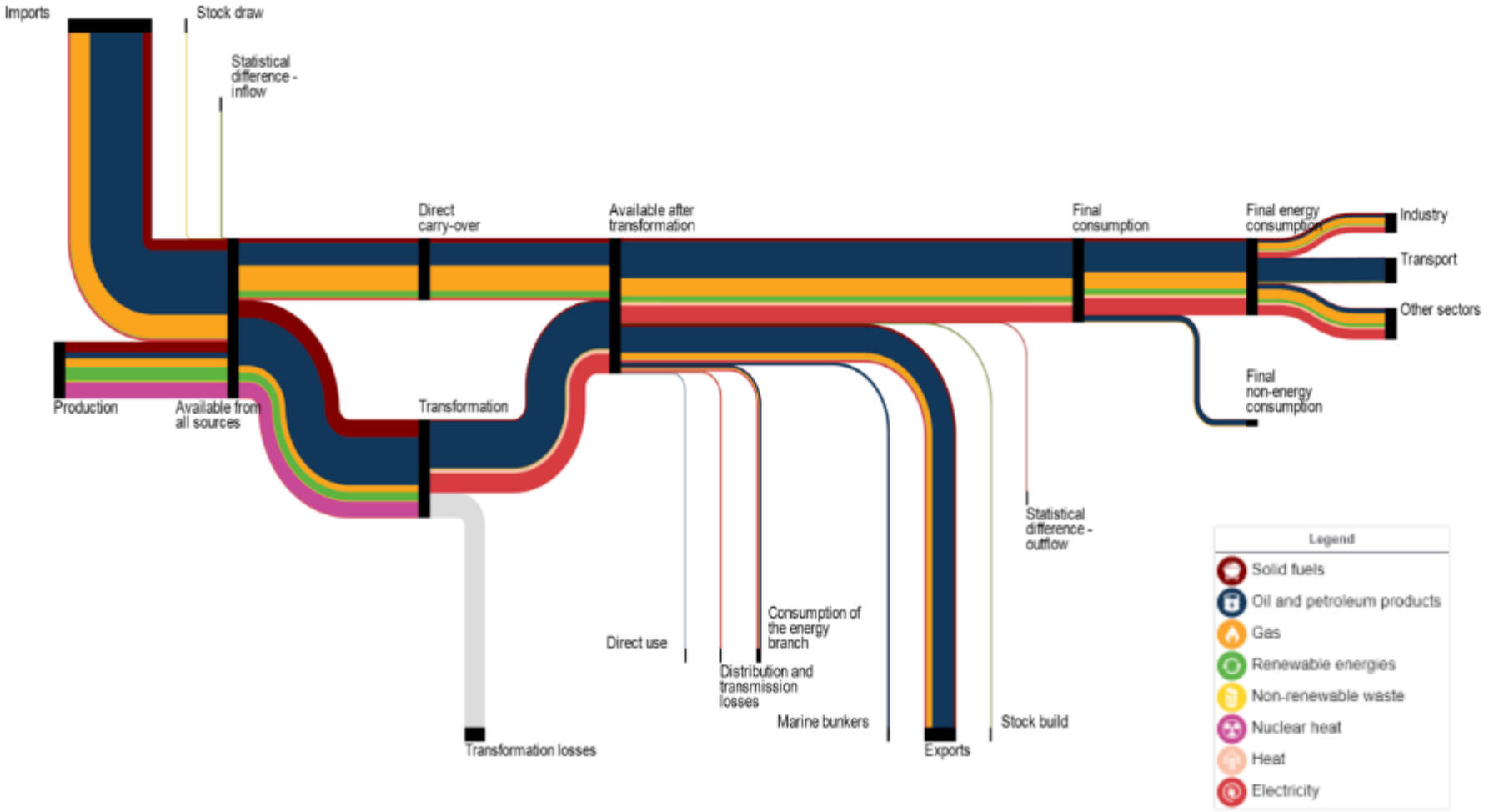
Energy Return on Energy Investment (EROI): A net-energy yardstick for the use of CCS in the transition to a low-carbon economy

VII TIEC - Legal Challenges at the End of the Fossil Fuel Era: Shaping Energy Futures Through Legal Intervention

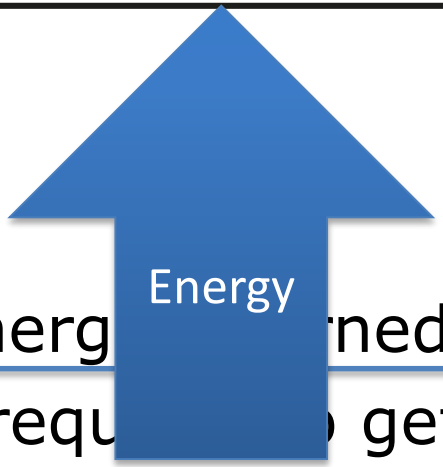
Universitat Rovira i Virgili, Tarragona, 26.5.2022

EU Energy Flow



https://ec.europa.eu/eurostat/web/energy/energy-flow-diagrams

- EROI



Energ rned to society

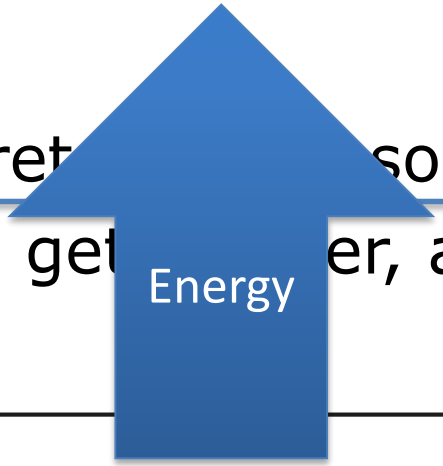
Energy requ get that energy

- EROIpou

gy re ociety

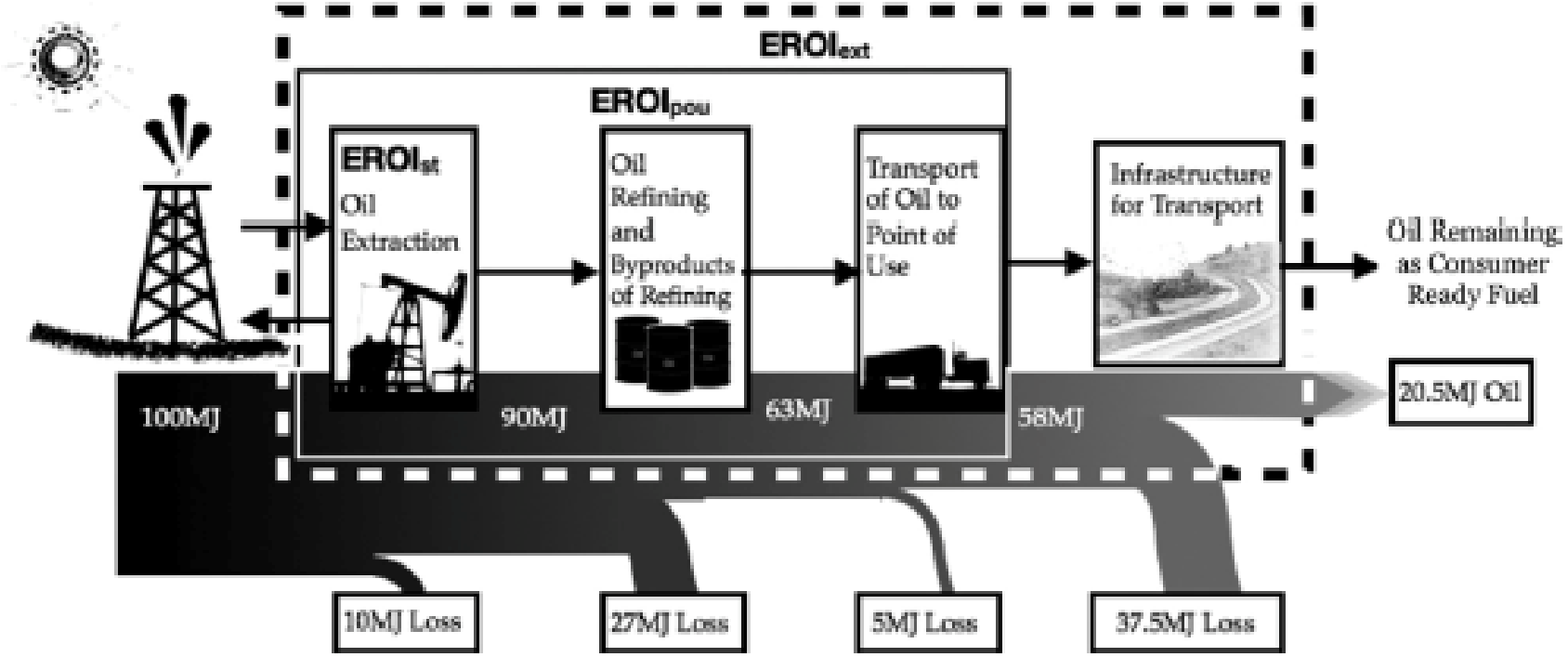
Energ equire l deliver that ener y

- EROIext

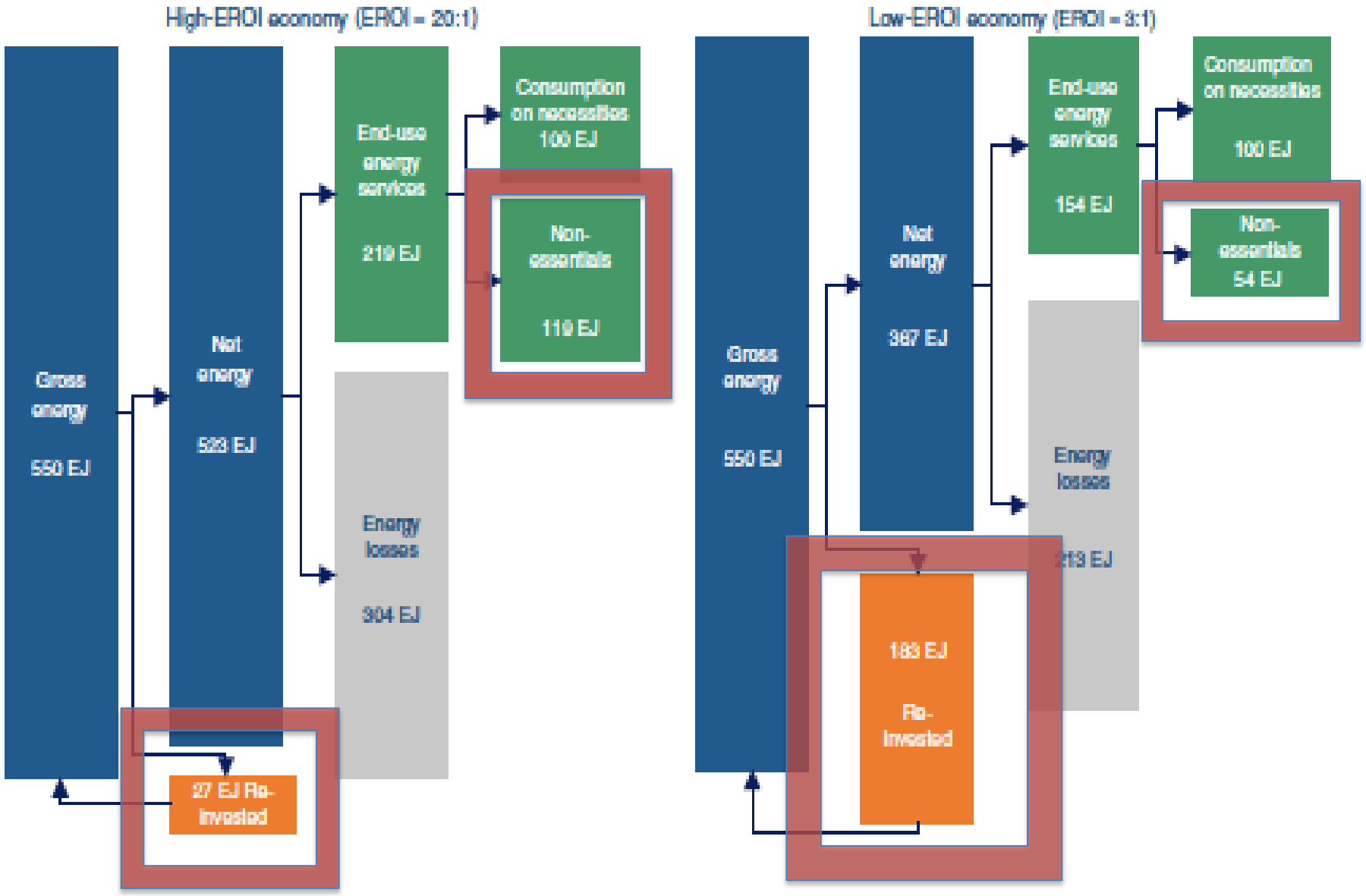


Energy ret society

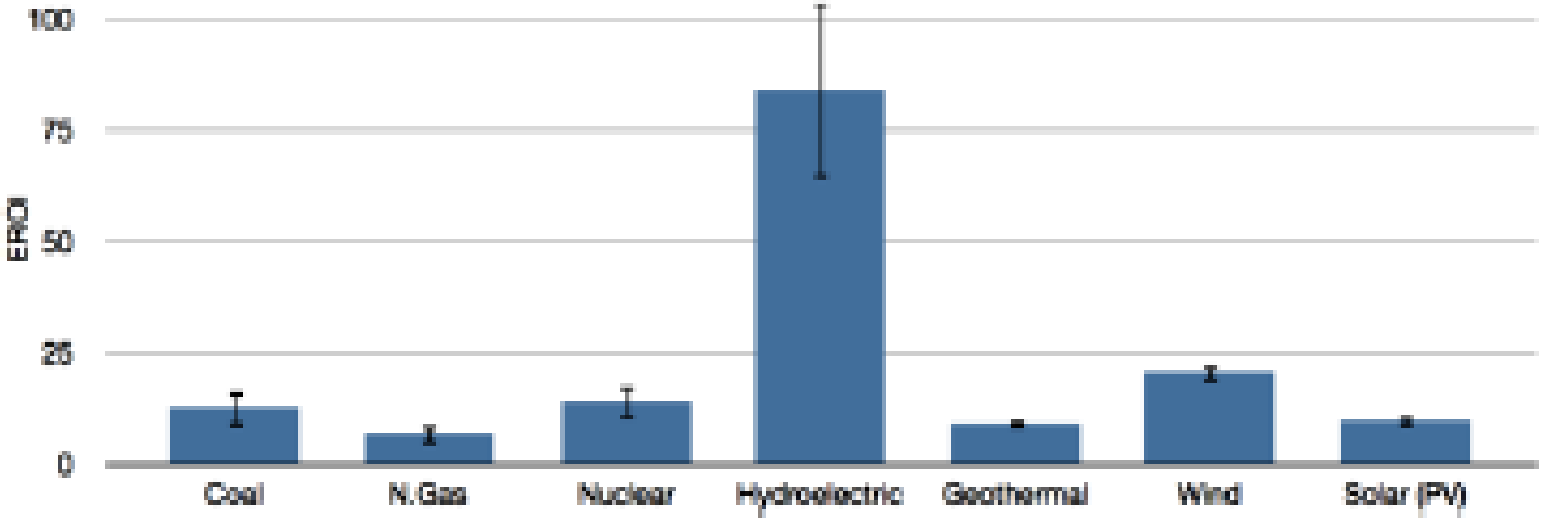
Energy required to get er, and use that energy

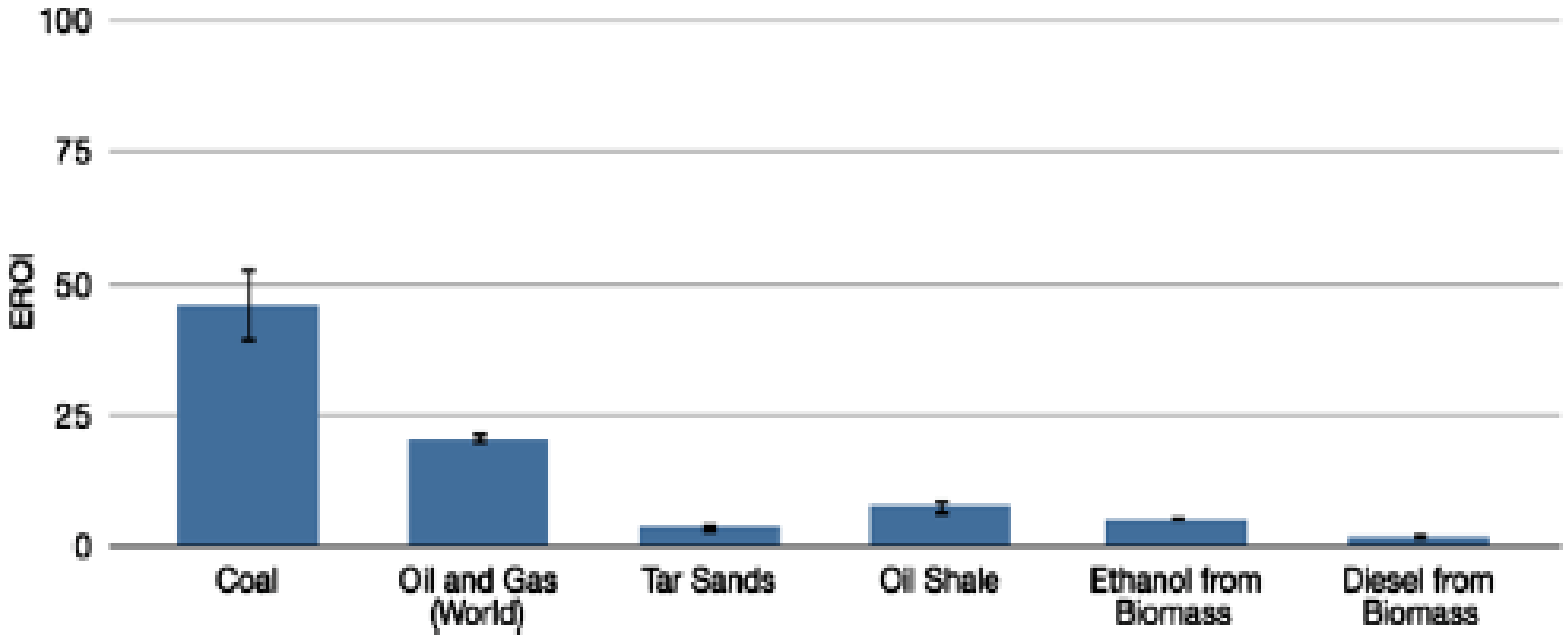


Source: Hall et al. (2014)



Source: King and van den Bergh (2019)





Source: Hall et al. (2014)

Key questions (Hall, 2017)	Key Challenges
1. How energetically expensive is the produced energy available to energy consumers for consumption (production + transformation + transportation, etc.)? 2. Has ERO(E)I been calculated, and if so, is it equal to 10:1 or better to sustain a viable modern economy? 3. Has the energetic cost of ancillary technologies (e.g., storage) been included in the ERO(E)I calculations? 4. More generally, does the proposed plan/activity allow for adequate net-energy to run the desired economy?	• Steadfast decline in Fossil Fuels ERO(E)I • Uncertainties about the actual ERO(E)I of RES and its adequacy to offset sudden decline of Fossil Fuels ERO(E)I • Lack of coherent and professional data-gathering on ERO(E)I • Inadequacy of conventional economics to deal with decline in FF and energy constraints to growth

ANALYSIS
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nature energy
Corrected: Author correction

Implications of net energy-return-on-investment for a low-carbon energy transition

Lewis C. King[1]* and Jeroen C. J. M. van den Bergh[1,2,3]

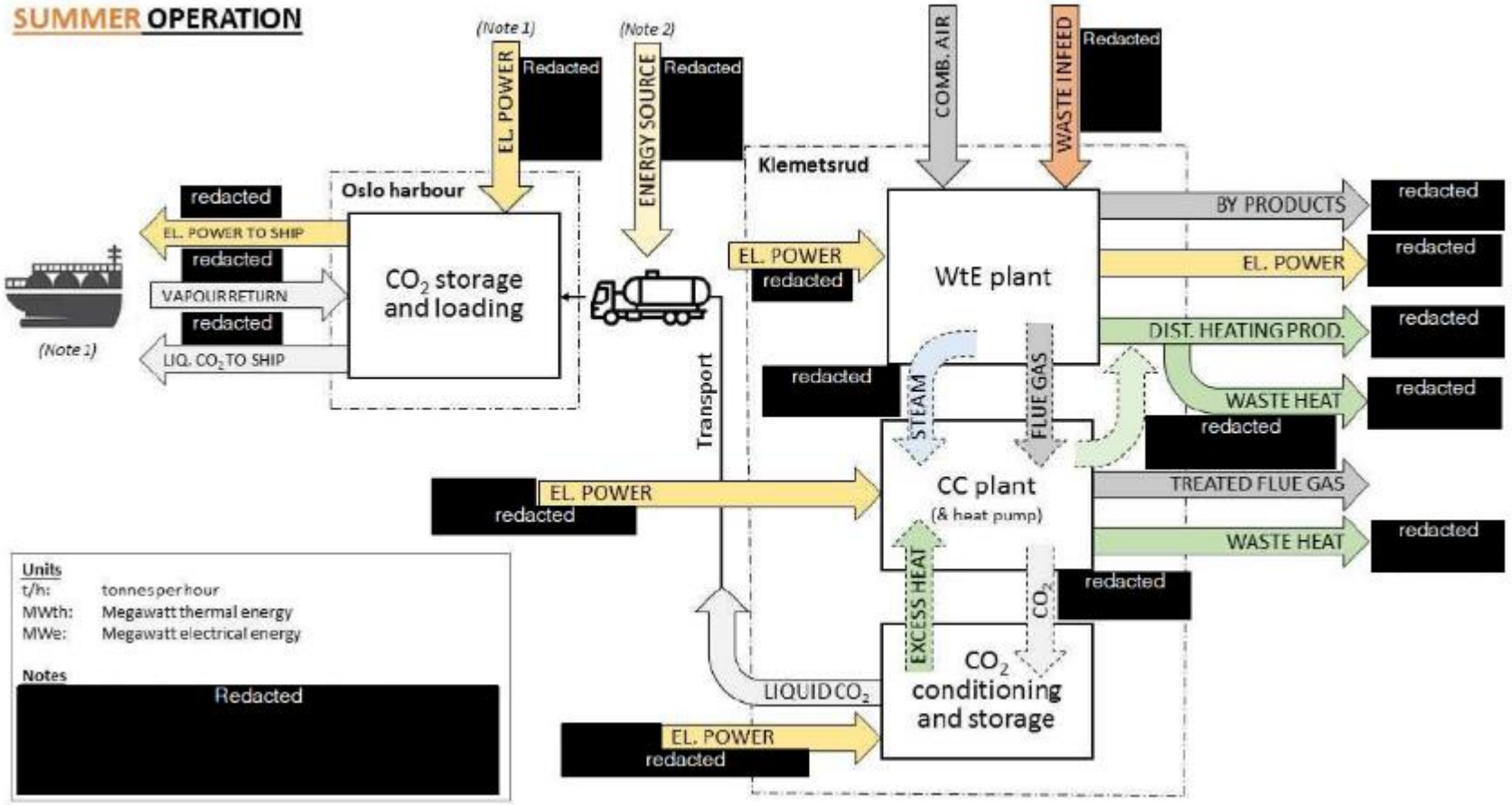
EROC=
1-1/EROI/(carbon emission factor)

Table 5 | EROC of combusting different fossil fuels

Energy source	EROI	Carbon emission factor[36] ($kgCO_2\,TJ^{-1}$)	EROC ($EJ\,GtCO_2^{-1}$)
Coal	46:1	94.6	10.3
Coal with CCS	9:1	9.5	65.1
Oil	19:1	73.3	12.9
Oil shale	7:1	107.0	8.0
Tar sands	4:1	107.0	7.0
Natural gas	19:1	56.1	16.9
Natural gas with CCS	4:1	5.6	101.9

CCS carbon emission factors are based on capturing 85% of CO_2 emissions, the midpoint of 80–90% range stated in the IPCC special report on CCS[37].

Welcome to the Klemetsrud WtE + CCS plant


SUMMER OPERATION
(Note 1)
EL. POWER
Redacted
(Note 2)
ENERGY SOURCE
Redacted
COMB. AIR
WASTE INFEED
Redacted
Klemetsrud
Oslo harbour
redacted
EL. POWER TO SHIP
redacted
VAPOUR RETURN
redacted
LIQ. CO_2 TO SHIP
CO_2 storage and loading
(Note 1)
Transport
EL. POWER
redacted
WtE plant
BY PRODUCTS
redacted
EL. POWER
redacted
DIST. HEATING PROD.
redacted
WASTE HEAT
redacted
redacted
STEAM
FLUE GAS
redacted
CC plant
(& heat pump)
TREATED FLUE GAS
WASTE HEAT
redacted
EXCESS HEAT
CO_2
redacted
CO_2 conditioning and storage
LIQUID CO_2
EL. POWER
redacted
EL. POWER
redacted
Units
t/h: tonnes per hour
MWth: Megawatt thermal energy
MWe: Megawatt electrical energy
Notes
Redacted

There's a V

- CCS storage permit assessment (art. 7; art. 10 **CCS Directive**)
  - Calculation of EROI throughout the whole project (e.g., with BECCS)

EIA Directive

- Art. 3→Impact factors: Climate

LCA + ERO(E)I to be adopted in:

- Art. 4(3)→Selection criteria
  - Annex III→ Use of natural resources; Intensity and complexity of the impact
- Art. 4(4)→Info provided by project's developer
  - Annex IIA→ Should include net-energy considerations
- Art. 5→Environmental Assessment Report
  - Annex IV→ Project description: Energy Demand and Energy Use; Natural Resources used; Climate Change Impacts

RES (+ storage); CCS; ETS; CAR; EE

Inf

Pl
Tr

ETS Directive

- Art. 10a→Free Allocation (Aviation; Power Generation; Heating/Cooling; Industry)
  - ERO(E)I Benchmark?
- Access to finance (e.g. Innovation Fund)
- Higher electricity prices for low ERO(E)I technologies

We Can Be ERO(E)I… One Day

- Economic decisions are generally made from a monetary perspective. Adding a biophysical perspective, ERO(E)I is instrumental to assess the gap between the development needs and actual options of society against cutting-edge technologies, primarily CCS.

- ERO(E)I provides a meaningful conceptual framework to benchmark decisions in several policy and regulatory sectors to achieve the energy transition (e.g., energy production; planning; transportation). However, it is not embedded in the current EU regulatory framework.

- ERO(E)I requires more data to be collected and refined, in order to be effectively integrated in policy-making and squared with carbon budget calculations.

Thank you for your attention!

Matteo Fermeglia
Assistant Professor of International and European Environmental Law
Post-Doctoral Assistant in Environmental and Administrative Law
Hasselt University, Faculty of Law, Centrum voor Overheid en Recht (CORe)

matteo.fermeglia@uhasselt.be
@MFermeglia90

Viktor Weber
Post-Doctoral Fellow
Center for International Law and Governance (CILG), University of Copenhagen

viktor.weber@jur.ku.dk

UHASSELT RECHTEN IN HASSELT 10 JAAR VERNIEUWEND

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