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Sustainability Metrics v Geothermal Energy

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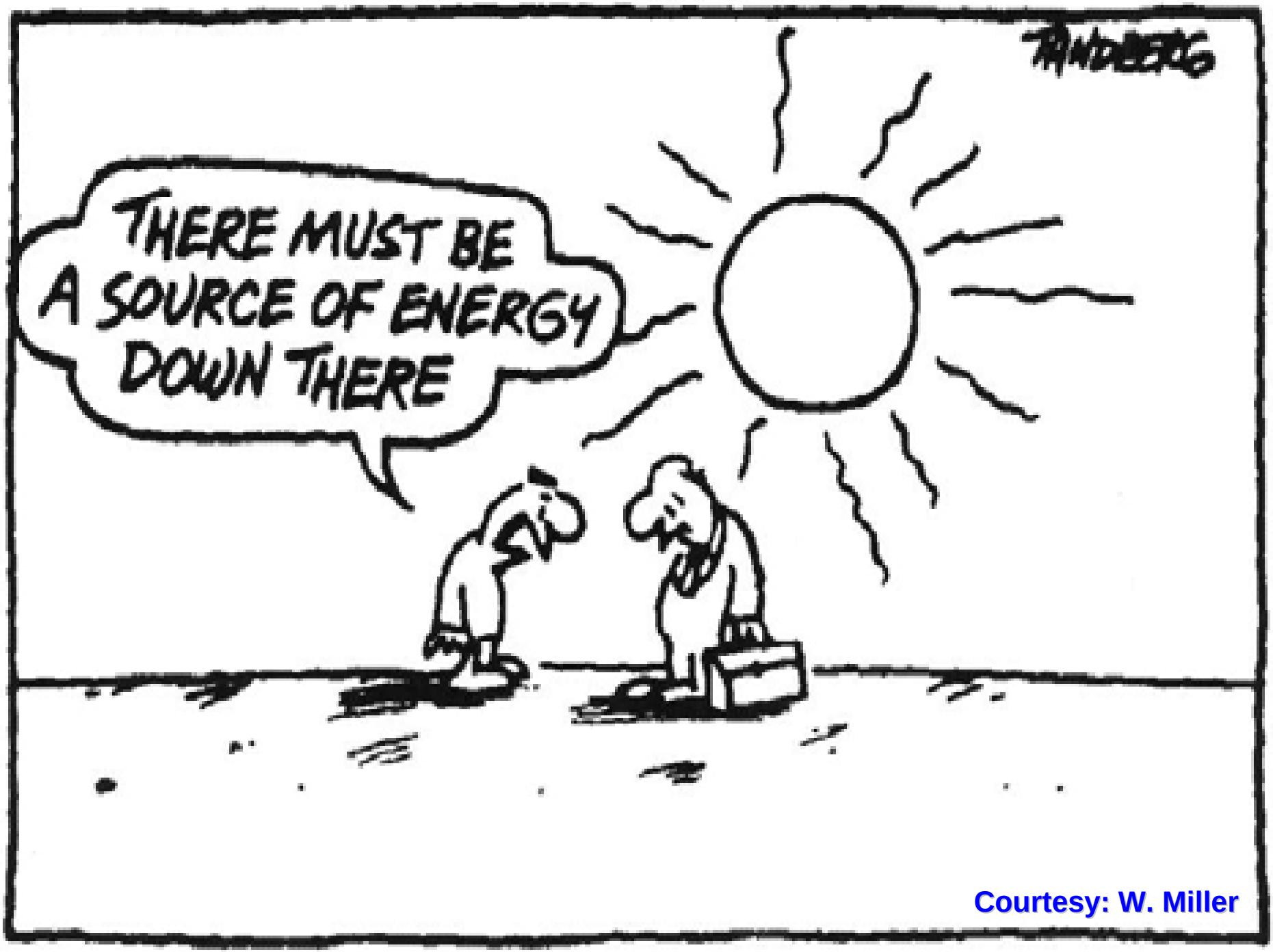


Courtesy: W. Miller

‘Sustainable’ Energy v Geothermal?

- The energy dilemma is perhaps the biggest challenge facing the planet this century
- Many forms of energy are touted as good ‘sustainable’ options …
- Geothermal energy is commonly claimed as having ‘zero’ greenhouse emissions and therefore a great sustainable energy

  – *but what’s the actual evidence?*

  (ie. versus mere hope & claims)

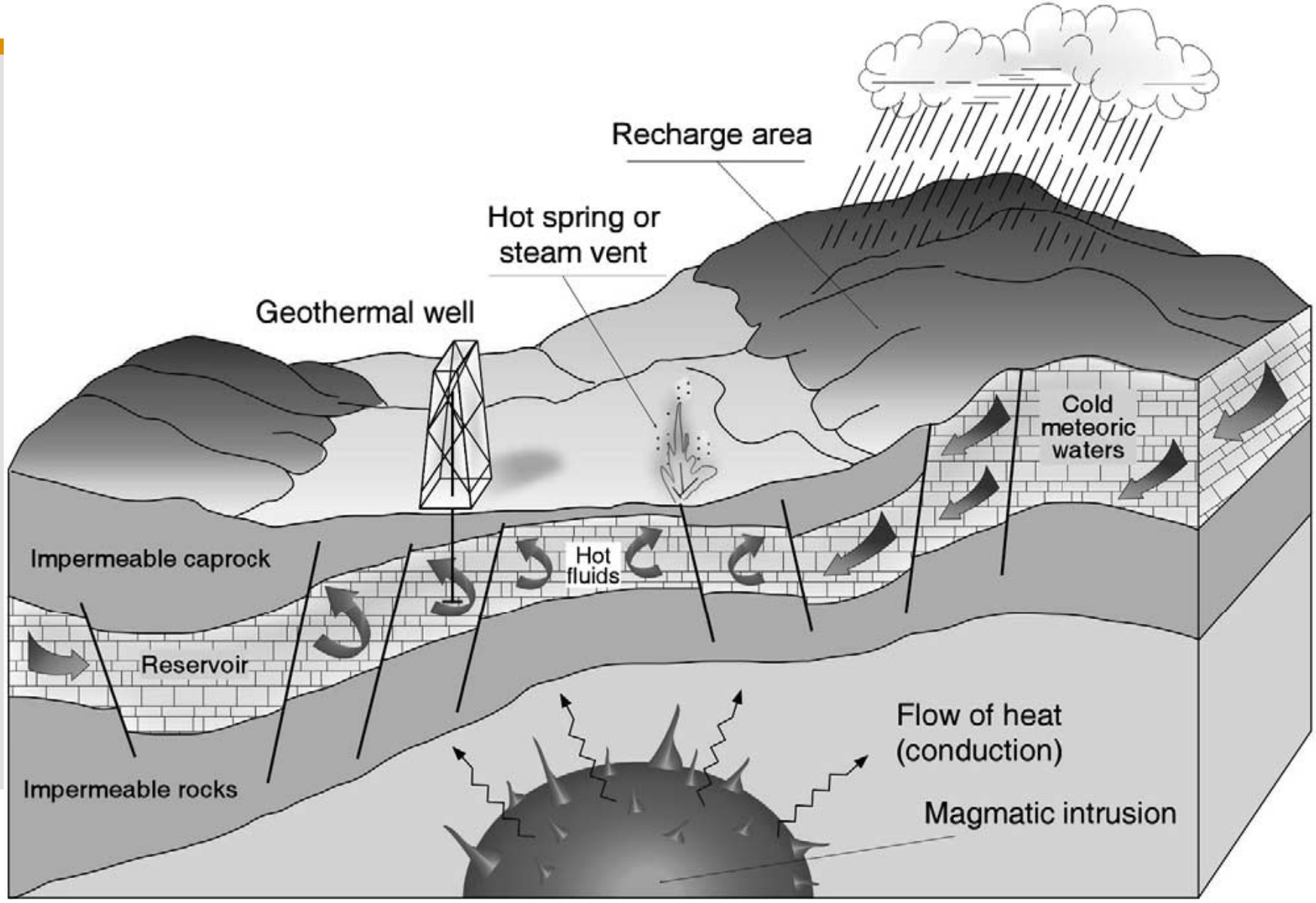
Geothermal Energy '101'

- At its simplest, geothermal energy taps into and extracts heat energy from the earth's crust, which is then used to create steam and drive electric turbines
- By 2007, there was about 9.73 GWe of geothermal capacity operating at 8.59 GWe to generate 75,251 GWh *(& growing fast)*
- Often claimed as 'zero' emissions & low environmental impact

Geothermal Energy Resources

- Five principal types of geothermal energy:
  - Vapour-dominated
  - Hot water
  - Geopressured
  - Hot dry rocks (aka ‘hot granites’)
  - Magma-derived
- At present, vapour-dominated are the most exploited type, followed by hot water
- Geopressured, hot dry rocks and magma are not being exploited commercially ***(YET)***

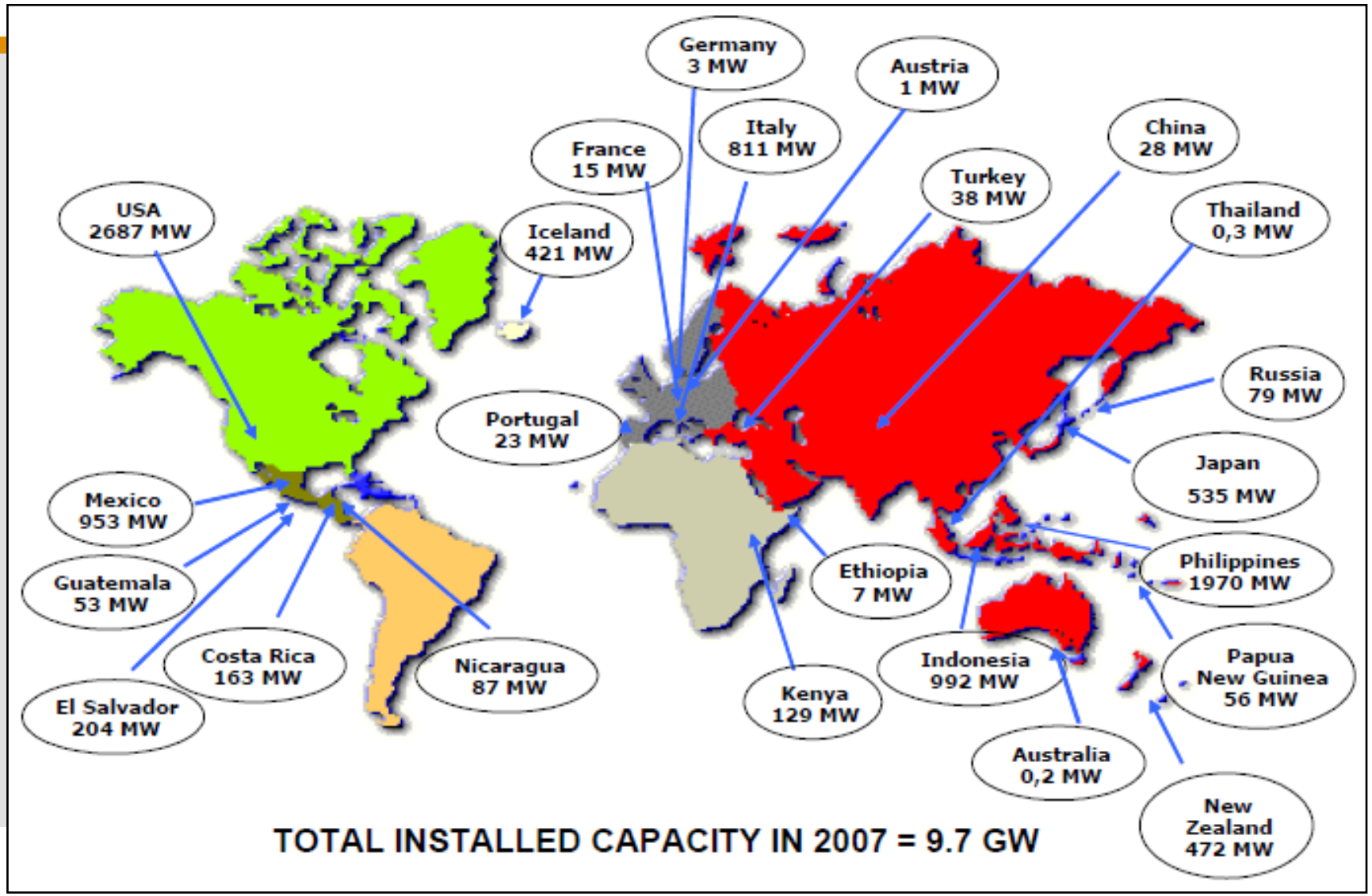
Geothermal Energy Schematic



Energy Extraction to Electricity …

- Various types of systems are used to convert heat energy to electricity:
  - Single flash (37%)
  - Dry steam (28%)
  - Double flash (26%)
  - Binary/CC/hybrid (8%)
  - Back pressure (1%)
- General move towards binary/combined cycle/hybrid systems (eg. Kalina cycle)

Global Geothermal Energy …



Environmental Impacts

- **Environmental impacts are associated with geothermal energy, including:**
  - **water consumption & quality**
  - **gaseous emissions (CO_2, CH_4, H_2S, …)**
  - **land use**
- **The extent of these impacts (and others) will vary with resource type, scale, design & operation, etc.**

How accurate is our understanding?

Sustainability Reporting

- We surveyed numerous available sustainability reports from energy companies active in geothermal
- Analysed reported data for CO_2, water, energy to synthesize up-to-date data
- Compared this to various studies, other energy sources

Simple in concept …

not so easy in reality …

Geothermal Energy …

- Numerous power companies around the world have major interests in geothermal
- Only a few produce sustainability reports, though varying widely in coverage & data:
  - Mighty River Power (NZ), Contact Energy (NZ), ENEL (Italy), Orkuveita Reykjavirkur (Finland)
- Reported data (~4-5 years) was analysed to produce metrics:

t CO_2/GWh and ML/GWh

Geothermal v Greenhouse, Water …

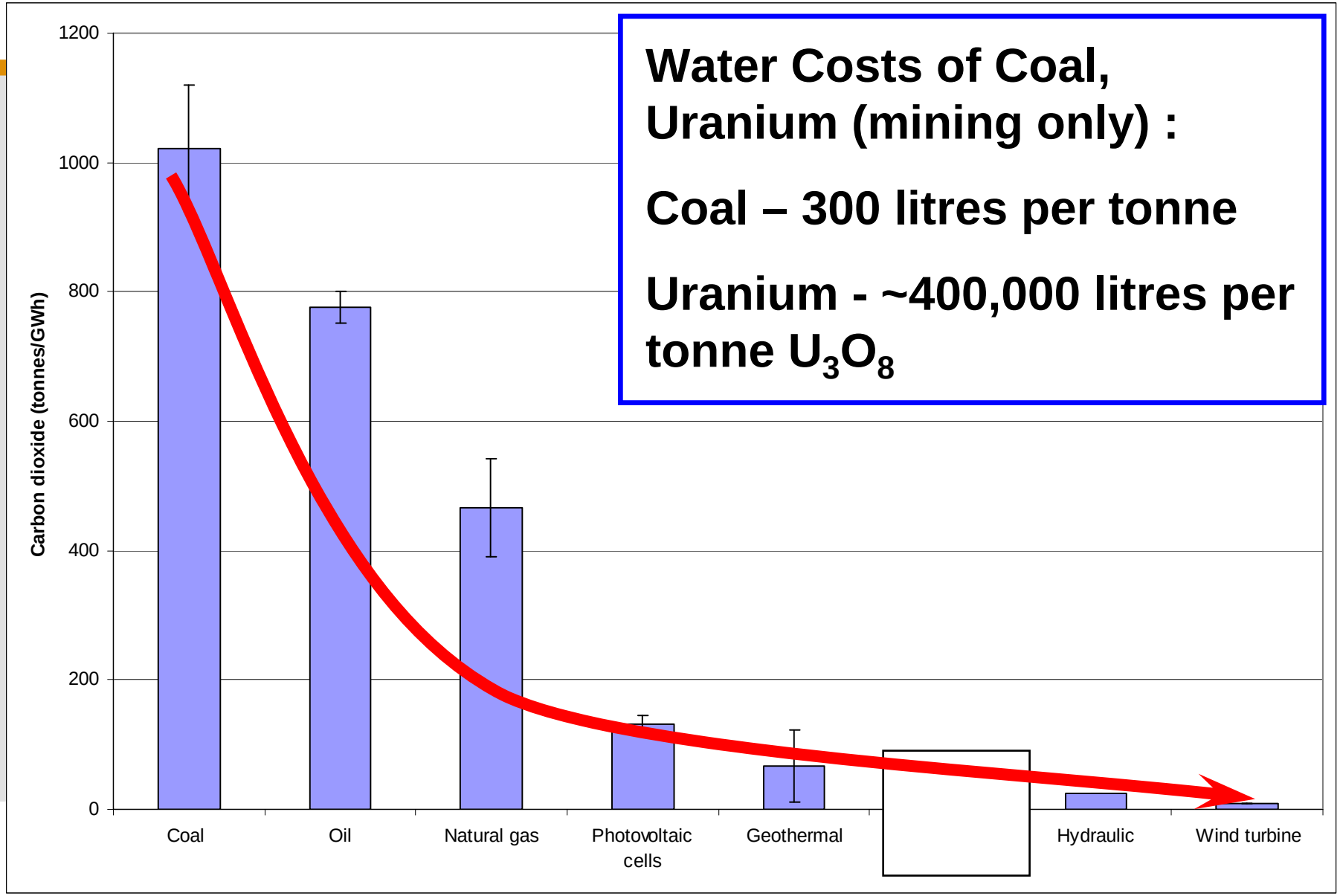
1) Unit Greenhouse Emissions (t CO_2/GWh)

Company	Country	Average	Minimum	Maximum	Reference
Mighty River Power	New Zealand	95.4 (4)	88.3	102.5	MRP, various
ENEL	various	4.2 (5)	2.1	5.9	ENEL, various
Contact Energy	New Zealand	87.8 (5)	68.1	113.1	CE, various
Orkuveita Reykjavirkur	Iceland	20.5 (5)	10.6	27.5	OR, various

2) Unit Water Costs (ML/GWh)

Company	Country	Average	Minimum	Maximum	Reference
ENEL	various	2.83 (5)	2.29	3.27	ENEL, various
Contact Energy	New Zealand	21.5 (1)	-	-	CE, various
Orkuveita Reykjavirkur	Iceland	125.4 (5)	84.4	144.4	OR, various

Greenhouse Cost of Energy Sources



Water Costs of Coal, Uranium (mining only) :

Coal – 300 litres per tonne

Uranium - ~400,000 litres per tonne U_3O_8

Ongoing Challenges …

- At present, there is only a small handful of data reported on the key environmental sustainability metrics for geothermal energy
- Some companies report certain aspects but not others (eg. CO_2 but not H_2O)
- High variability between major projects & lack of complete data on configuration hampers more accurate comparison

Geothermal is Sustainable Energy.

- Geothermal energy is presently a major source of electricity around the world
- Given it's low environmental impacts, especially unit greenhouse emissions, it is expected to continue to grow rapidly
- Major need for improved reporting
- Future developments in geothermal, such as hot dry rocks and binary/combined cycle systems, look very promising … ***(but)***