Review of the INPRO Methodology Economics: User Requirement and Criterion from the power market perspective in Chile

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Gobierno de Chile

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Chile

- Placed in South America.
  - 756,102 Km2 → South America Land.
  - 1,265,853.7 km2 → Magallanes and Antartic plate.
  - 163.6 km2 → Eastern Island

- GDP 2013 (PPP) 2013 US$335.57 billion, per capita USD$19,067.

- Average currency exchange (2010-2013) USD$1 = CLP$493

- Population 17,62 million.
  - Average density of 22.00 pop/km2

- From 2010, Chile become a OECD Member.

Sources: World Bank, INE www.ine.cl , Boletín Julio 2014 Banco Central de Chile, Instituto Geografico Militar www.igm.cl .

Installed Generation Capacity in Chile
Total net power 2013: 18,130MW

SING
Northern Interconnected System
22,9%
4.149 MW
- Renewable: 0,8%
- Conventional: 99,2%

SIC
Central Interconnected System
76,3%
13.826 MW
- Renewable: 6,3%
- Conventional 93,7%

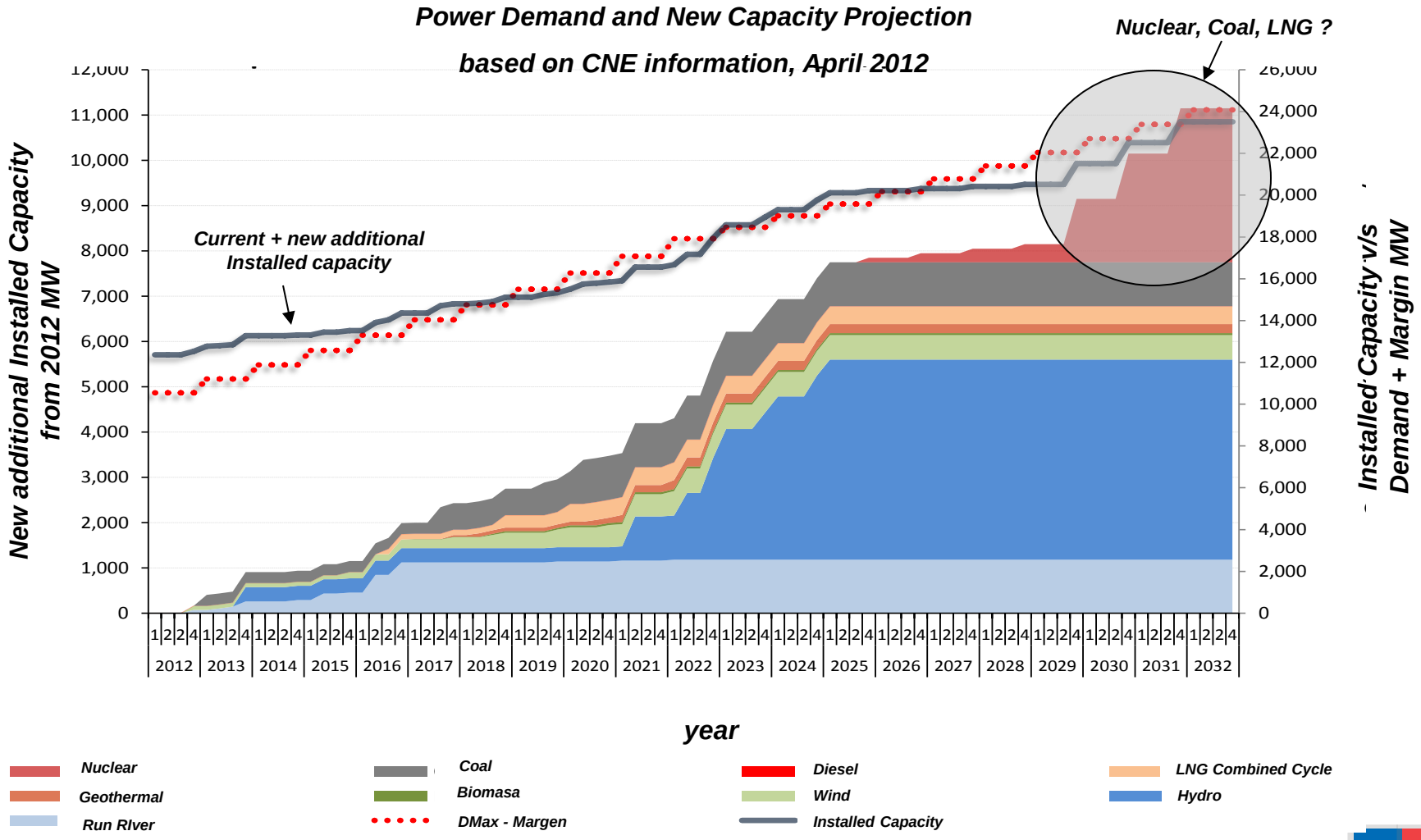
SSMM Los Lagos
0,03%
6 MW
- Renewable: 12,4 %
- Conventional 87,6%

SSMM Aysén
0,3%
50 MW
- Renewable: 49,0 %
- Conventional 51,0%

SSMM Magallanes
0,55%
99 MW
- Renewable: 0,0 %
- Conventional 100%

Power demand proyection

Energy Projection shows a gap where a first NES is a potential option to be considered in the mix.



Obs: Not official projection

Source: Mr. Ricardo Fuentes MSc Thesis : Economic Analysis of a Cogeneration System using Small Medium Reactor Technology

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Review of Economics issues from chilean power market drivers perspective

❑Considerations in the Chilean Competitive Market

The chilean electricity market, could be defined as a **contract market**, where prices of the energy are structured **around three schemes**: **Spot** (generators), **Free Consumers** (mainly mining consumers) and **Regulated** (residential and small consumers).

❑**Spot market (Spot prices):** The dispatch is independent of a genco's contracts. Genco's which sell more energy than they produce are required to buy the difference in the spot market at the spot price.

❑ **Free Consumer market**: The free consumers, those with installed power of more than 500kW, are **able to negotiate** its power and energy supply in a free market. The free consumer can negotiate energy contracts **directly with genco's**. These contracts **establish prices, supply and reliability conditions**.

❑ **Regulated market (Auction prices):** The regulated prices are paid by residential and small consumers (not declared as Free Consumers). These **prices are calculated after a auction process** carry out by CNE (National Energy Commission) and they **correspond to the prices offered by genco's** to supply a **distribution company** (power and energy) **during the time period established in the contract**.

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❑ Considerations in the Chilean Competitive Market

- ❑ All technologies are competitive, and their **marginal cost price establishes their dispatch option in the spot market**.
- ❑ The generation unit **with energy contracts** – with a price capable to be dispatched in the spot market – **assume a lower risk** in the market.
- ❑ **All technologies are alternatives to be dispatch**, in order to supply the demand.
  - ❑ The **lower price units** will supply the **base demand**.
  - ❑ The **highest price units** compete to cover the **peak demand**.
- ❑ **There are not privileges** for technologies in a competitive market.
  - ❑ Only NCRE technologies has a special amendments by law, with a dispatched representative of a % of generation of conventional units.
- ❑ **In general: If any technology accomplished with the Environmental Restrictions and It has a competitive Marginal Cost → It will be dispatch.**

Review of Economics issues from chilean power market drivers perpective → UR1 (Cost of energy)

User Requirement	Criterion	Indicator (IN) and Acceptance Limit (AL)
UR1 (Cost of energy): *The cost of energy supplied by nuclear energy systems, taking all relevant costs and credits into account, C_N, should be competitive with that of alternative energy sources, C_A that are available for a given application in the same time frame and geographic region/jurisdiction*	CR1.1 cost competitiveness	IN1.1: Cost of energy.
		AL1.1: $C_N \leq k^*C_A$ (C_N = cost of nuclear energy, and C_A = cost of energy from alternative source; factor k is usually ≥ 1 and is based on strategic considerations.)
UR2 (Ability to finance): *The total investment required to design, construct, and commission nuclear energy systems, including interest during construction, should be such that the necessary investment funds can be raised.*	**CR2.1** attractiveness of investment	**IN2.1:** Financial figures of merit.
		AL2.1: Figures of merit for investing in a NES are comparable with or better than those for competing energy technologies.
	CR2.2 investment limit	**IN2.2:** Total investment.
		AL2.2: The total investment required should be compatible with the ability to raise capital in a given market climate.
UR3 (Investment risk): *The risk of investment in nuclear energy systems should be acceptable to investors.*	**CR3.1** maturity of design	**IN3.1:** technical and regulatory status.
		AL3.1: Technical development and status of licensing of a design to be installed or developed are sufficiently mature
	CR3.2 construction schedule	**IN3.2:** Project construction and commissioning times used in economic evaluation.
		AL3.2: Times for construction and commissioning used in economic evaluation are sufficiently accurate, i.e. realistic and not optimistic.
	CR3.3 uncertainty of economic input parameters	**IN3.3:** A sensitivity analysis of important input parameters for calculating costs and financial figures of merit has been performed.
		AL3.3: Sensitivity to changes in selected parameters is acceptable to investor.
	CR3.4 political environment	**IN3.4:** Long term commitment to nuclear option.
		AL3.4: Commitment sufficient to enable a return on investment.
UR4 (Flexibility): *Innovative nuclear energy systems should be compatible with meeting the requirements of different markets.*	**CR4.1** flexibility	**IN4.1**: Are the innovative NES components adaptable to different markets?
		AL4.1: Yes.

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Review of Economics issues from chilean power market drivers perspective

- **User Requirement UR1 (Cost of energy)**
  - **Criteria CR1.1: Cost competitiveness**

$$C_N \leq k \cdot C_A$$

Proposal

- To considered in the calculation of C_N and C_A (using LUEC methodology), a sensitive parameter about penalties associated to transmission congestion.

  → *In general two technologies doesn't compete for the site/region or connection point. They compete for install capacity, availability and energy in the mix.*

- The generation technology cost comparison should include some "penalty factor" due to the relative generation plant location in the power system, instead of consider all power injection in a single node to compare de power production cost (C_N and C_A).

Review of Economics issues from chilean power market drivers perspective → UR2 (Ability to finance)

User Requirement	Criterion	Indicator (IN) and Acceptance Limit (AL)
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Review of Economics issues from chilean power market drivers perspective

- **User Requirement UR2 (Ability to finance)**
  - **Criteria CR2.1: Attractiveness of investment**

Figures of merit for investing in a NES are comparable with or better than those for competing energy technologies

Proposal

- The inclusion of a “penalty factor” which gives some economic signal about the relative location of each power plant option in order to compare its production costs and revenues in the calculation of IRR or ROI.

- ROI (Return of Investment).
- IRR (Interest Rate Return).

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Review of Economics issues from chilean power market drivers perspective

User Requirement UR2 (Ability to finance)

- Criteria CR2.2: Investment limit

The total investment required should be compatible with the ability to raise capital in a given market climate

Proposal

- The inclusion or of an alternative indicator which compares the NES total investment cost per MW installed with the total unitary investment cost expended in a competitive technology in a real project installed in the country in the past 5 year. If the NES total investment cost per MW is in the range ± 10%, the criteria is fulfilled.

Review of Economics issues from chilean power market drivers perpective → UR3 (Investment risk)

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UR4 (Flexibility): *Innovative nuclear energy systems should be compatible with meeting the requirements of different markets.*	CR4.1 flexibility	IN4.1: Are the innovative NES components adaptable to different markets? AL4.1: Yes.

Comment: From the cost point of view, the regulatory framework cost might be cover by the government.

Comment:These aspects related to the construction investment and regulatory infrastructure for nuclear technology are independent of the electrical market conditions while has not been taken a energy contract obligation.

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Review of Economics issues from chilean power market drivers perspective

- **User Requirement UR3 (Investment risk)**
  - **Criteria CR3.3: Uncertainty of economic input parameters.**

In order to reduce the investment risk, in competitiveness markets, should be assure that the NPP must be continually dispatched in the energy mix.

Proposal

An indicator or an additional acceptance limit for CR.3.3, such as:

- To assure **contracts in the long term,** for all the installed capacity.
  - → The USD$/MWh by contract should be higher than C_N for the NPP.

- To assure the **sustainability of the nuclear fuel** for keeping a competitive marginal cost in the spot price. Could be used acceptance limits, such as:
  - → Nuclear Fuel contracts in the Long Term.
  - → Diversity of suppliers.

Review of Economics issues from chilean power market drivers perpective → UR4 (Flexibility)

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Comment → Difficult to check AL 3.4, It depends of the market conditions, and C_N. Political environment is not easy to check in the medium or long term.

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Review of Economics issues from chilean power market drivers perspective

- **User Requirement UR4 (Flexibility)**
  - **Criteria CR4.1: Flexibility.**

Positive impact, or side benefits/outcomes of Nuclear Technology deployment

Proposal

- An indicator or acceptance limit which shows the side benefits for the innovative nuclear energy systems. Whom produced profits associated to another products.

i.e.

- Electrical market → Capability to provide ancillary services. (such as Voltage reference Unit, frequency regulation).
- Agriculture → Desalinization capability.

Thank you

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