



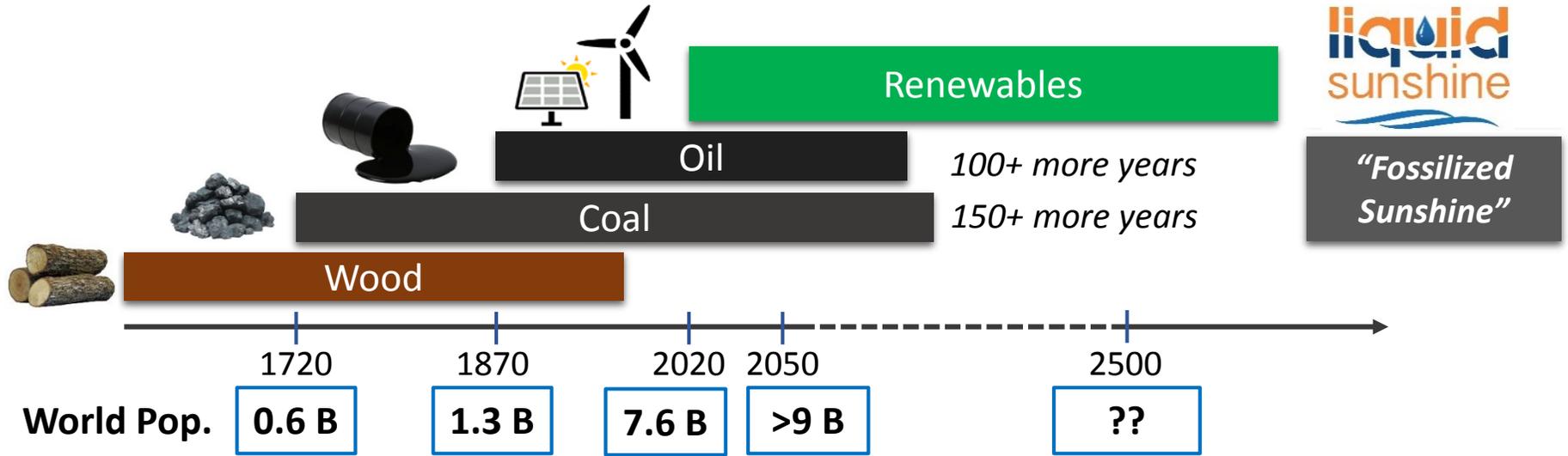
**Efficient, Economic, Environmental (3E) Energy Systems
for Sustainable Development**

A Viable Global Energy Strategy

2 May 2017

Energy is Humankind's Biggest Challenge!

Three Existential Threats



Fossil fuels and the existential threats:

- 1 Environment degradation → direct and immediate harmful health effects
- 2 Climate change – Greenhouse gas → Long-term adverse planet-scale effects
- 3 Global energy system runs on *exhaustible* fossil fuels – *fossilized sunshine*

Common man solution is needed now!

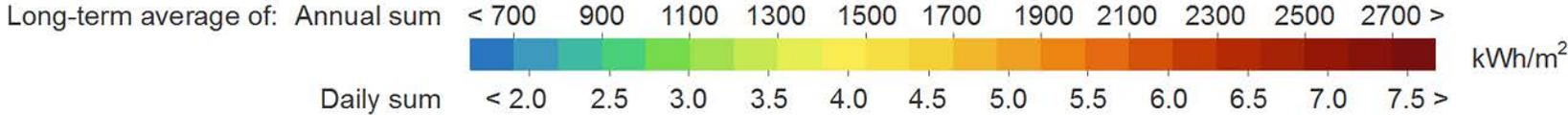
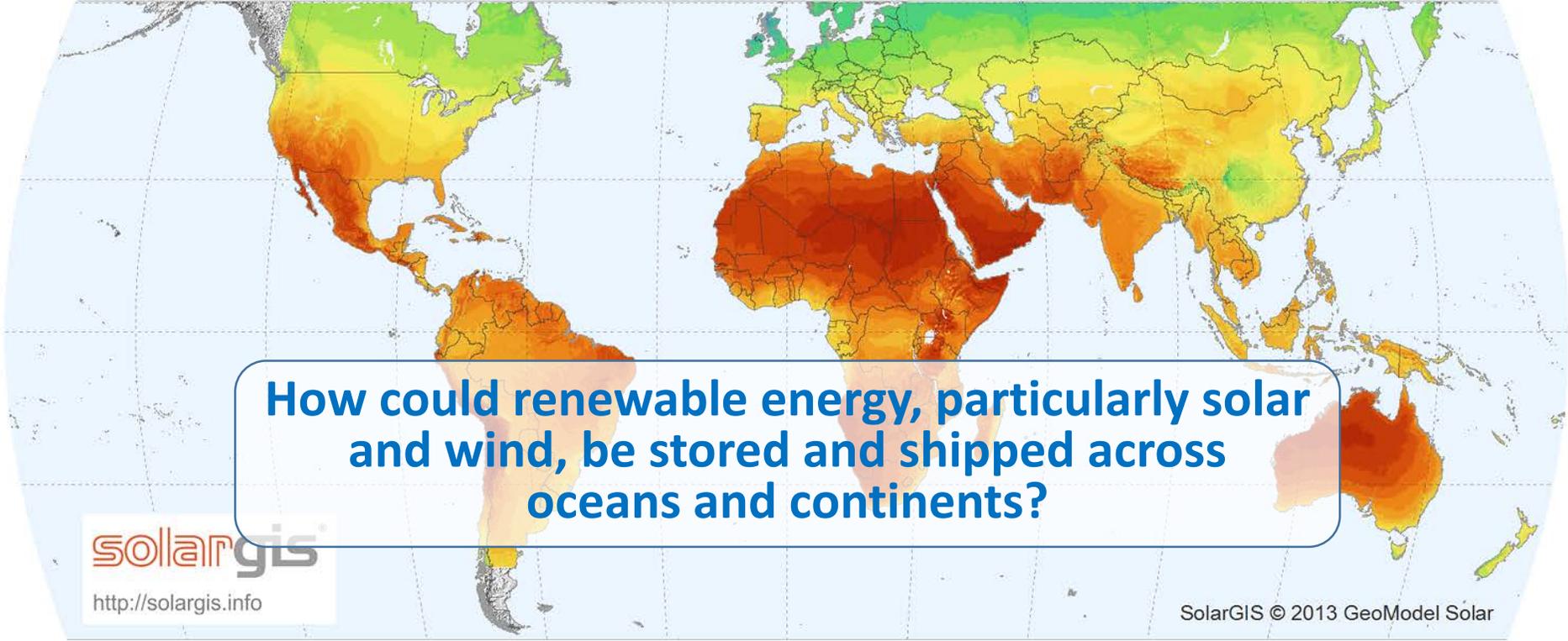
Proposition: Affordable, scalable energy systems that are ready to go and can build pathways to harnessing Earth's inexhaustible energy resource – SUNSHINE



A Viable Long-Term Solution

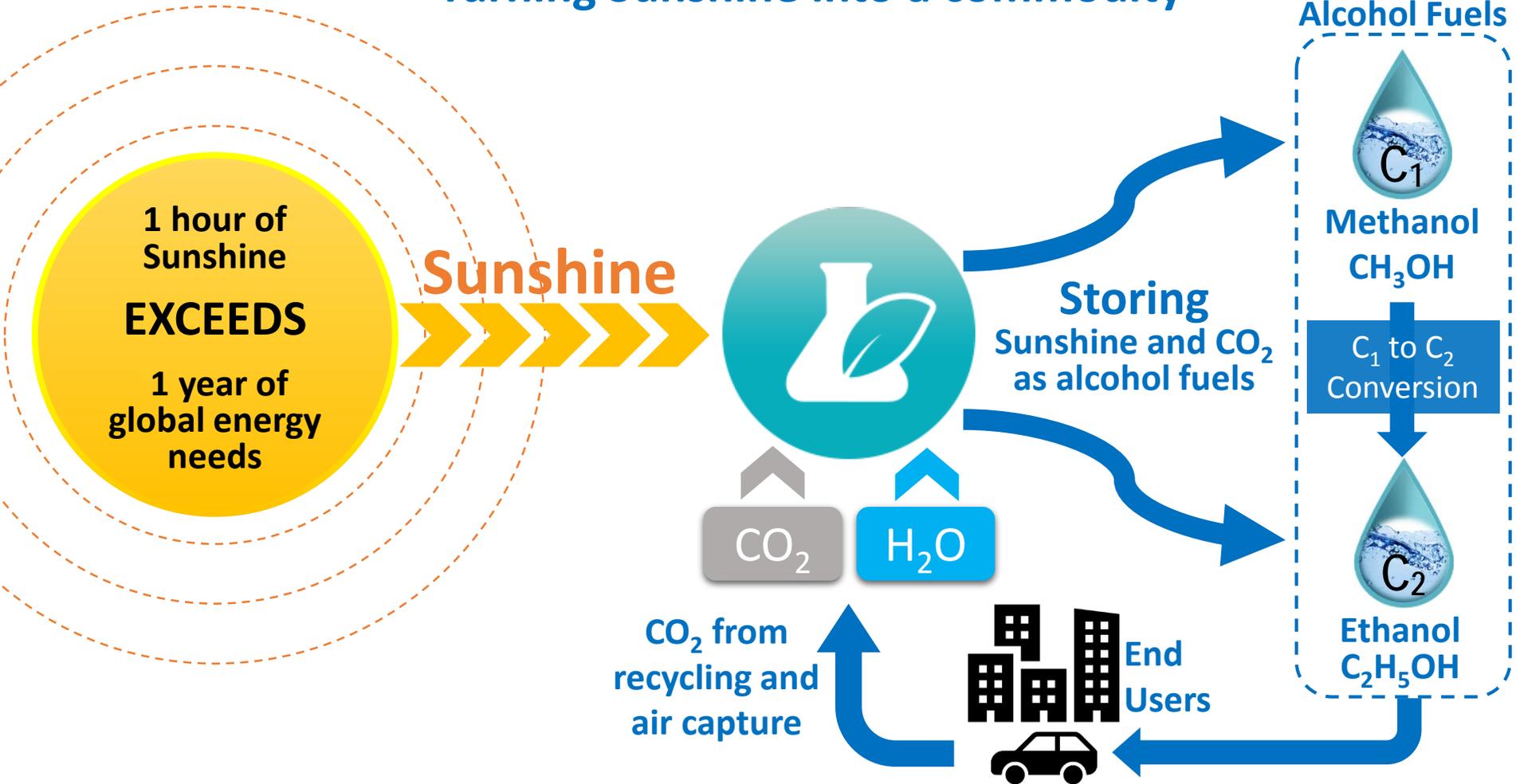
Harnessing, Storing & Distributing Sunshine

Sunshine is humankind's vast inexhaustible clean energy resource
1 hour of Sunshine > 1 year of global energy needs



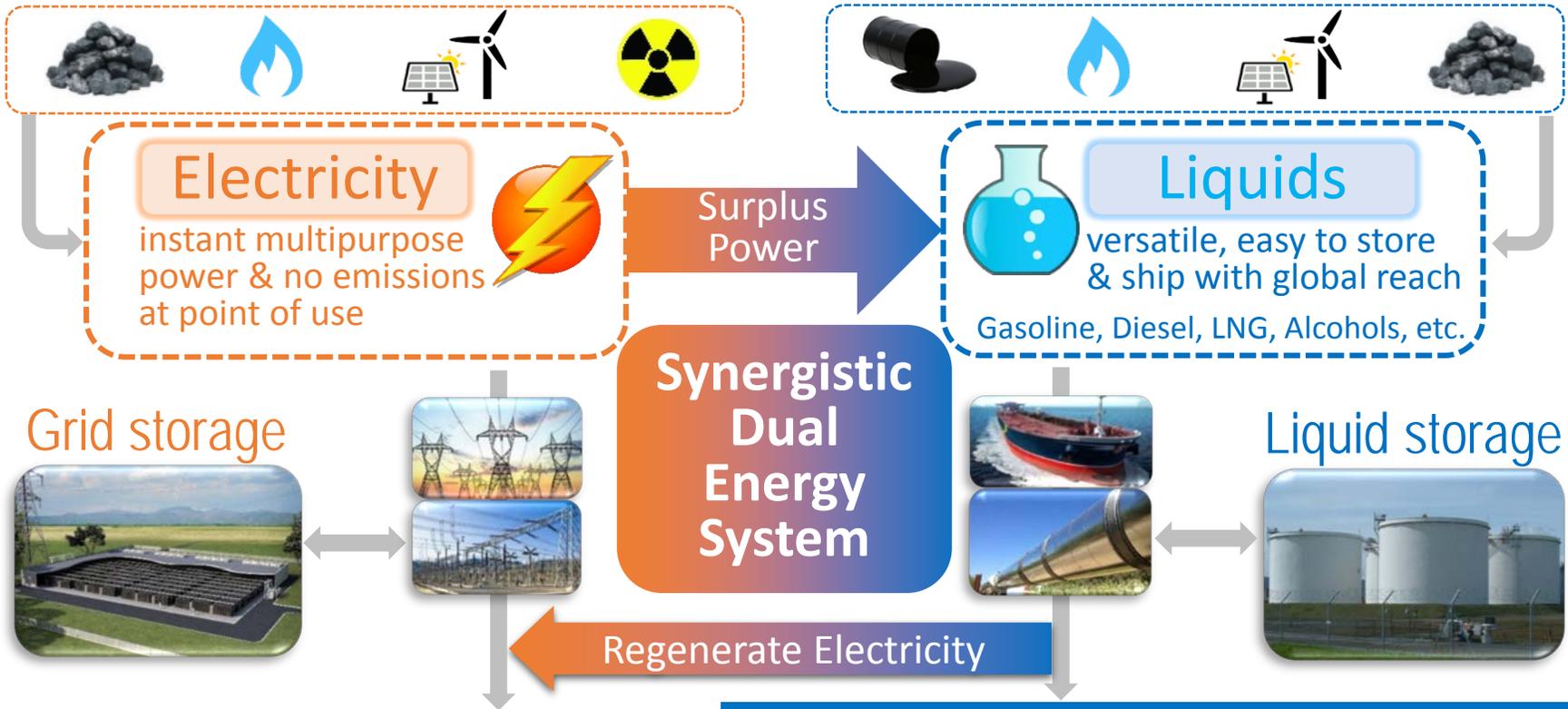
Liquid Sunshine Concept

Turning Sunshine into a commodity



Harnessing and bringing together sunshine and CO₂ to produce renewable storable alcohol fuels is the Liquid Sunshine concept.

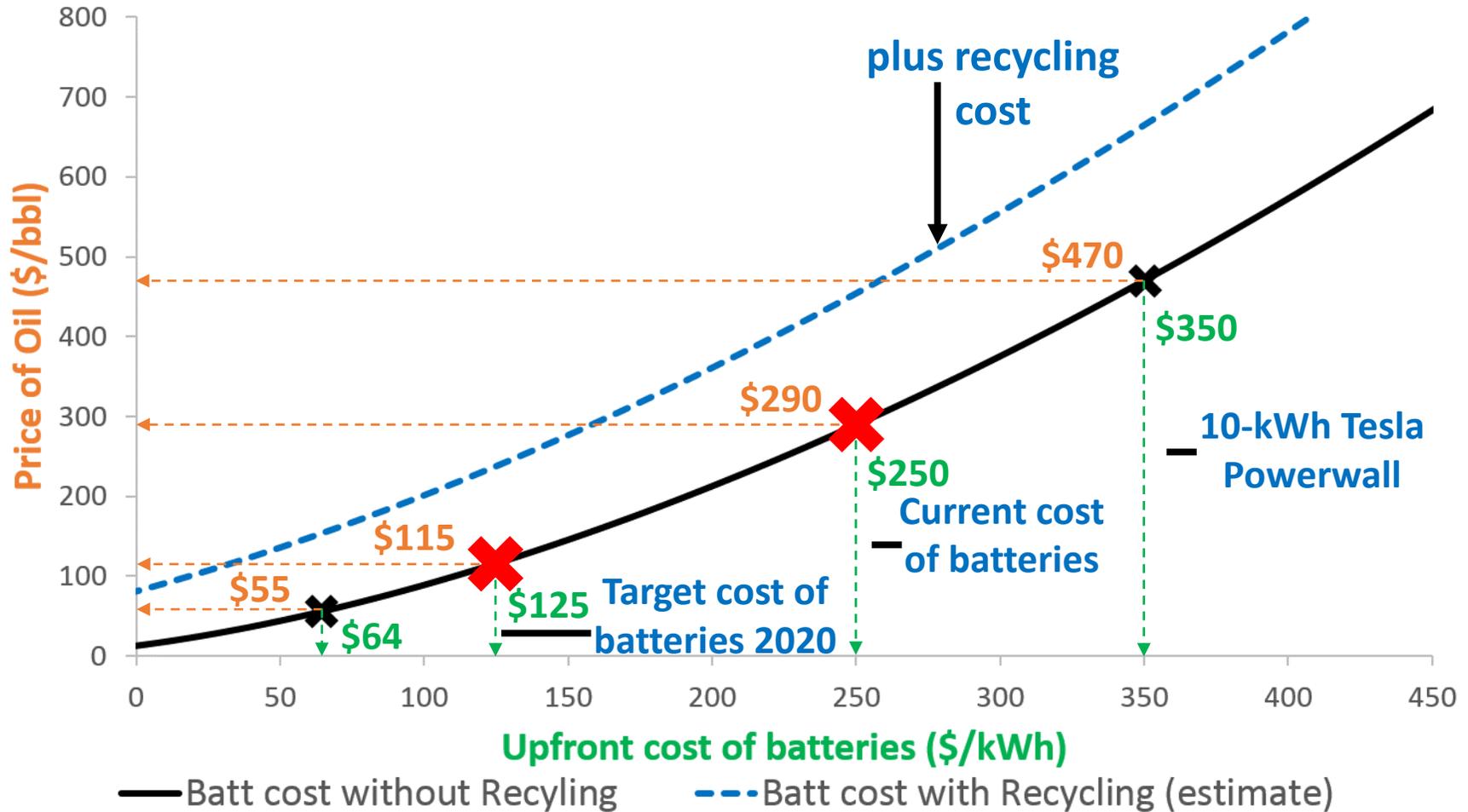
Synergy of Electricity and Liquids



| Light / AC | Appliances | Mobile gadgets | Transportation | Machinery | Materials |
|------------|------------|----------------|----------------|-----------|-----------|
| | | | | | |

Reality: Battery is Costly

Breakeven economics and end-of-life recycling costs



Adapted from: Covert, Thomas, Michael Greenstone, and Christopher R. Knittel. "Will We Ever Stop Using Fossil Fuels?" *Journal of Economic Perspectives* 30, no. 1 (February 2016): 117–138.

Recycling assumption: Net cost of battery recycling assumed to be \$150/kWh in 10 years

Technology Roadmap to Liquid Sunshine

First to Fifth Generation (G) Methanol Technology



*1G-Coal to methanol has higher CO₂ emissions due to its higher carbon to hydrogen ratio. This can be mitigated by introducing a separate hydrogen-rich source into the process, thereby also improving the yield.

Liquid Sunshine Technology Roadmap



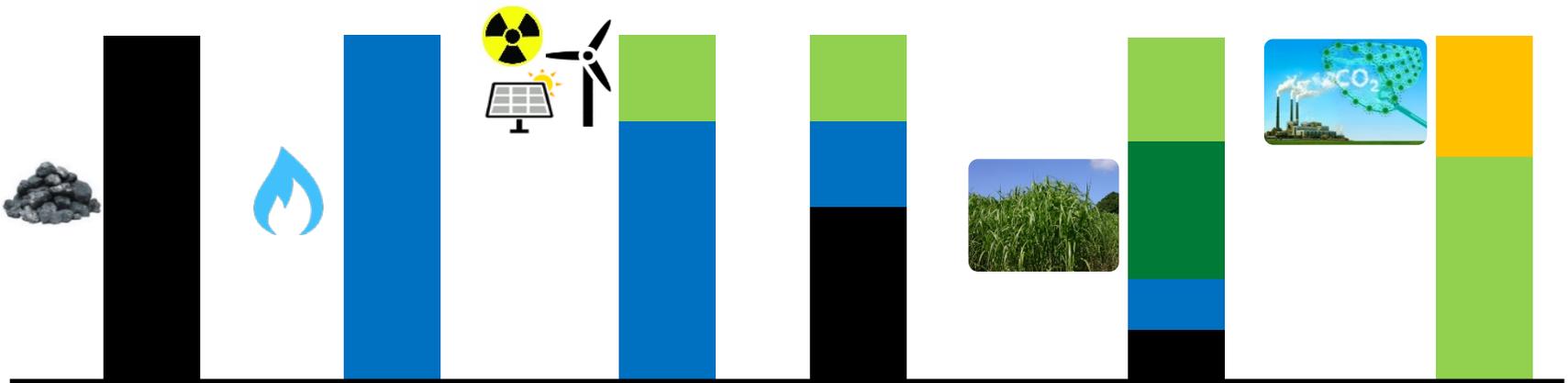
| Phase I Carbon-Intensive | | Phase II Carbon-Light | | Phase III Carbon-Neutral | |
|-----------------------------|--------|--------------------------|---------|-----------------------------|----|
| 1G-Coal | 2G-Gas | 3G-Gas | 3G-Coal | 4G-Biomass | 5G |

ULE
 Ready for large-scale deployment

Deployed in China Deployed worldwide Ready for pilot testing Almost carbon-neutral



← Existing Technologies → ← New Technologies →



Coal
 Gas

Nuclear
 Renewable

Biomass
 CO₂ Capture

Alcohol-Based Fuels For Electricity, Heat and Mobility



Turbines



Fuel cells



Engines



Burners



Utility scale power generation

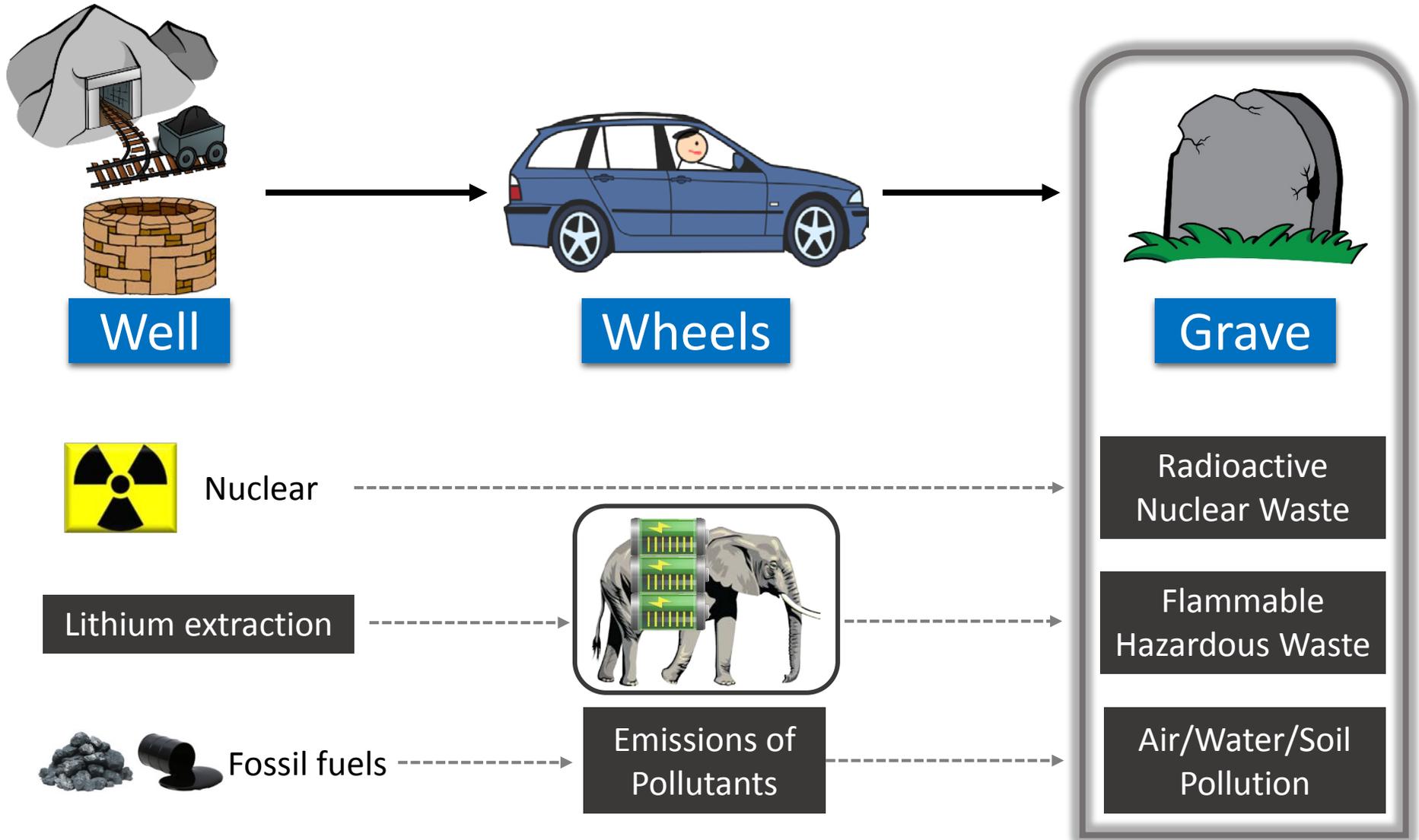
Off-grid power generation

Industrial

Transportation

Residential applications – Dimethyl-ether (DME), derived from methanol, can be used as fuel for cooking, space heating, water heating

Tackling Today's Challenges Today





*Treat the earth well – it is borrowed from
our children and our children's children.*
collective wisdom from the early centuries to the present

