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Large Scale Solar Energy Development in Northern Chile: opportunities, difficulties and barriers

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Contents:

- ***The XX century versus the XXI:*** the energy model that *must* be developed during this century.
- ***Chile's exceptional position:*** our great abundance in renewable energy in general and solar energy in particular.
- ***Large Scale Solar in Chile:*** a unique opportunity to exploit the natural simbiosis between energy and mining.
- ***The model that we need to build:*** or the transition from a resource based society to a knowledge based society. The main difficulties we need to face.
- ***Conclusions:*** and the opportunities that lie along this road.

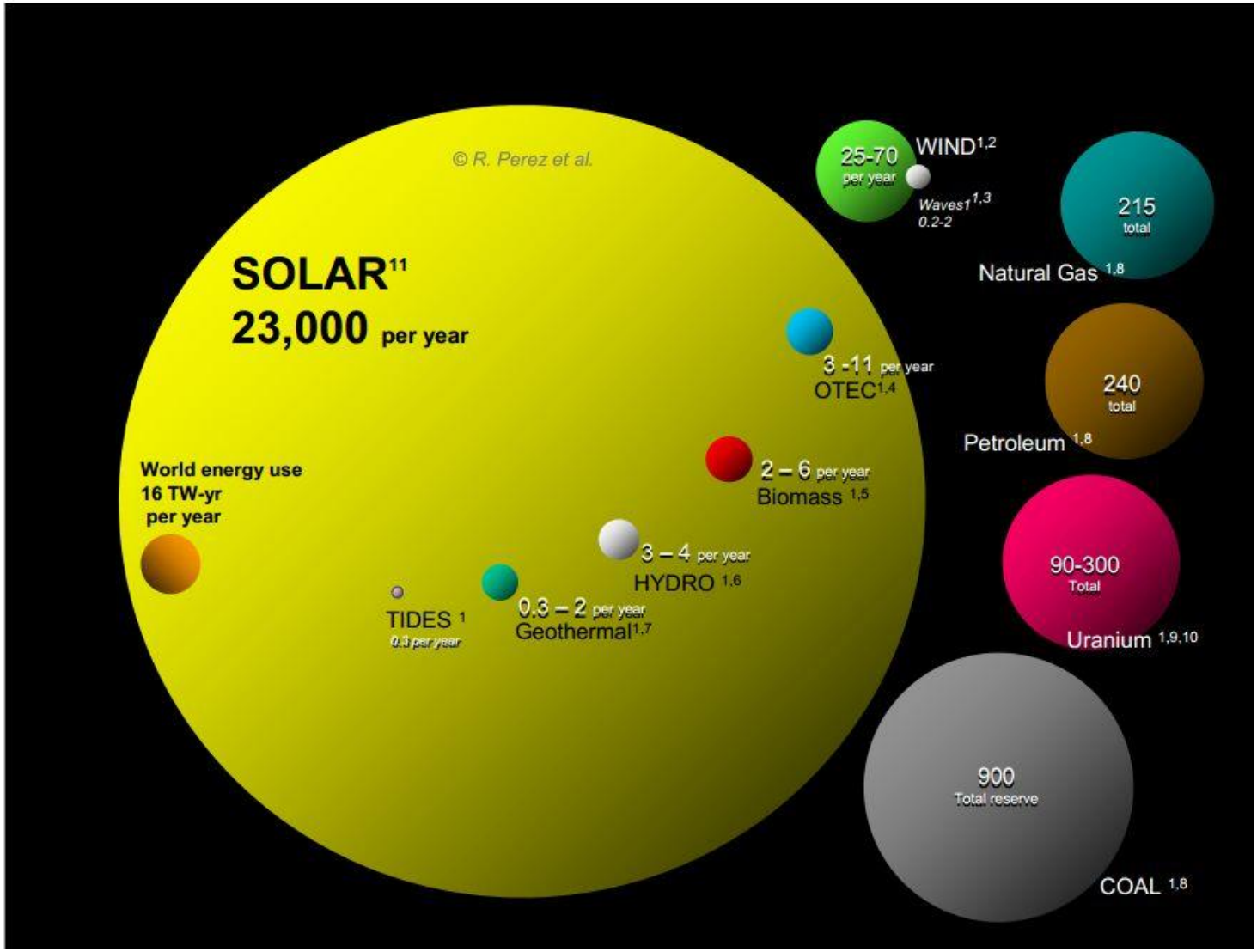
XXth Centry versus XXI:

- **XXth Century:** Is properly the *Century of Fossil Fuels.* Over 80% of fossil fuel use has been in this Century. Most of the carbon emmissions has been caused by fossil fuel use, deforestation and other antropic impacts.
- **IPCC Alert Signal:** A few weeks ago an Alert Signal was put out by the IPCC. In short they say that: "*..if we want to limit climate change to a range of not more than 2°C, then the additional amount of fossil fuels that can be burnt is severly limited. From here to 2050 all electrical power generation must be done without CO_2 emmissions; and from here to 2100* ***all energy generation*** *must be done without emmitting greenhouse gases".*
- **XXIst Century, A transition to a renewable energy World:** This is the ISES (International Solar Energy Society) Mission Statement, and has to be our roadmap for this Century…

XXth Century versus XXIst:

- **XXIst Century Goal:** Can this target be met?. Without doubt. There's *more tan enough* renewable energy available. Specially in Chile
- **XXth Century Model:** The energy model was essentially *top-down:* large scale suppliers fed distributed end users. Also this was an *open ended* model. An infinite supply chain of raw goods fed the manufacturing sector (and agricultura), which after a short use ended up as garbage, landfill or effluents.
- **XXIst Century:** Energy generation must change to *distributed, dynamic and intelligent systems.* Production systems must be flexible and essentially closed-loop (i.e. intense recycling and reuse). Overall impacts must be assessed.
- **Chile's Role:** we can choose to be a part (and contribute) to this sea of change, or simply stand by and see it come to pass. Not a good idea at all…

Solar energy absorbed by the earth in 1 year is 1400 times greater tan all human use, 25 times greater tan all coal reserves. And except for geothermal energy, all renewables get their drive from solar energy.



Source: Richard Pérez 2008

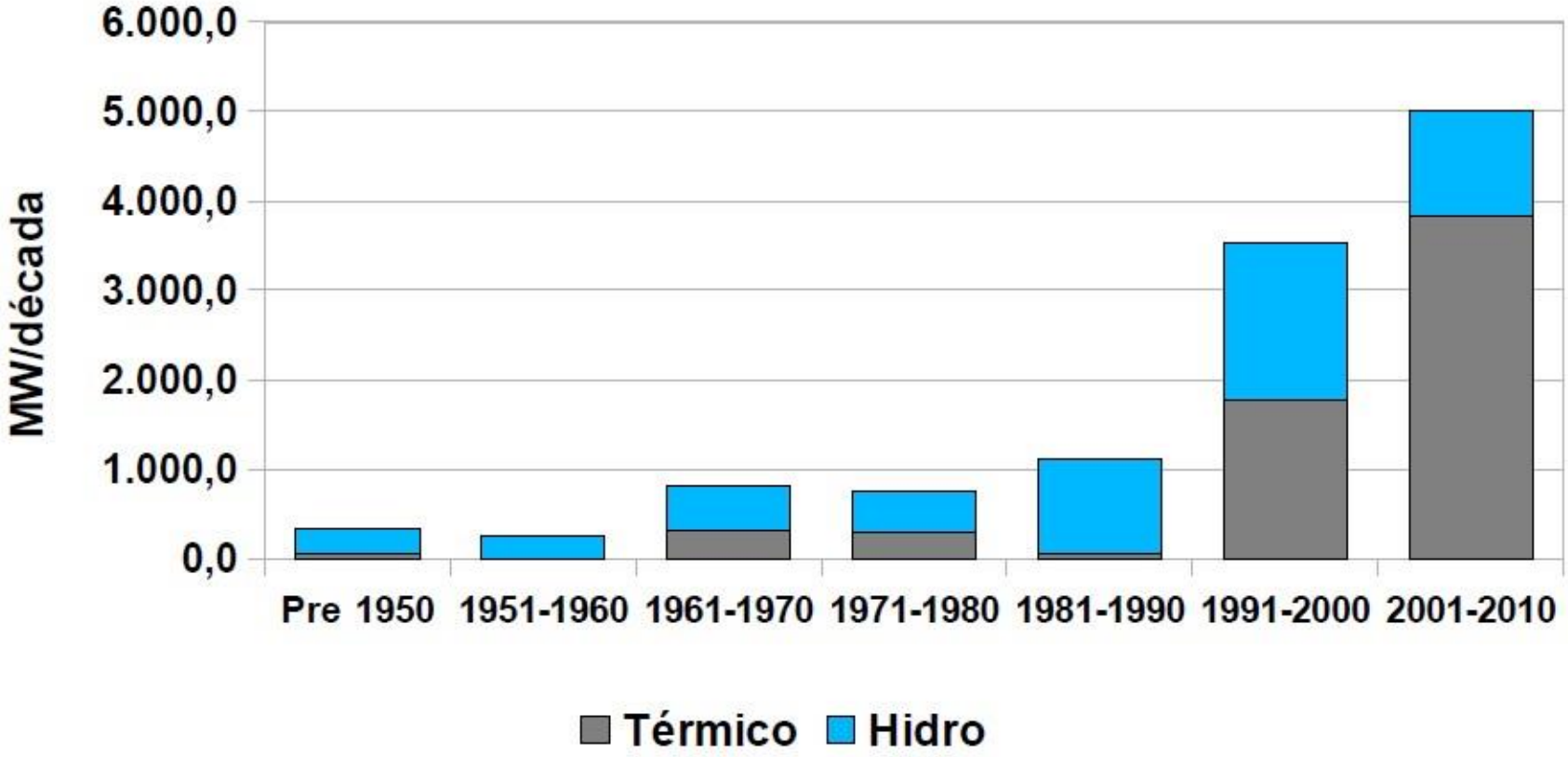
Our electrical System:

- **Short term projects:** projects tend to be with a short term time frame. This has led to a series of strategic errors and also “point to point systems” and not the development of a true energy grid.

- **The effect of Mining:** From 1990 onwards there has been a huge increase in the mining sector. Mining accounts for around 30-40% of Chilean electrical energy demand (over 85% in the SING system) and will account for around 60% of *new* electrical energy demand. The present system has supplied them with the “cheapest” posible projects. But they are cheap in investment, not in operational or environmental costs. So this generation has produced great instabilities and environmental impact.

- **The poker table:** A new power plant comes online not because of a systemic necessity, but because an investor gets an Environmental Approval for a Project, then wraps up energy sale contracts and *then* obtains financing. This has led to a loss of systemic visión.

Development of the SIC System:



New power plants added by decades.

Are there enough renewables in Chile:

Región o zona	Potencial disponible								Cartera de proyectos eólicos		Total
	CSP		PV con seguimiento (1 eje)		Hidroeléctrico		Eólico				
	(MW)	f.p.	(MW)	f.p.	(MW)	f.p.	(MW)	f.p.	(MW)	f.p.	(MW)
De Arica y Parinacota	6.311	0,51	36.647	0,32							42.958
De Tarapacá	136.085	0,51	168.098	0,32							304.182
De Antofagasta (sin Taltal)	390.476	0,53	883.651	0,33			2.622	0,32	240	0,37	1.276.988
Taltal (interior)							11.479	0,36	99	0,41	11.578
De Atacama	15.607	0,51	171.707	0,34			86	0,34	533	0,34	187.933
De Coquimbo			3.240	0,31			389	0,36	777	0,35	4.406
De Valparaíso			64	0,30	104	0,75					168
Metropolitana de Santiago					840	0,65					840
Del L. B. O'Higgins					722	0,61	75	0,34			798
Del Maule					2.127	0,55					2.127
Del Biobío					3.152	0,62	4.581	0,33	419	0,32	8.152
De La Araucanía					1.828	0,66	1.933	0,33	407	0,38	4.169
De Los Ríos					2.610	0,67	2.863	0,35	51	0,39	5.524
De Los Lagos (sin Chiloé)					1.025	0,64	3.770	0,36			4.795
Isla Grande de Chiloé					63	0,66	9.678	0,34	428	0,39	10.169
Total	**548.478**	**0,52**	**1.263.407**	**0,33**	**12.472**	**0,63**	**37.477**	**0,34**	**2.975**	**0,36**	**1.864.809**

Usable renewable potential is at least 100 times greater than present demand. And this doesn't count either geothermal (at least 16.000 MW) and rooftop solar.

Fuente: El Potencial de ERNC de Arica a Chiloé. GIZ-Minenergia-2014

Renewable energy characteristics:

Investment is much greater tan in a fossil fuel plant, but operational costs are nearly zero.

So we must change from a short term optic (3-4 years) to at least a 10 year visión.

Even though there are almost no special breaks for renewables, in a few years they *already* account for nearly 10% of total electrical generation.

Because of this, attaining the target of 20% of electrical generation by 2025 is almost trivial. The *true target* that we must set is producing 100% of electrical energy without CO_2 emmissions by 2050 and 100% of Chilean energy by 2100.

Central Amanecer Solar 100 MW (Sun Edison)

Provides 15% of CAP's energy needs in the north and was built in less than a year


El Tesoro


Pampa Elvira Solar


Pukara de Hatur


Esperanza (RTS)


Pozo Almonte 2/3


La Huayca


Diego de Almagro


Amanecer


San Andrés

Northern Chile's solar advantage:

- Resource 30 to 40% better than the best places in Europe.
- Resource 15 to 20% better than the best places in the World.
- Chile's solar advantage is due to:
    - The Atacama desert lies between 18°S and 25°S latitude. Less seasonal variation.
    - The intermediate plateau is between 2000 to 4000 meters above sea level. Less air mass and less solar absortion, diffusion and dispersion.
    - Very dry climate with over 90% of totally clear days. Average clearness indexes K_T of over 0,70.

Large scale solar in Chile Today:

- **PV projects:** Today there is over 3500 MW of projects with their environmental studies approved. About 250 MW are in operation and 300 MW is being built. In the SING system, not more than 400 to 600 MW of PV is feasible without adaptations of the grid..
- **CSP Power projects:** One project, by ABENGOA was recently approved in a contest sponsored by the Government. It will be a 110 MW power tower with 17 hours of molten salt storage. Plus an additional 100 MW of PV is considered. In addition there are two other projects with the environmental studies approved. One is a 4x90 MW parabolic trough system (with molten salt storage) and the second one a 4x100 MW power tower system (with storage). These last two projects were presented by Ibereólica Solar Atacama.
- **CSP Thermal projects:** There are three in operation. These provide process heat for electrowinning plants. One 2 MW in Minera El Tesoro (parabolic trough by ABENGOA); one in Constanza mine (350 kW of flat plate collectors, 80% solar heat fraction) and one in Minera Gabriela Mistral (39.000 m² flata plate collectors, 80% solar heat fraction). Several other projects are in the pipeline either at the call for tenders phase or initial studies.

Large scale solar today

Minera Constanza (Antofagasta)

Minera el Tesoro

Minera Gabriela Mistral

Solar energy and mining:
Natural partners in Chile

Mining demands

- **Water:** in the North, the mining companies control a very large portion of the water rights in that region..
- **Electrical Energy:** In the SING, mining accounts for 80 to 90% of electrical demand. In the SIC system, mining accounts for around 30% of demand. But the National Energy Commission projects that 60% of **new** electrical demand will come from the mining sector. Electricity is used for ore crushing and milling, material transport, pumps and electrowinning.
- **Thermal energy:** Low grade thermal energy is used in some processes. The main one is electrowinning. Typical electrowinning plants demand between 5 to 20 MWth on a constant basis.

Solar energy and mining:
Natural partners in Chile

Our mines need to:

- **Reduce carbon footprint:** ethis is essential. Markets will demand this in not more than 5 to 10 years.

- **Predictible costs:** Renewable energy has the huge advantage of being able to control cost increases in the future.

- **Diversify processes and providers:** Today the options for power production lie with very few Companies. And this affects prices. There are also new ways to provide energy for processes such as water desalinatiion, process heat in metallic and non-metallic mining and other processes.

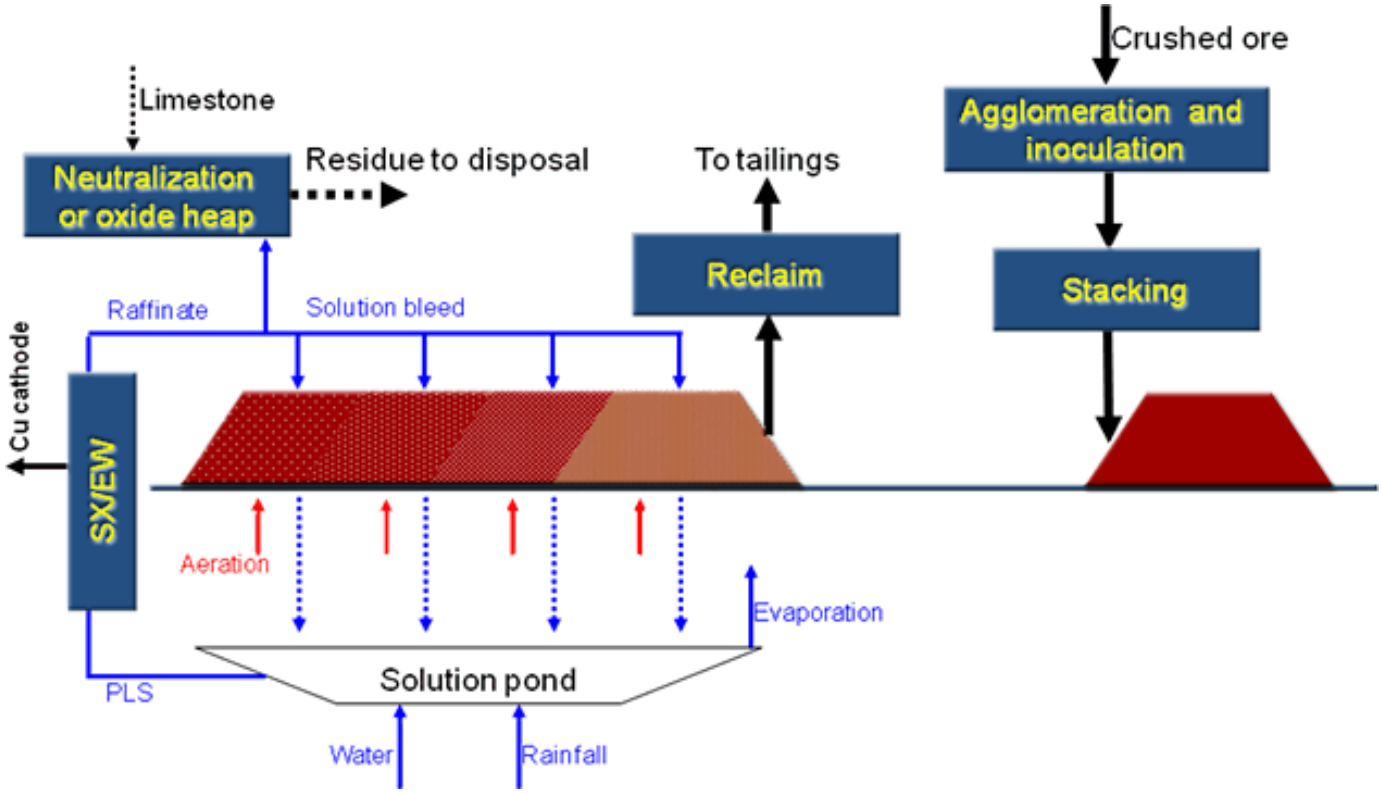
Solar energy and mining:
Natural partners in Chile

If one wants to produce electricity by CSP plants, the natural place to do it is at altitudes over 2000 meters. Thus taking advantage of the very high DNI. But water is very scarce in this zone, so the options are:

- **Use air cooled condensing towers:** This penalizes power output between 7 to 10% because of the power demanded by the cooling fans..
- **Or use "Solar Cogeneration":** the waste heat from the Thermodynamic cycle is used in the mining process.

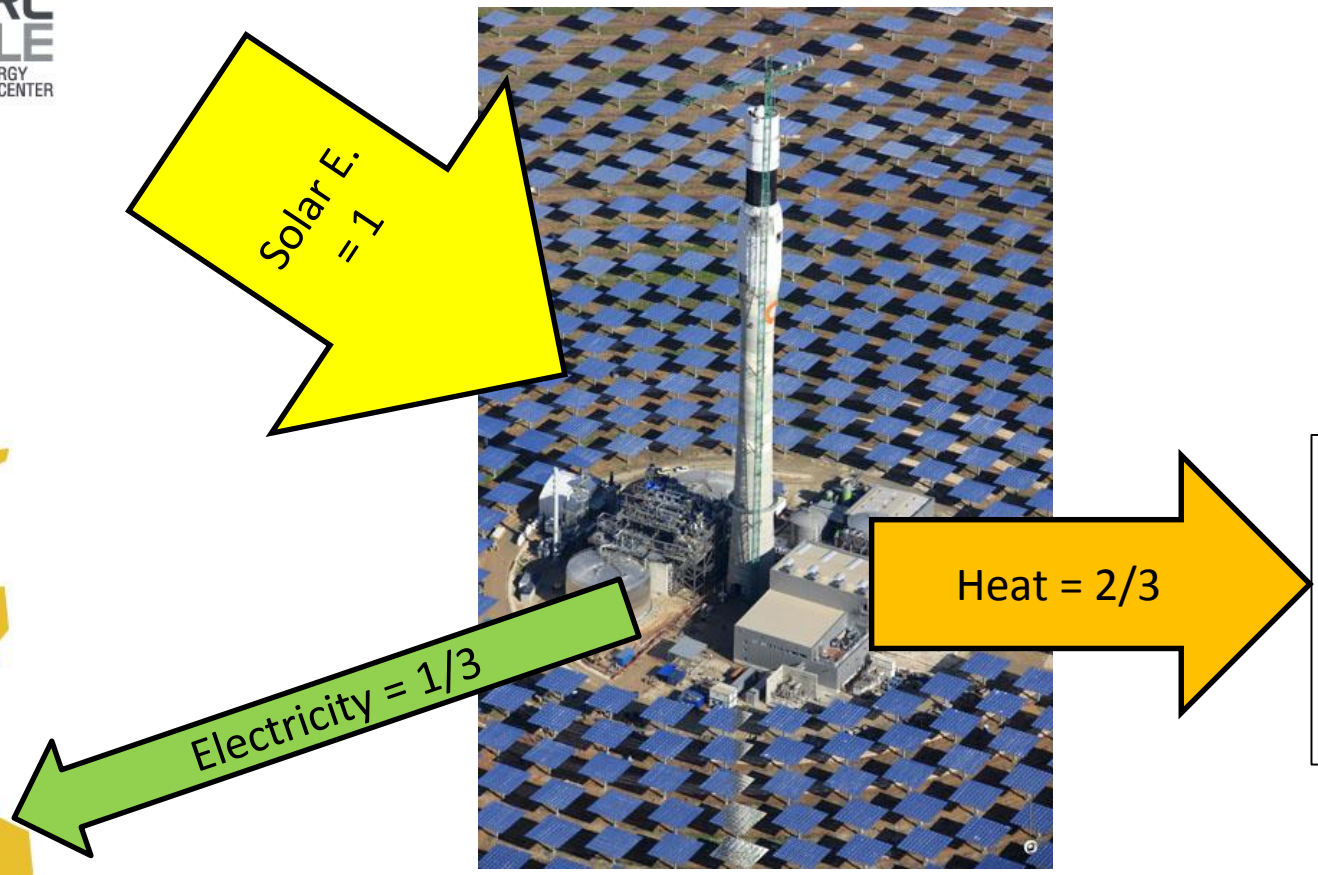
- **Large scale heat demand in mining processes:** these are in leaching piles (order of magnitude of thousands of cubic meters of solution per hour). In evaporation of water (nitrate and lithium carbonate production). Other large scale processes. Leaching piles heat demand is such that typically they are not heated.

Copper leaching process



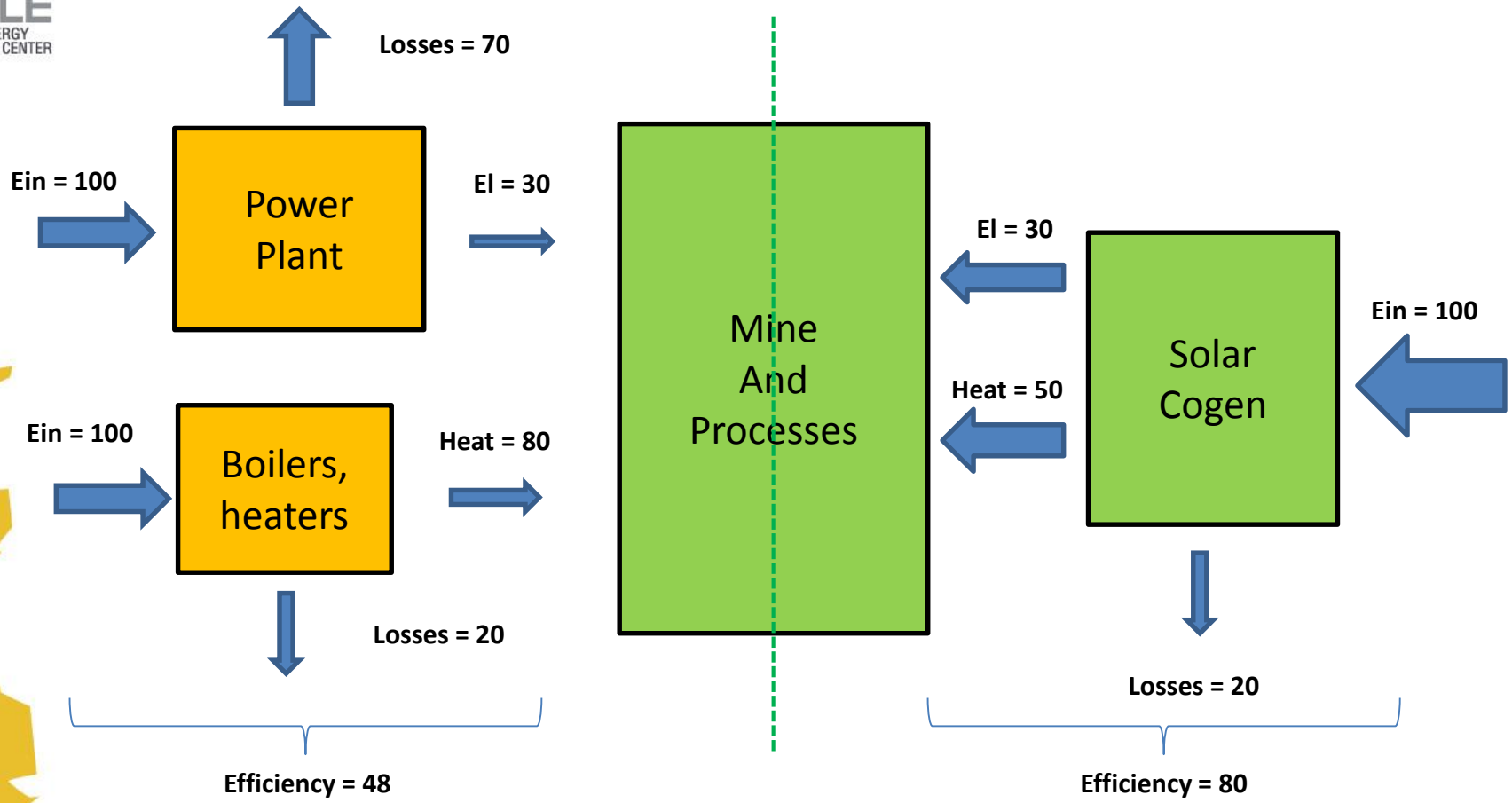
A very simplified schematic…

Solar Cogeneration: the concept



Rejected heat can be used in mining processes. In particular, in the leaching piles.

Comparison of a conventional approach vs Solar Cogeneration:



There is a significant improvement in overall process efficiency

And literature shows that the leaching process improves very much

Solar cogeneration: **Main obstacles**

- **Effects on leaching:** even though very positive effects have been shown in the Laboratory and in small scale (better copper extraction, faster leaching) it's essential to conduct large scale tests to show, under actual working conditions how the process is improved. In other words, pass "The Valley of Death"….
- **Effects of the environment:** since one changes the leaching process, effects have to be measured. In particular how to control evaporation in the leaching piles and how the environment close to the mine affects the solar plant.
- **The introduction of new technologies:** to convince the mining sector to use new processes is not easy. Our first approach to use solar in electrowinning was with Minera El Abra in the year 2000. And the first applications only saw the light at the end of 2012. The mining sector moves very carefully because of the magnitude of the investments. So a special strategy has to be used to show that it's feasible, practical and can produce significant benefits.

Solar in mining: **Main barriers**

- **Water:** scarce to non-existant. So CSP plants have to overcome this very important barrier. Practically all the water rights belong to the mining companies.
- **Environment:** Strong and changing winds. Ocassional sandstorms in many places. Very fine dust that tends to cling to objects. Saline environment in many places. In the case of projects near mines, the occasional presence of acid droplets..
- **"Business as Usual":** The large generating companies don't want their present business changed (they're **very** happy as it is), so they'll try to block changes. In the case of the mines, technological changes that affect their core processes are not easy to implement.

Conclusions:

- **The transition will come anyhow:** it's absolutely essential to develop an energy system with a very high penetration of Renewables in Chile and worldwide. The world demands it. And we have exceptional resources.
- **Solar energy and Mining:** In Chile they are natural partners, that complement each other. Mining could develop in a more sustainable way and solar has a huge opportunity for technological improvements.
- **A very large playing field:** existing opportunities provide many options that can be very attractive, with much space for many actors and technologies.

Thank You!

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