Net energy availability and environmental performance of the Chilean electricity grids: potential for improvements

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Structure of the presentation

1. Electricity supply in Chile: the SIC and SING grid mixes
2. NEA and LCA: different (and complementary) approaches
3. Results of the analysis
4. Potential for improvements
5. Future work

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Chile

- Chile is one of the fastest-growing countries in Latin America
- Its population is projected to reach over 20 million by 2035
- Its fossil-fuelled electricity demand is expected to reach 100 TWh/yr by 2020(*)

(*) Ministerio de Energìa, 2015

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Chile

- Chile is one of the fastest-growing countries in Latin America

Chile – the energy transition

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Chile is experiencing a radical energy transition with ambitious targets:

- to generate 60% of its electricity from locally-available renewable energies by 2035
- to achieve a 45% renewable share for new electric installed capacity (2014-2018 Energy Programme)

The Atacama desert (northern Chile)

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The Atacama desert (northern Chile)

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…with the exception of a “flowering desert” phenomenon usually occurring every five to seven years…

Chile - electric grids

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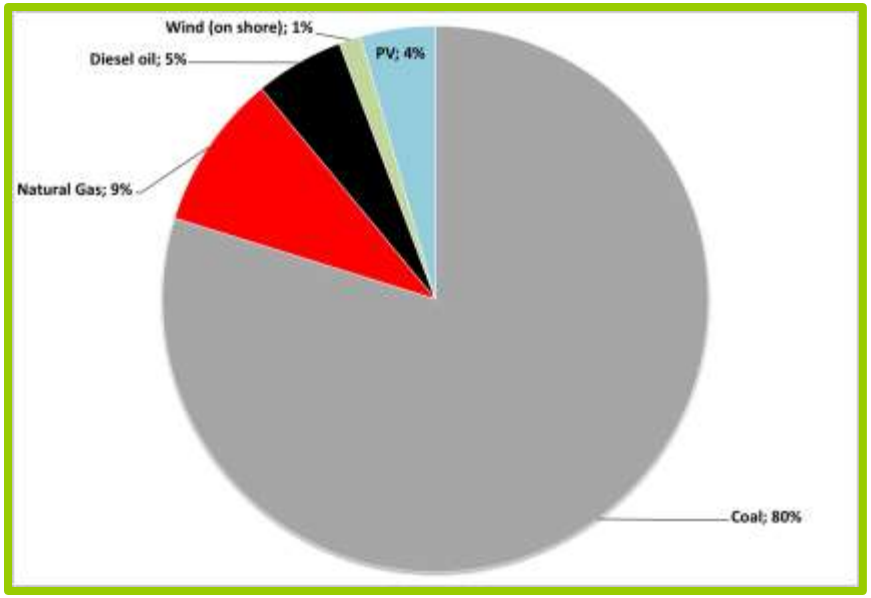

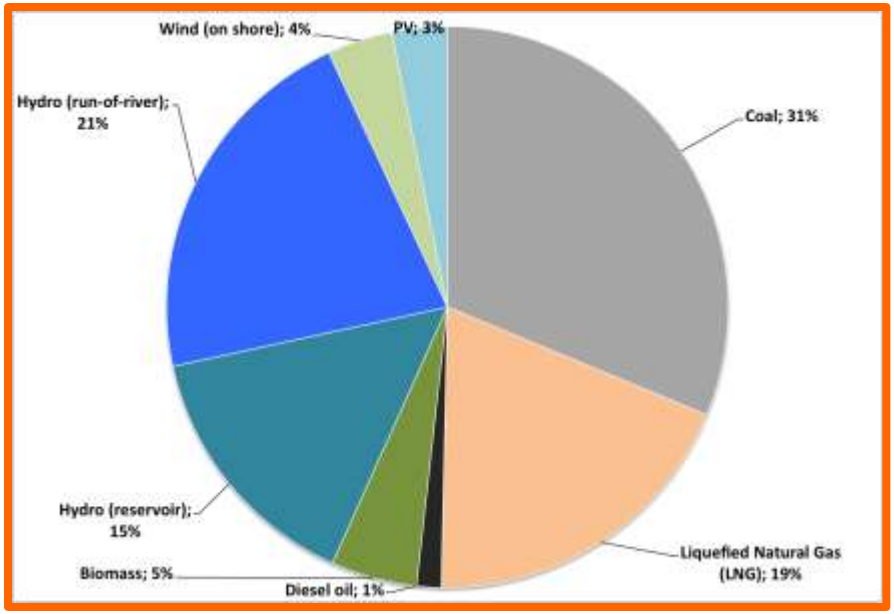

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Net Energy Analysis (NEA): Energy Return On Investment

- seeks to understand how effectively

  energy investments are used to

  exploit **primary energy sources** and upgrade them into

  usable energy carriers (*"bang for the buck"*)

- NEA is not equipped to say anything about the long-term sustainability of an energy technology, since:

  1. the actual amounts of **primary energy stocks and flows** that are directly extracted and upgraded into the **'returned' energy carriers** are not included in the calculations;
  2. it (typically) does not differentiate between *renewable* and *non-renewable* energy.

Life Cycle Assessment (LCA)
(non-ren.) Cumulative Energy Demand

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- seeks to understand how much

  total (non-renewable) primary energy
  (*i.e.* **primary stocks and flows** *PLUS* all **energy investments**)
  must be withdrawn from the environment to produce
  usable energy carriers

- LCA is not equipped to say anything about the immediate viability of an energy technology, since:
  - it does not differentiate between the energy that is **directly extracted and upgraded** and the energy that is **invested** in order to do so.

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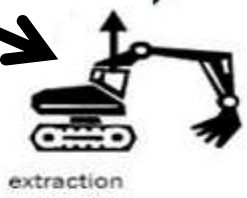
Conventional thermal energy supply chains

Primary Energy Resource



Energy Investment

Energy carrier

(e.g.:
- crude oil at well head;
- harvested wood)

Energy Investment

Energy carrier

(e.g.:
- crude oil at refinery;
- wood at processing plant)

Energy Investment

Energy carrier

(e.g.:
- HFO;
- wood pellets)

Energy Investment

Energy Investment

Energy carrier (electricity)

$$EROI = \frac{\text{Energy carrier}}{\sum(\text{Investments})}$$

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Conventional thermal energy supply chains

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- HFO;
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Energy carrier (electricity)

Energy Investment

$$CED = \frac{\text{Primary Energy} + \sum(\text{Investments})}{\text{Energy carrier}}$$

Non-thermal (renewable) energy supply chains

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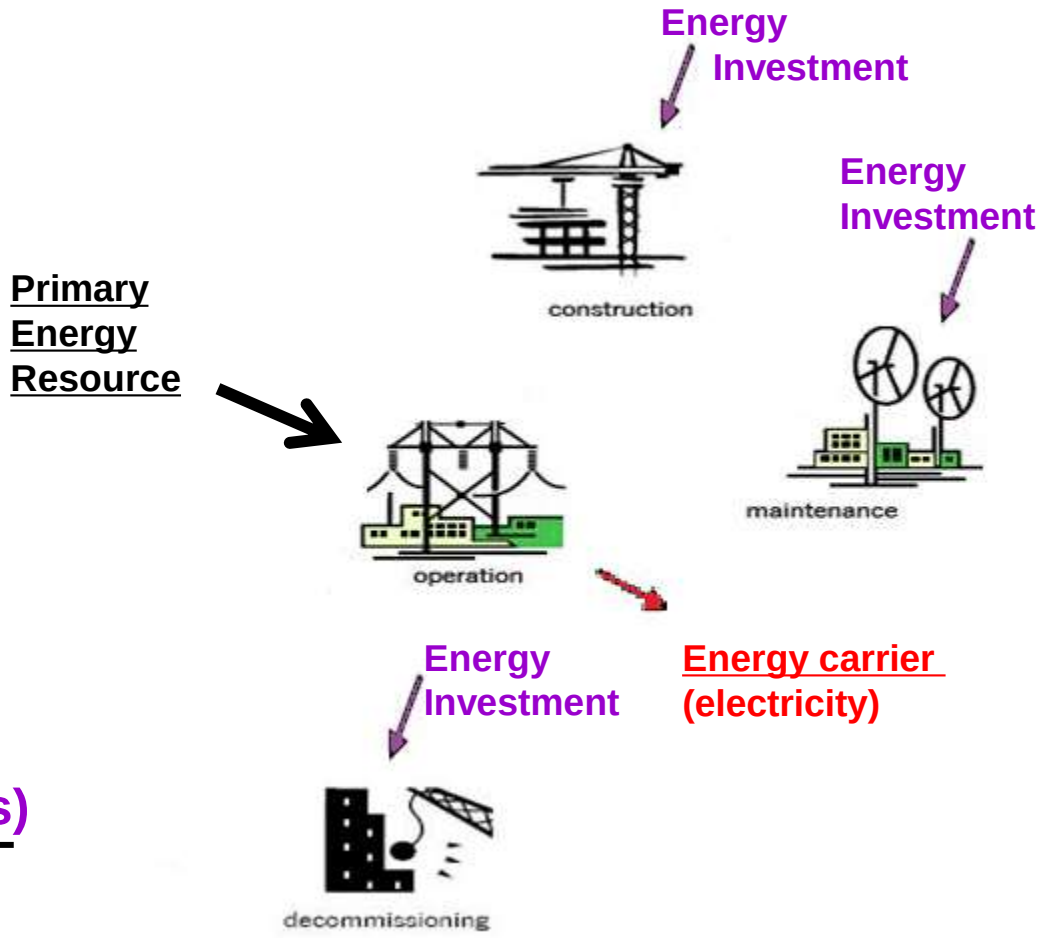

$$EROI = \frac{\text{Energy carrier}}{\sum(\text{Investments})}$$

$$CED = \frac{\text{Primary Energy} + \sum(\text{Investments})}{\text{Energy carrier}}$$

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NEA *vs.* LCA

Indicator (ratio)	EROI	CED (and nr-CED)
Numerator	Energy delivered to society **Return** – *or* – **(Return/η_{grid})** [MJ_{EC}] – *or* – [$MJ_{PE\text{-}eq}$]	Total energy withdrawn from nature **Primary En. + ∑(Investments)** [MJ_{PE}]
Denominator	Sum of already available energy carriers diverted from other societal uses **∑(Investments)** [MJ_{PE}]	Energy delivered to society **Return** [MJ_{EC}]
Distinction between renewable and non-renewable	No, not needed	Yes, recommended
Safeguard subject	Economical / effective use of available energy carriers	Sustainable / efficient use of energy resources
Time perspective	Short term	Long term

Results (NEA: $EROI_{el}$)

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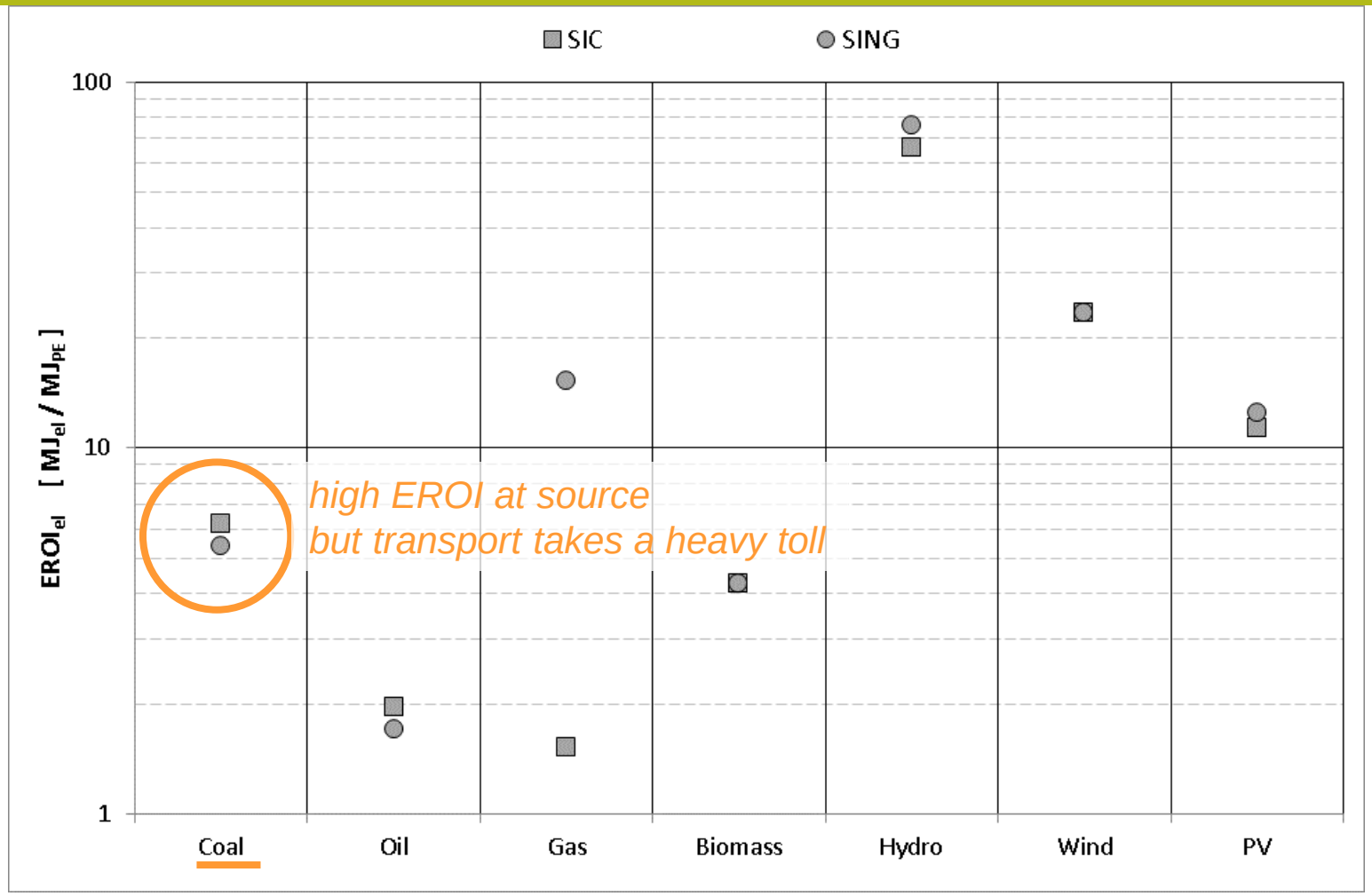

Results (NEA: $EROI_{el}$)

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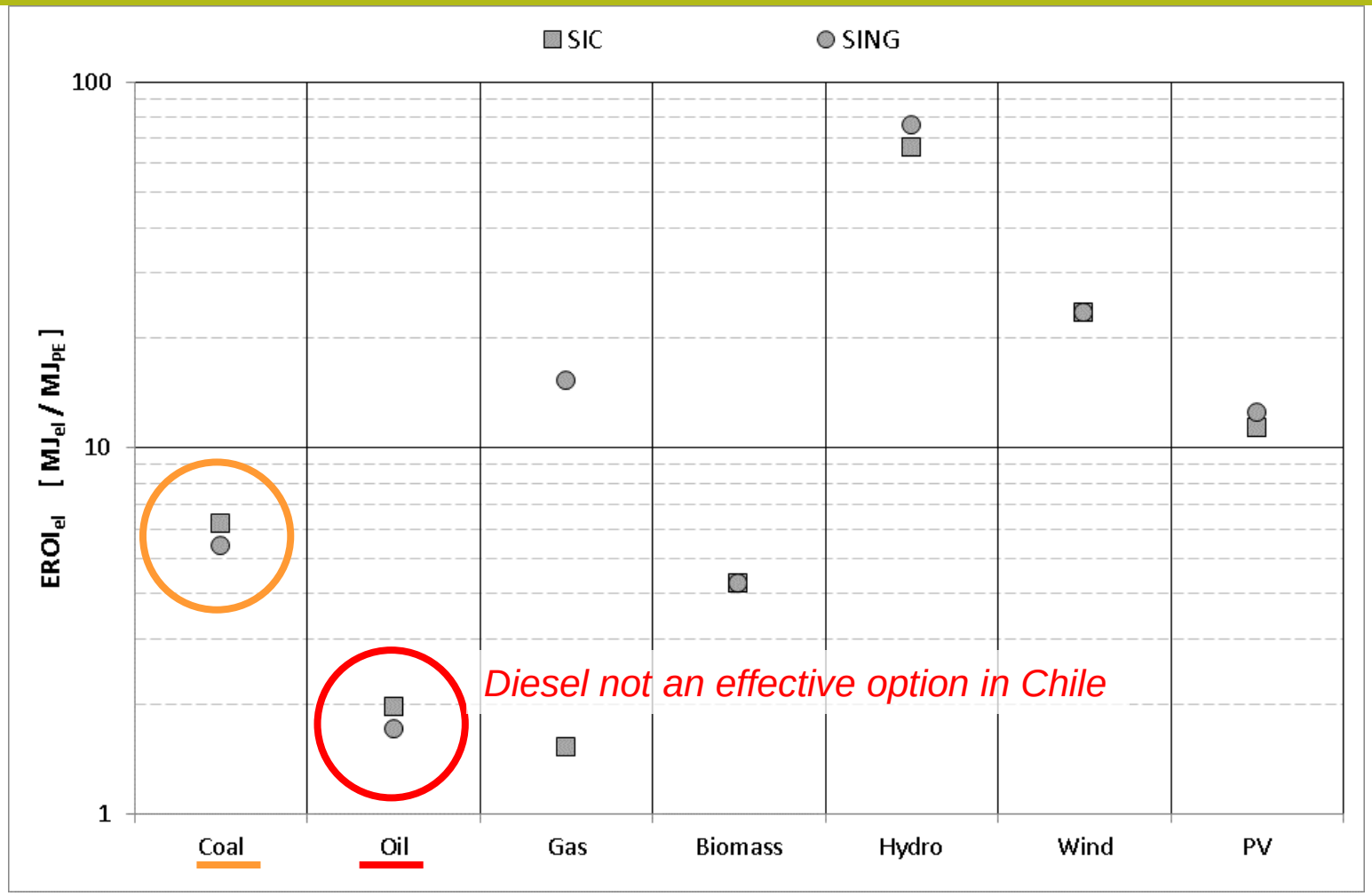

Results (NEA: $EROI_{el}$)

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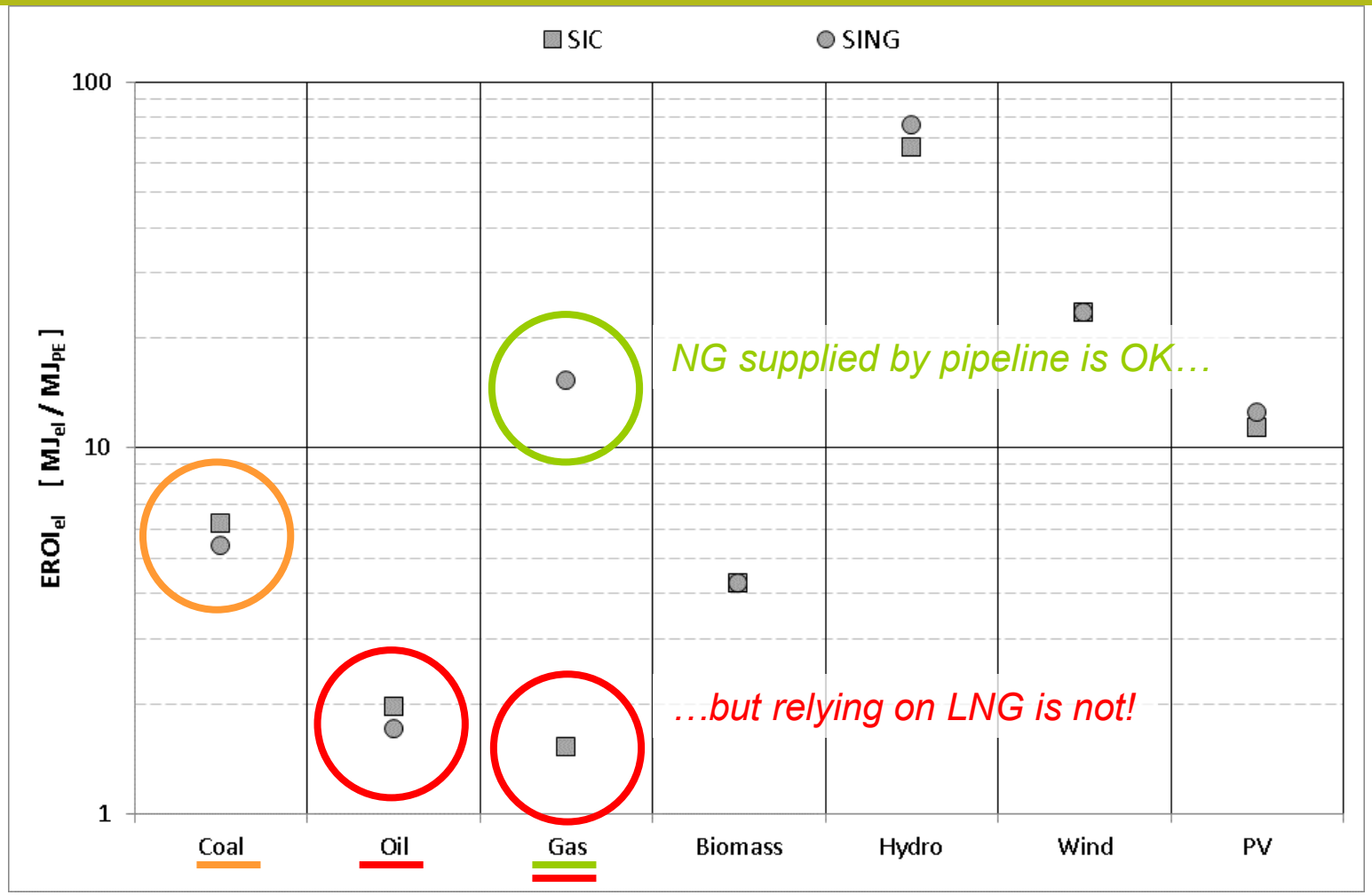
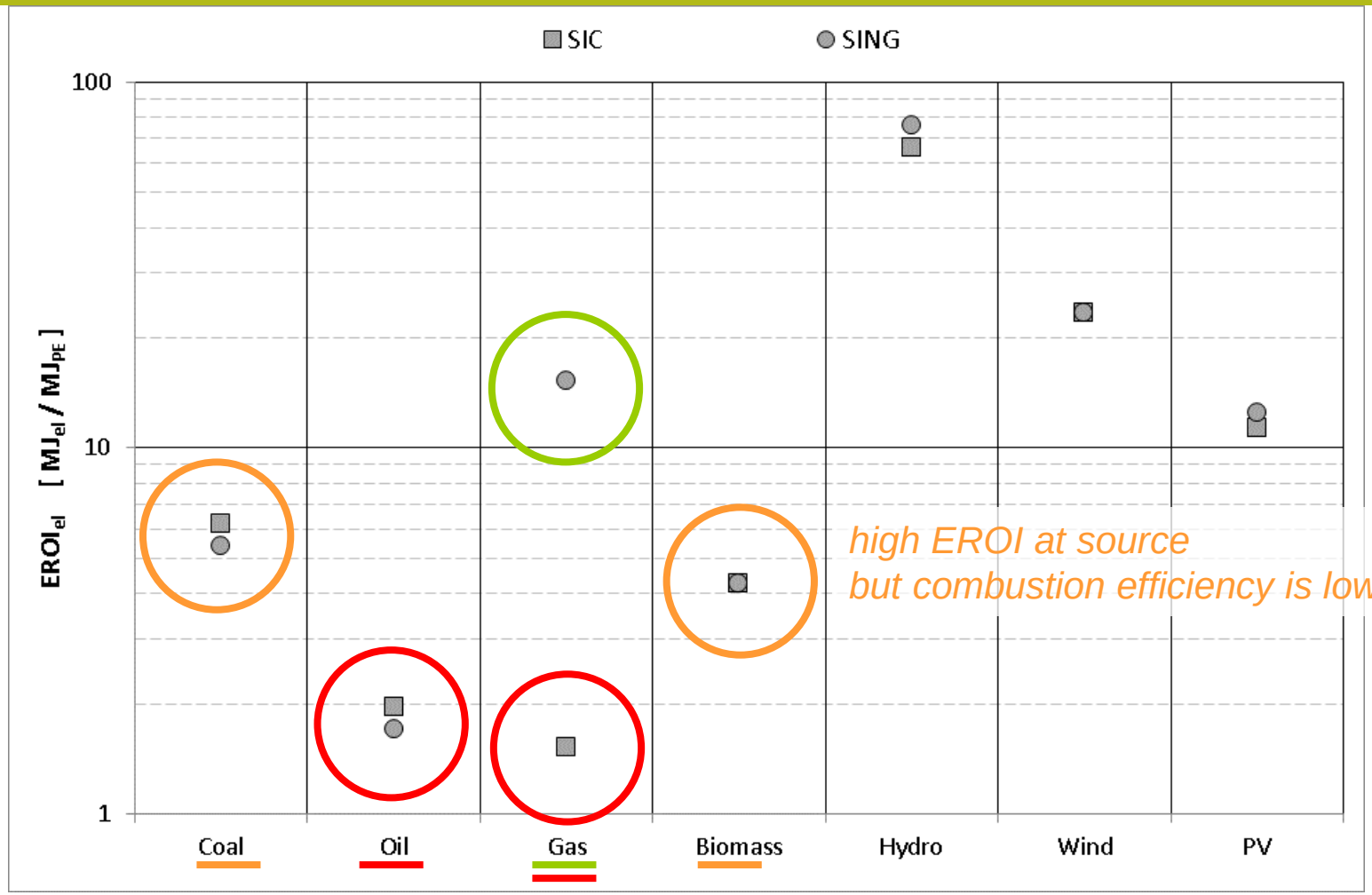


Results (NEA: $EROI_{el}$)



Results (NEA: $EROI_{el}$)

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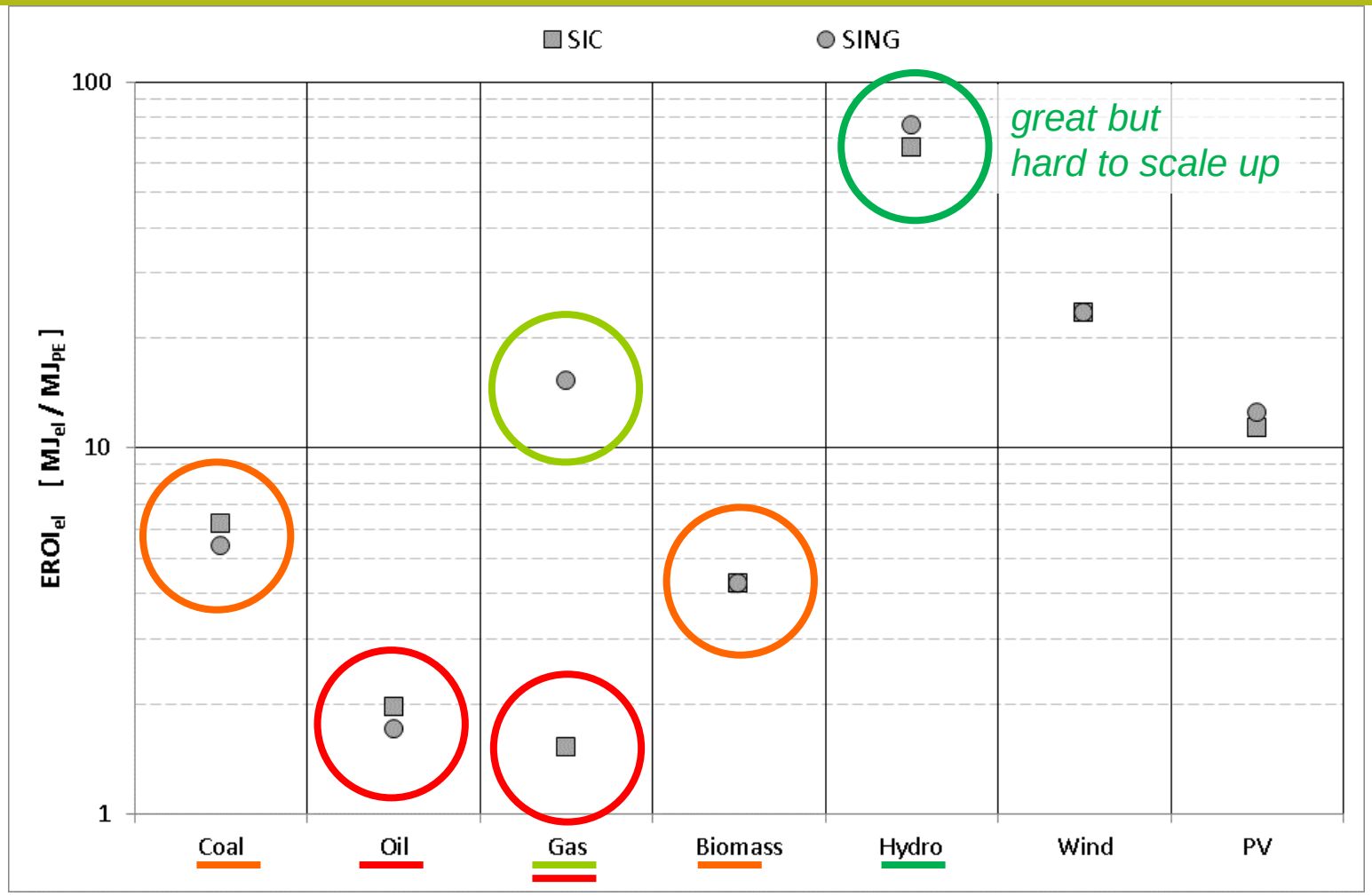

Results (NEA: $EROI_{el}$)

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Results (LCA: nr-CED)

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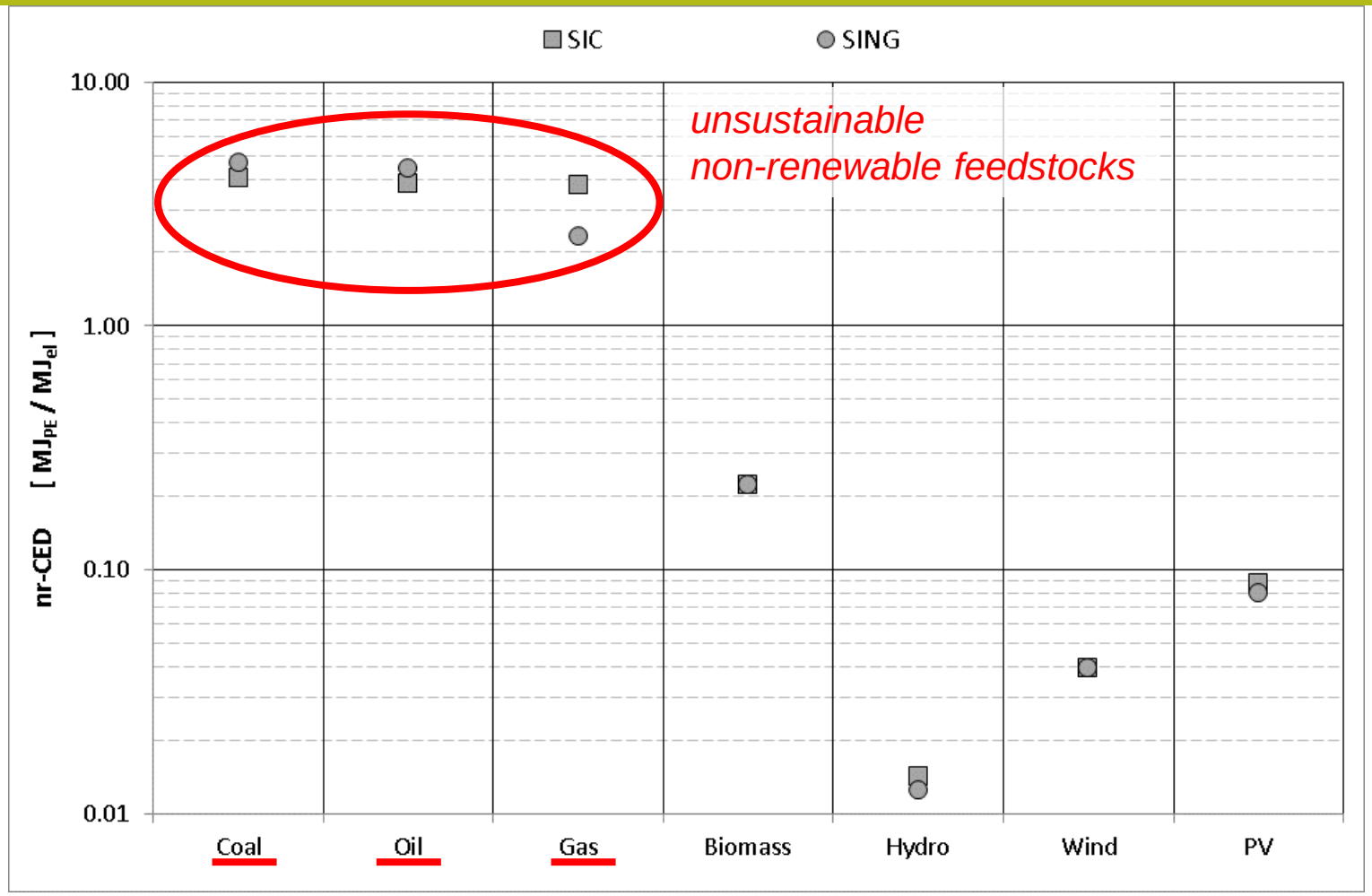

Results (LCA: nr-CED)

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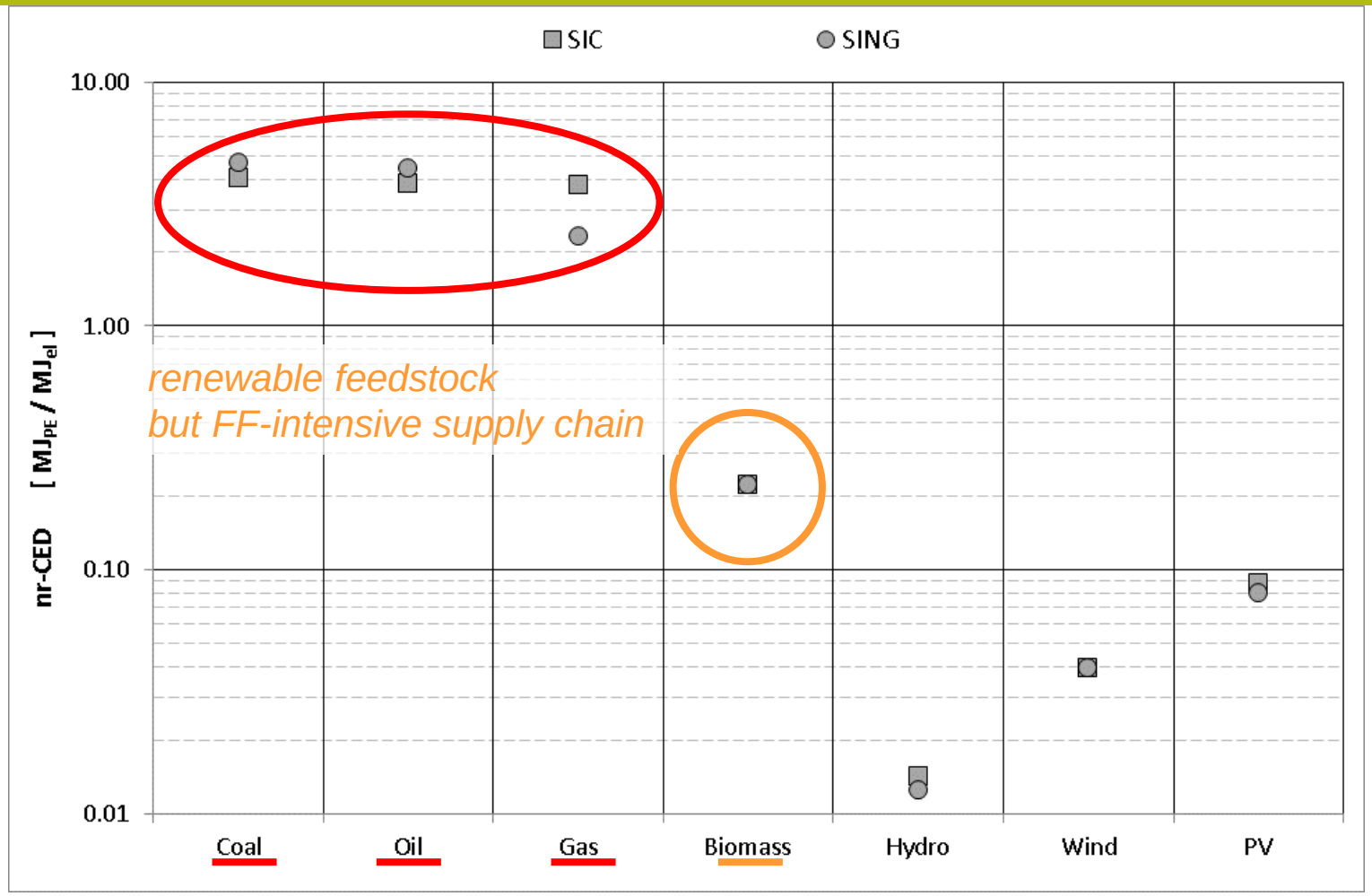

Results (LCA: nr-CED)

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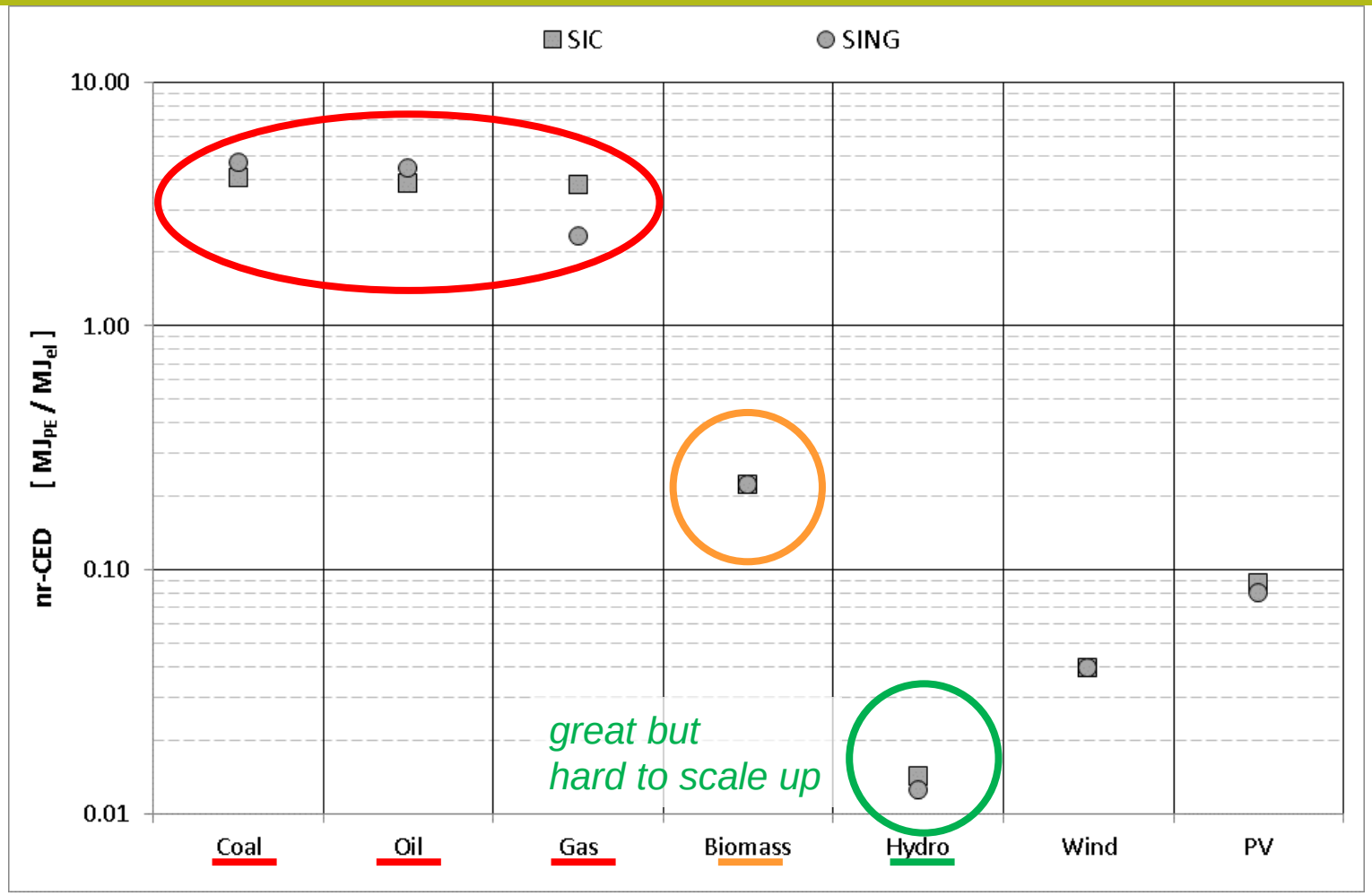

Results (LCA: nr-CED)

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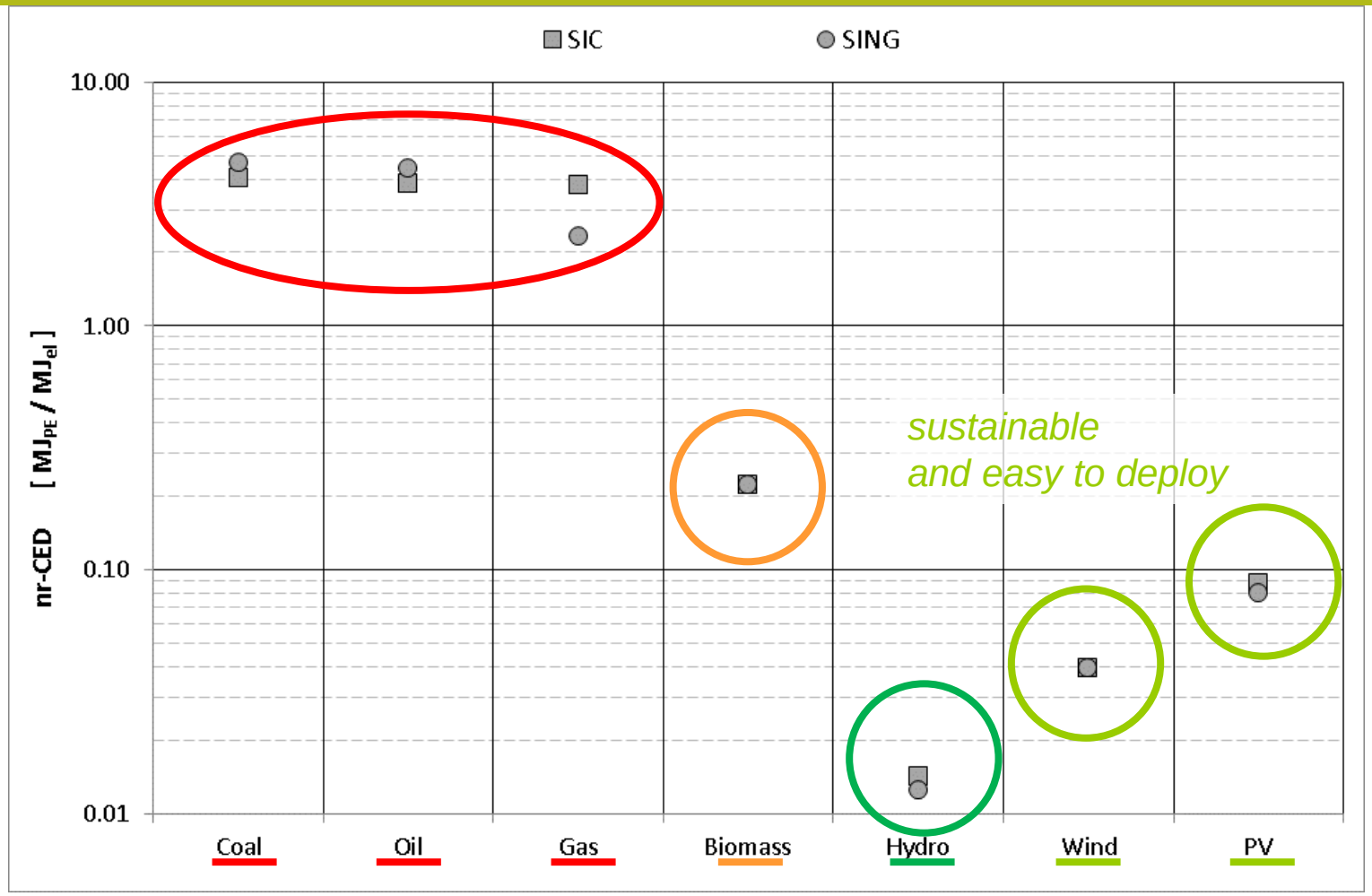

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Potential for improvements

- PV and wind are the most promising technologies overall to improve the energy performance of electricity supply in Chile
- PV is the technology that has the greatest potential for further expansion
- *However*, PV and wind are intermittent, and their large-scale deployment will require storage (pumped hydro) and/or will incur in curtailment
- Gas is important to provide readily despatchable capacity but must be supplied via pipeline (LNG production is inefficient)

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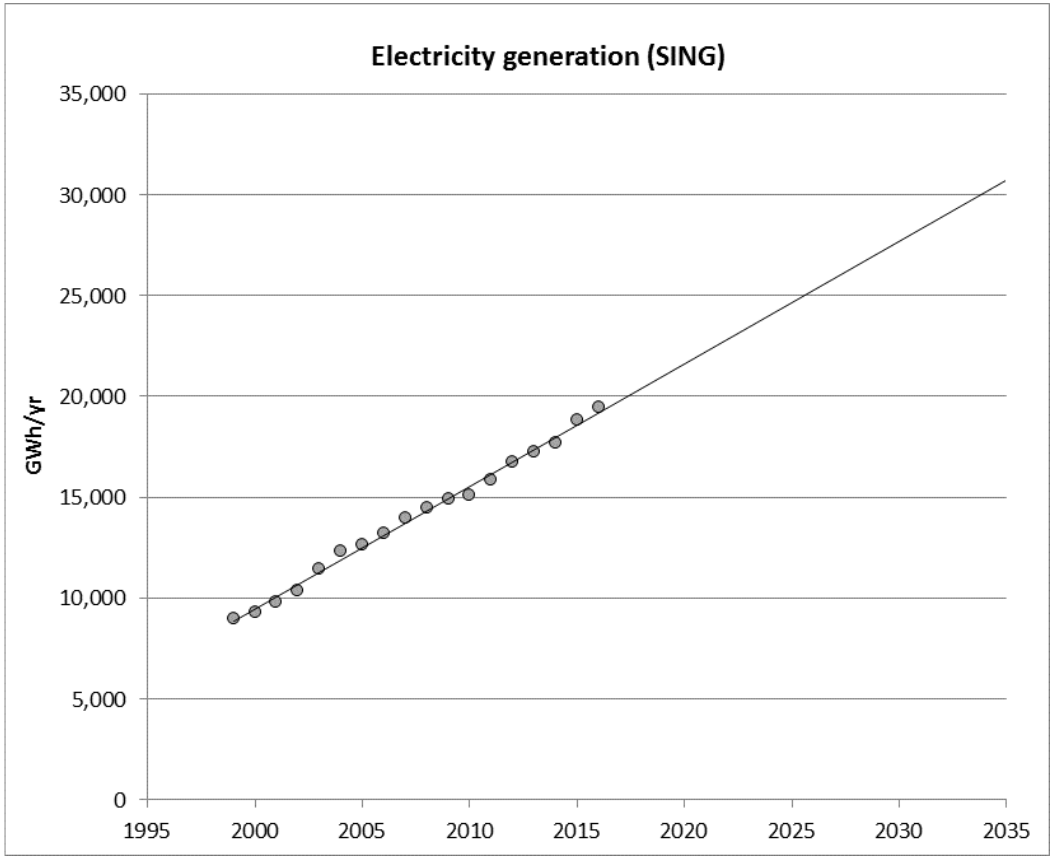
Future work

- Electricity demand in Chile is rising steadily



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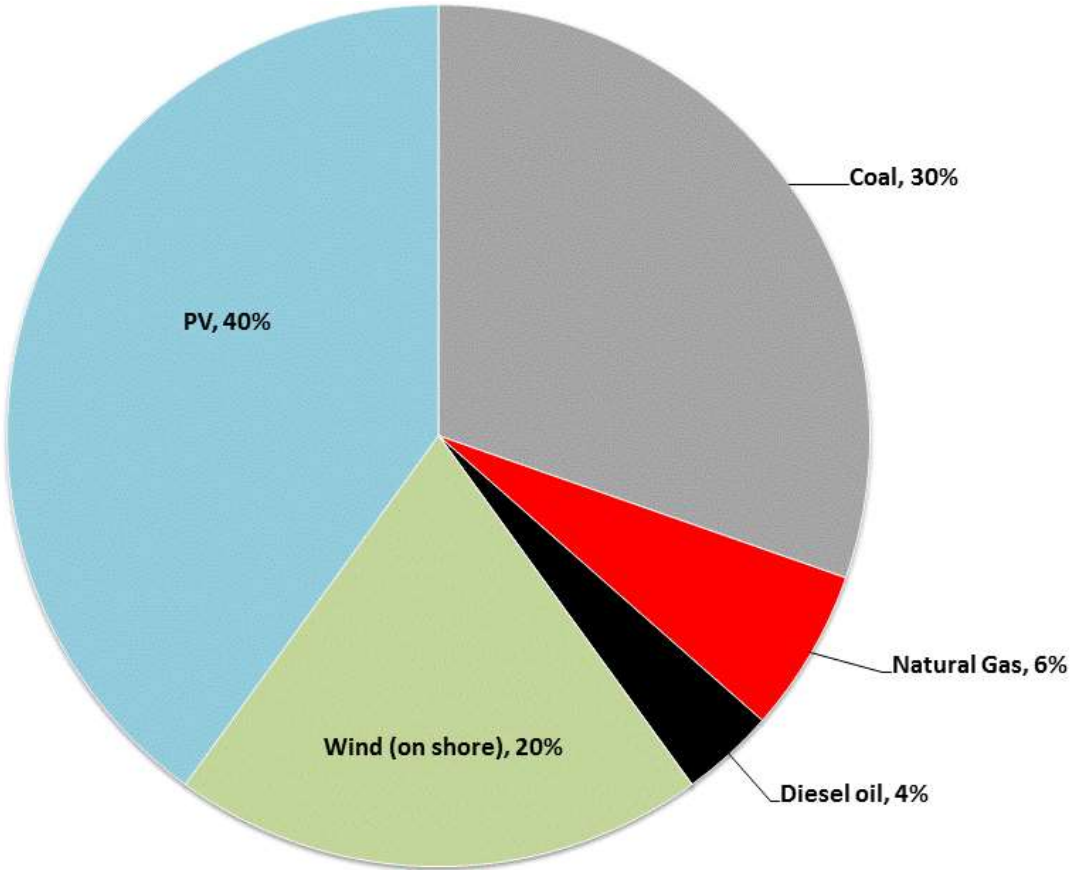
Future work

- Electricity demand in Chile is rising steadily
- An analysis of a future scenario for the SING grid mix is under way, considering a joint large-scale deployment of PV and wind, and enhanced transmission and energy storage.



Thank you

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