discount rate. A summary of the headline quoted costs and benefits are as follows:
 - Present value of investment and O&MA costs in 2009-2017: US\$ 54 million
 - Present value of operational cost savings in 2009-2017 :US\$ 222 million
 - Net present value (updated at April 2009): US\$ 168 million
- Transelec proposed to CNE the option to change the design of the 500 kV line from a single circuit to a double circuit tower in order to avoid the construction of another 500 kV line in the future. CNE accepted Transelec's proposal.
- The project was approved by CNE in January 2009, with a single circuit 500 kV on a double circuit tower, with a value of investment of US\$ 184 million.

- The generation company Endesa presented a discrepancy to the Experts Panel against the double circuit tower design, arguing that it was not needed in the short term.
- CNE presented the evaluation of the option to change the design of the 1x500 kV line from a single circuit tower (investment US\$ 160 million) to a double circuit tower (US\$ 184 million). The evaluation demonstrated that if the second 500 kV circuit is needed before year 2030, then it is a more economic and sustainable solution to construct the new line with double circuit towers.
- The Experts Panel rejected the discrepancy of Endesa and confirmed the project defined by the CNE.
- In May 2009 the project was included in Decree Nr. 642 in order to be internationally auctioned by CDEC-SIC, considering 39 months for commissioning.
- Anyway Endesa was worried about congestion in the period before the new line commissioning.

Additional Investment under Bilateral Agreement Mitigating congestion in 2010-2013



- The two new 350 MW coal fired power plants were expected to be commissioned in 2010 in the south (Charrúa area).
- To overcome the expected congestion in the 500 kV corridor in 2010-2013, Transelec and Endesa evaluated and agreed bilaterally a transmission solution:
 - SVC+STATCOM to increase 500 kV transmission capacity in 200 MW
 - The project was commissioned in March 2011 and later recognized as a trunk system facility in the TTS 2010

Trunk Project Auction by CDEC-SIC in 2009

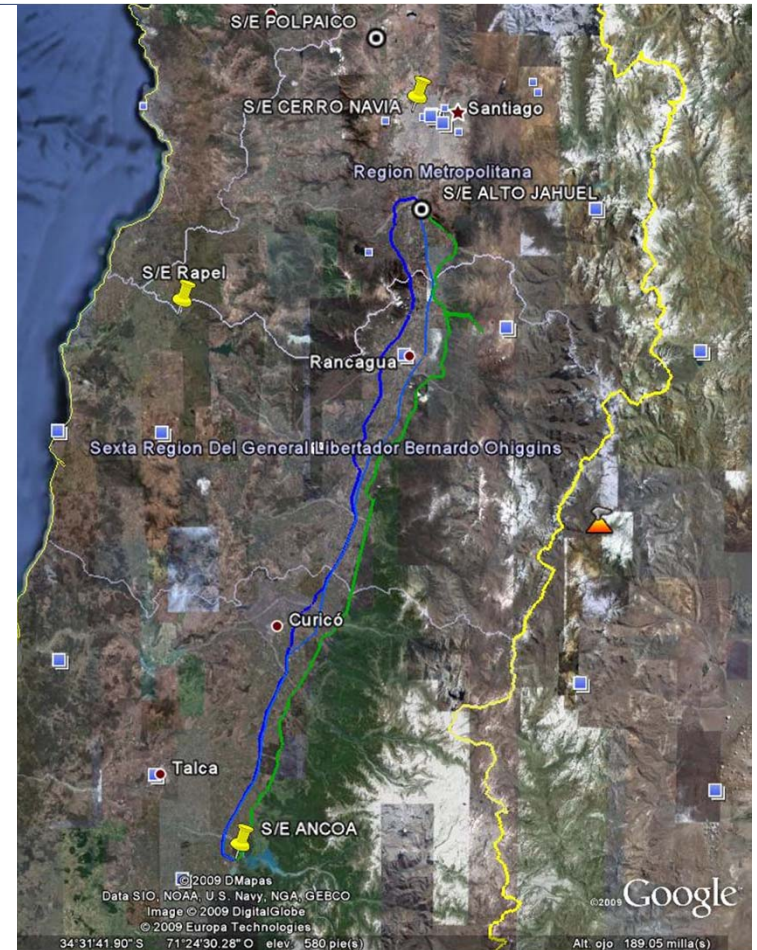
Description

The project consists in the design and construction of the following transmission assets:

- A new 258 km long 2x500 kV line from Ancoa to Alto Jahuel substation. In this stage, only one circuit will be tendered, with a thermal capacity of 1,700 MVA.
- Two 500 kV line bays (Ancoa & Alto Jahuel substations).
- Two shunt reactors (Ancoa & Alto Jahuel substations).
- Two 500 kV reactor bays (Ancoa & A.Jahuel substations).
- 500 kV series compensation at Ancoa substation.

Key design criteria considered by competitors:

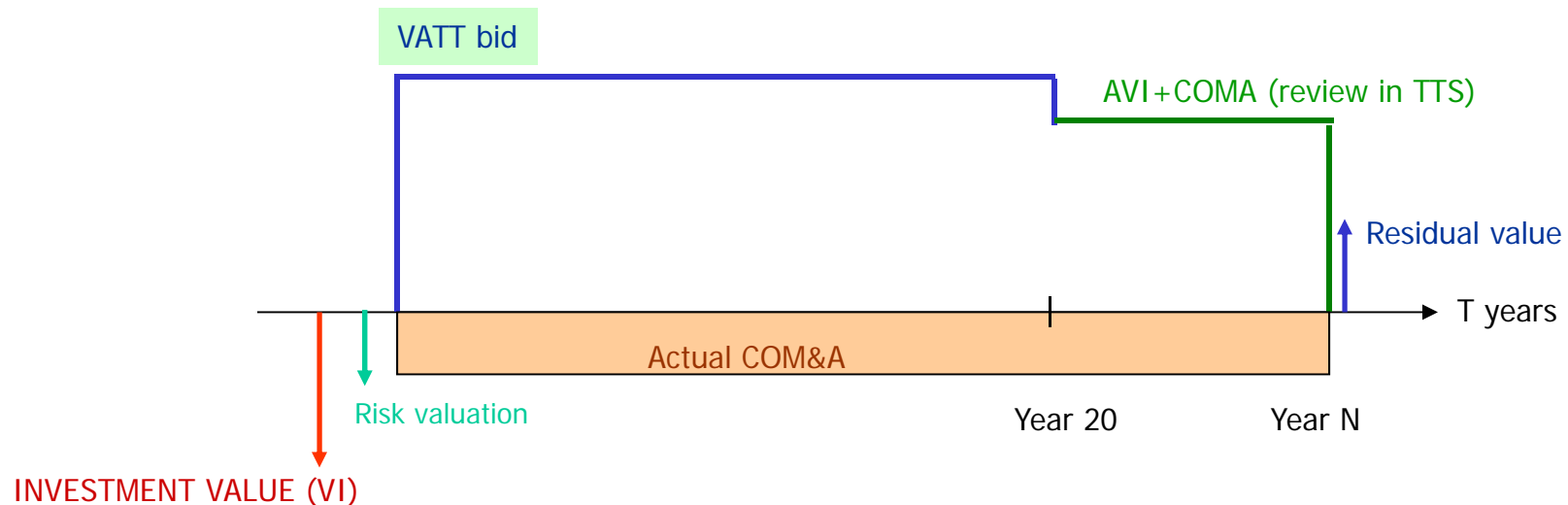
- Optimizing line route length.
- Reducing environmental impacts, avoiding protected areas.
- Optimizing and reducing the number of land owners affected by the line route.



— 500 kV Transelec's existing transmission lines

Competing in Trunk Network Auctions

Main model's parameters are defined as follows:



The model represents net cash flows

- Revenues: VATT bid for 20 years and later AVI+COMA in Trunk Transmission Study (TTS)
- Operation, Maintenance & Administration Costs
- Depreciation (tax impact in cash)
- Taxes
- Financial costs
- Investment Cost
- Risk Valuation (overrun, fines)

Criteria to set VATT bid:
 $NPV(WACC, VATT\ bid) = 0$

Results of the Project Auction

Company	Technical Score	VATT (MUSD\$)	Diff (%)
Elecnor S.A.	6,9	18,6	-
Abengoa Chile S.A.	6,7	23,5	26%
Transelec S.A.	6,8	29,6	59%
Alupar	6,5	29,9	61%

- The new 500 kV Ancoa – Alto Jahuel transmission line was tendered by CDEC-SIC under an international auction process and awarded in November 2009 to the Spanish construction company Elecnor.
- The new 500 kV line was expected to be commissioned in July 2013.

- The key risk factors have been the rights of way negotiations with the land owners and the environmental impact assessment (EIA) evaluation, that are full responsibility of the awarded company. The project may initiate its construction on the ground only after the approval of the EIA .
- Elecnor asked for an extension of one year to complete the project (from 39 to 51 months). The extension was accepted by the Ministry of Energy in 2012.
- Additionally, Elecnor won the two upgrade tendering processes called by Transelec to extend the 500 kV busbars at Ancoa and Alto Jahuel.

NEW TRUNK TRANSMISSION LINE	LENGTH Km	TRANSMISSION OWNER	DURATION (Months)	
			DECREE	ACTUAL
Charrúa-Cautín 220 kV	200	Transchile	37	56
El Rodeo-Chena 220 kV	20	Transelec	31	49
Nogales-Polpaico 220 kV	90	Transelec	24	42
Ancoa-Alto Jahuel 500 kV	260	Elecnor	39	51 (expected)

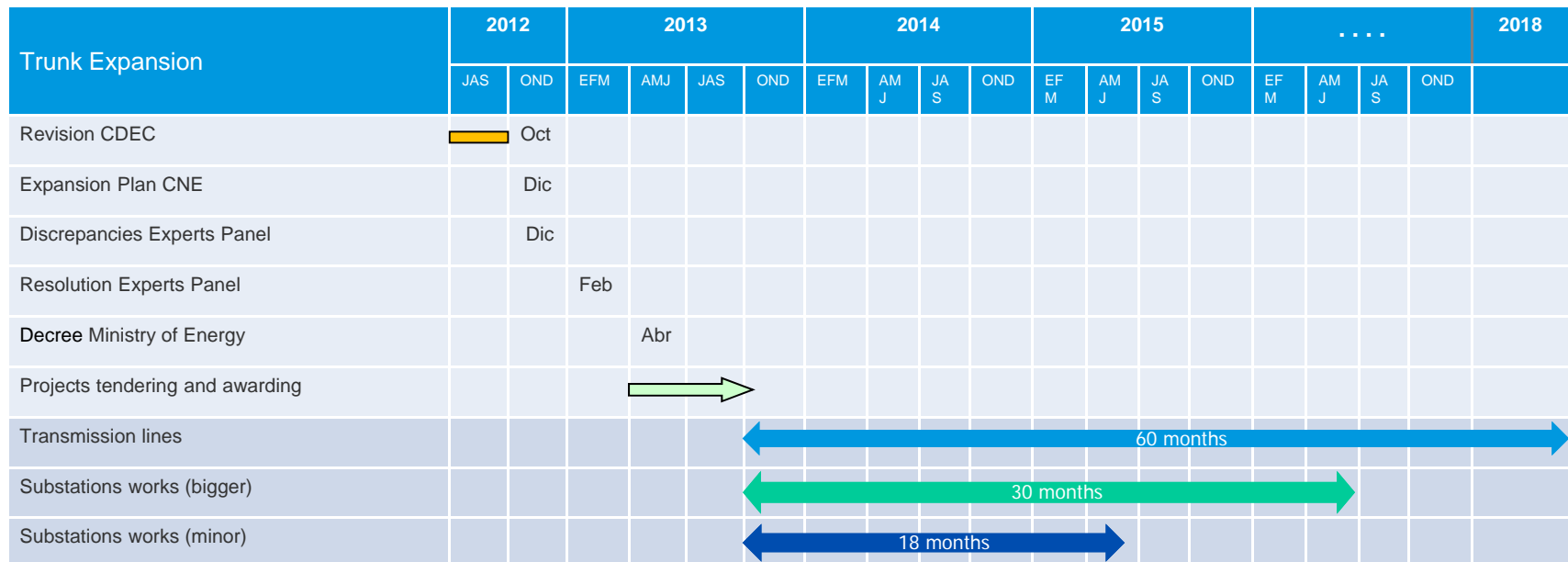
Annex

Trunk Transmission Expansion Process

Trunk System Expansion Plan

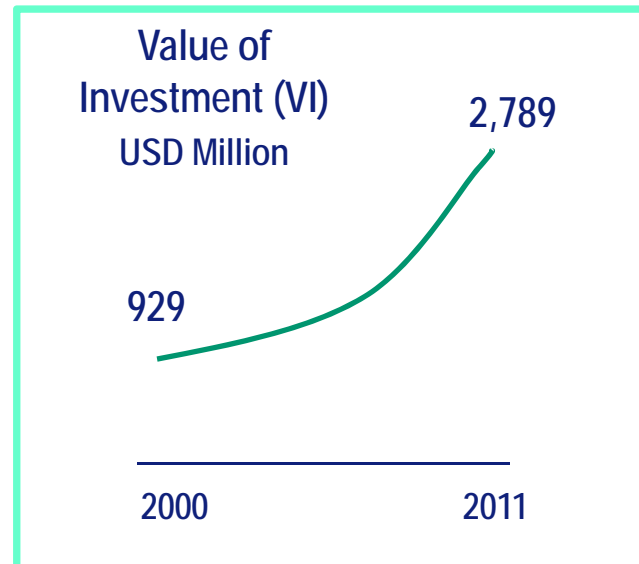
- There is open access to network capacity and CDEC manages the reliable and economic dispatch.
- The valuation and expansion of the trunk system is determined every 4 years through a Trunk System Study (TSS) prepared by an external consultant.
- All market agents participate in the TSS via a consultation process.
- TSS determines the Value of Investment (VI), Costs of Operation, Maintenance and Administration (COMA), Economic Lifespan and Indexation Formula.
- Transmission revenues = AVI + COMA, are allocated on generation and demand.
- A 4-years Referential Expansion Plan is determined in the TSS. Annually the expansion plan is revised by CDEC and afterwards the regulator CNE enacts the definitive plan.

Trunk Expansion Plan Annual Revision Process



- The trunk network projects maybe upgrades of the existing network or new projects:
 - Upgrades are assigned to the facility owner. He must tender the project and award to the contractor that bids the minimum VI, with a cap VI+15%
 - New projects are awarded through a competitive auction called by CDEC. The winner is the TO that bids the minimum AVI+COMA, valid for 20 years

- Market share: trunk system (90%), subtransmission (15%), additional systems (30%)
- 8,525 Km lines and 54 substations
 - SING: 959 km and 4 substations
 - SIC: 7,566 km and 50 substations
- 12,824 MVA of transformation capacity





Uniting Chile with energy