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EROI & Energy Policy (2)

(Key UK renewables:

PV, wind, biofuels)

Marco Raugei

EROI Workshop

30 June 2017, London, UK

ENERGY

- *"Ability to do work"* [Young, 1805]

[etymology: Greek 'en' (=at) + 'ergon' (=work)]

- Measured in J [SI] / cal / kWh / BTU / …

A Joule is a Joule is a Joule… NOT!

1 MJ ≠ **1 MJ**

Crude oil **Electricity**

Anything wrong with this figure?

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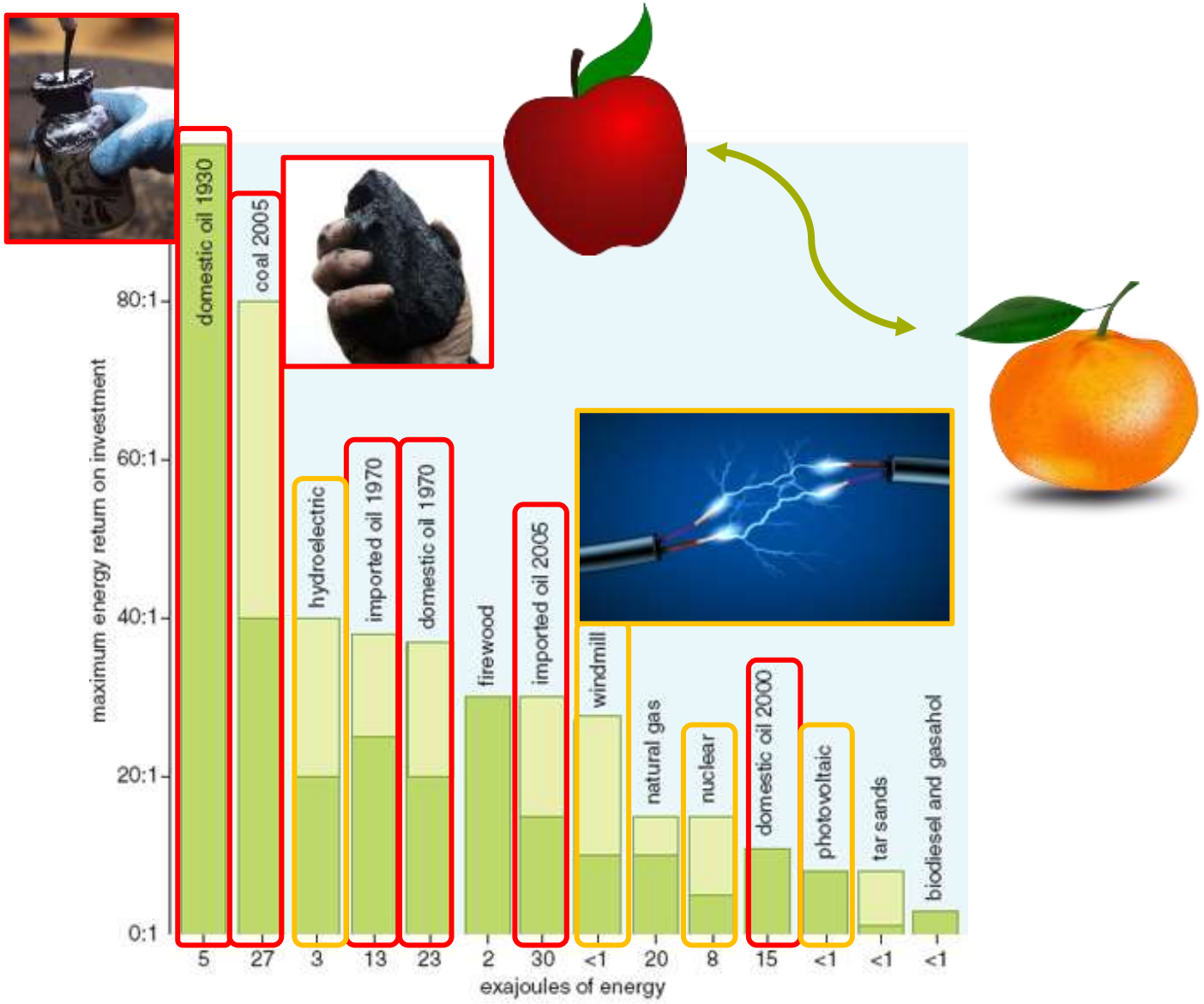

Source: Hall and Day, 2009. *American Scientist* **97**:230-237

A conventional thermal energy supply chain (applies to biofuels)

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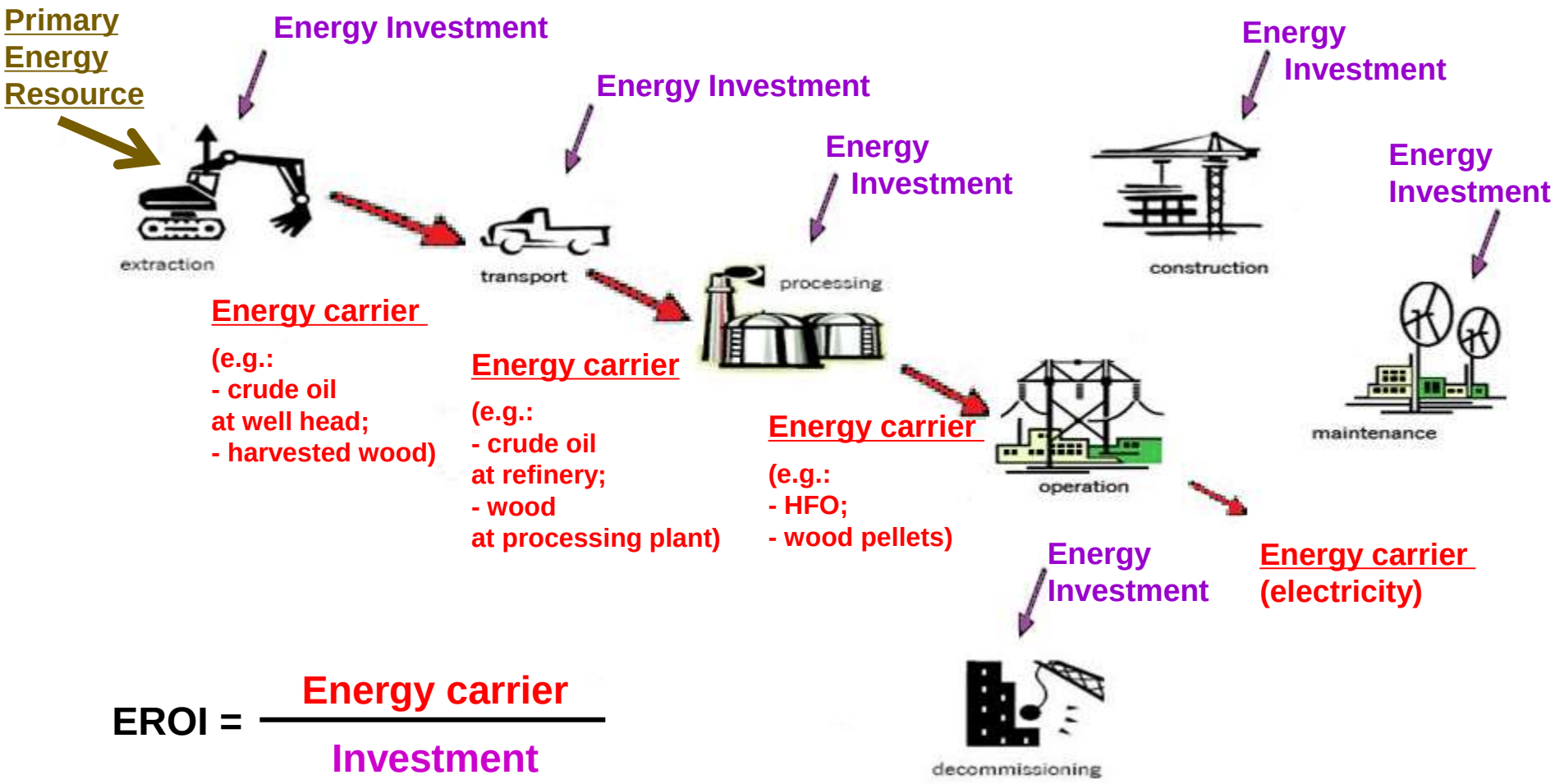

$$\text{EROI} = \frac{\text{Energy carrier}}{\text{Investment}}$$

A non-thermal renewable energy supply chain (applies to wind and PV)

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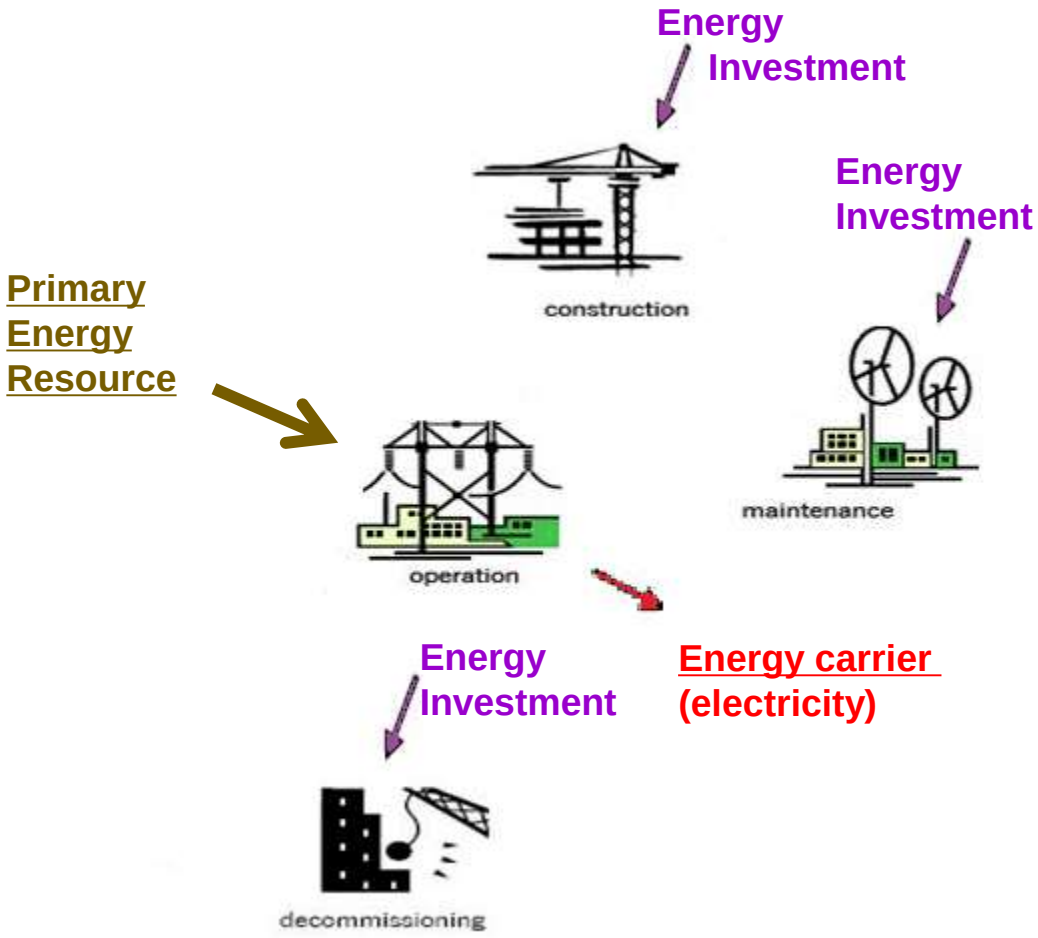

$$\text{EROI} = \frac{\text{Energy carrier}}{\text{Investment}}$$

POTENTIAL METHODOLOGICAL ISSUES

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- Inconsistent **functional units**
  - E.g., comparison of **EROI $_{(source)}$** - *vs.* - **EROI $_{(point\ of\ use)}$**

N.B. This inconsistency cannot be resolved by just multiplying one "return" by a fixed "conversion factor" (e.g., ~3 for electricity). All "investments" must be accounted for, up to the point where both "returns" perform the same function.

And there's more:

- E.g., even 1 kWh of coal-fired *electricity* is not truly functionally equivalent to 1 kWh of PV *electricity*, since:
  (i) the former entails more GHG emissions (may require CCS),
  (ii) the latter is intermittent (may require energy storage).

Ref.: Hall et al., 2014. EROI of different fuels and the implications for society. *Energy Policy* **64**:141-152

POTENTIAL METHODOLOGICAL ISSUES

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- Inconsistencies in **'goal' definition**

i.e. is it: (A) to compare alternative technologies *per se*;

or (B) to assess the ability of one technology to single-handedly support an industrial society?

  - E.g., How much (if any) energy storage is to be included in a NEA of PV? (if taken in isolation, baseload technologies such as large coal and nuclear power plants are also unable to follow electricity demand, and they too should be required to deploy some storage capacity)

- Inconsistencies in **'scope' definition**

i.e. is the analysis carried out: (A) at the level of an individual installation;

or (B) at the level of the entire industry / country?

  - Which system boundaries are appropriate depends on the scope!

Ref.: Carbajales-Dale et al., 2015. Energy return on investment (EROI) of solar PV: an attempt at reconciliation. *Proceedings of the IEEE*, 103(7):995-999

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A comprehensive assessment of the energy performance of the full range of electricity generation technologies deployed in the United Kingdom

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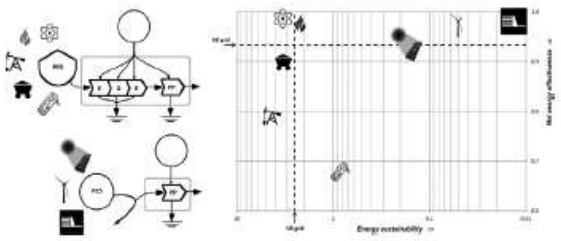
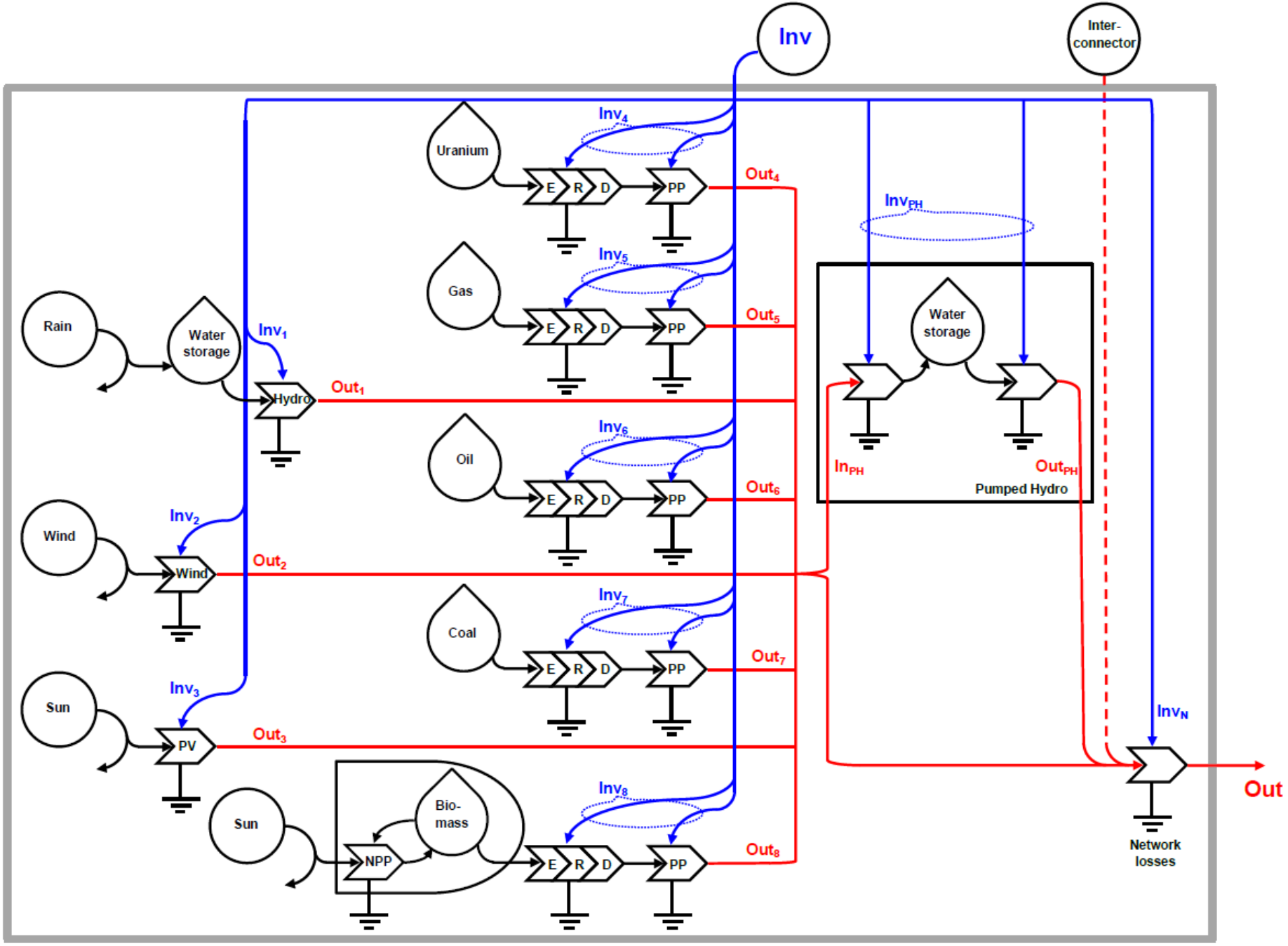
HIGHLIGHTS

- We assess the energy performance of electricity generation technologies in the UK.
- The NEA and LCA methodologies are reviewed and discussed.
- *Net energy gain* and *non-renewable cumulative energy demand* are deemed key metrics.
- Wind, and to a lesser extent PV, are found to be the most recommendable technologies.
- Natural gas combined cycles are also recognised as important for dispatchability.

GRAPHICAL ABSTRACT

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Inter-connector
Uranium
Gas
Oil
Coal
Rain
Water storage
Hydro
Wind
Wind
Sun
PV
Sun
Bio-mass
NPP
E
R
D
PP
Water storage
Pumped Hydro
Network losses
Out

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Current UK grid mix

Table 1
Electricity production technologies comprising the UK electric grid mix and relative shares of total electricity output in the year 2013 (Department of Energy & Climate Change (DECC), 2014a; National Grid, 2014a).

Technology	Share of total grid output (%)
Coal	37.0
Oil	0.6
Gas	1.3
Gas combined cycle	26.7
Nuclear	19.1
Biomass	4.8
Hydro	1.4
Wind (on shore)	4.0
Wind (off-shore)	4.4
PV	0.7

EROI of electricity in the UK

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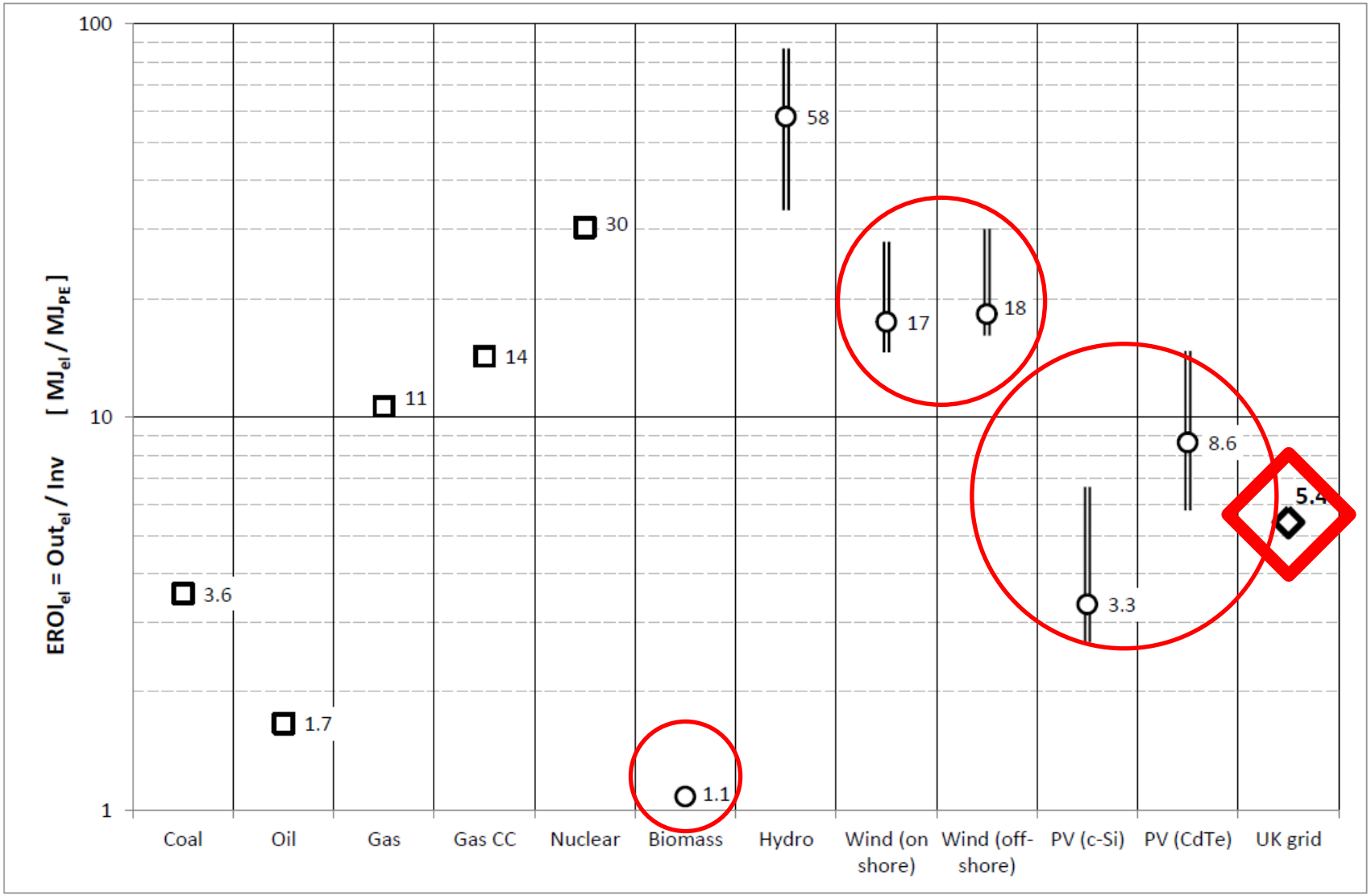

Thank you

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