Blue Hydrogen as an Interim Phase of the Just Transition;

Is it a Feasible Proposition for South Africa?

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Relevance to the Conference Theme

- "Towards a Just Transition - The Role of Industrial Policy"
- Main Proposition: Blue hydrogen could be produced as an interim measure to retain operational coal mines whilst (partially) decarbonizing energy systems

Blue Hydrogen as a Transition Step

- From the Hydrogen Society Roadmap

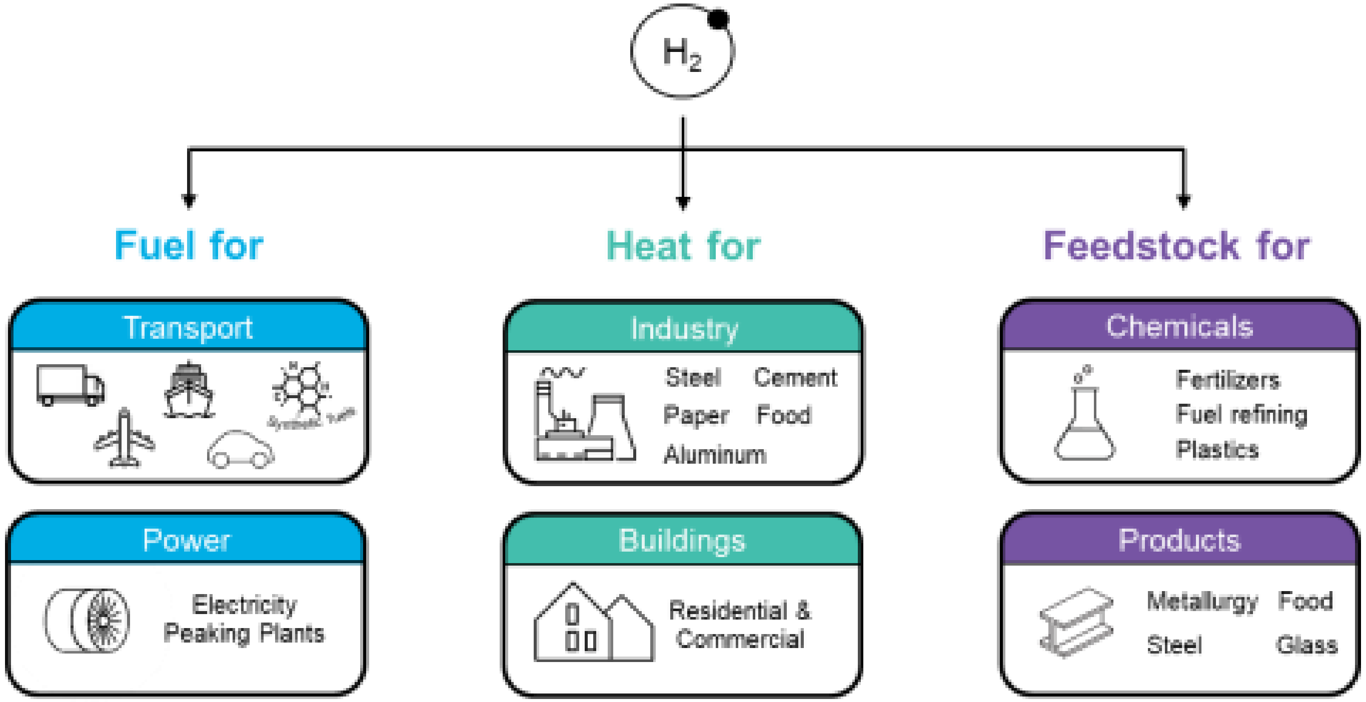
“Prioritise blue hydrogen (relative to green and grey) over the period 2021 to 2050, driven by the need to

  - preserve asset value
  - conserve employment whilst diversifying employment opportunities
  - allow the slow introduction of socio-economic adjustments to the new business practices (of the hydrogen economy)”

Main Questions of the Presentation

- What is blue hydrogen?
- How does carbon capture and storage work (CCS)?
- What are the techno-economic and political economy consequences of following this strategy?
- What are the final recommendations?

The Hydrogen Economy

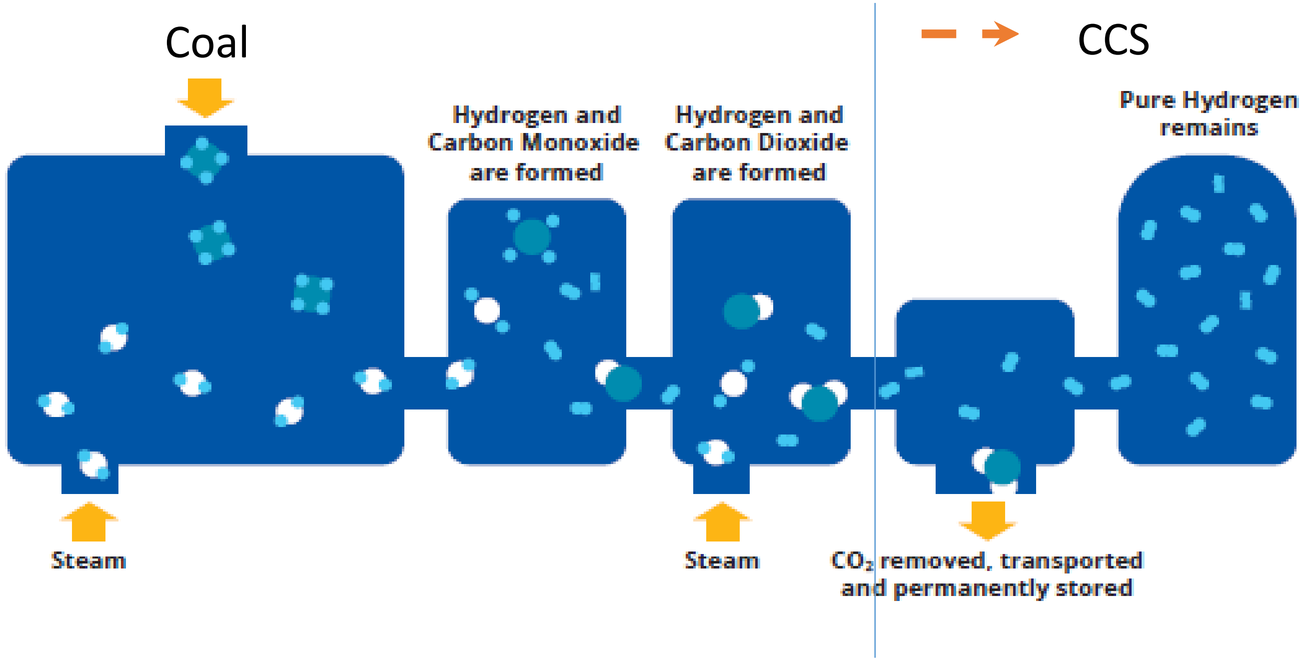


Mobility and Electricity

Heating Fuel

Chemical Feedstock

Blue Hydrogen



- Hydrogen is very colourful!
  - Black; from coal without CCS
  - Grey; from oil/gas without CCS
  - Blue; from fossil fuels with CCS
  - Pink; from nuclear energy via hydrolysis
  - Turquoise; from gas to produce H_2 and carbon black
  - Green; from renewable energy via electrolysis

Commercial Facilities for CCS

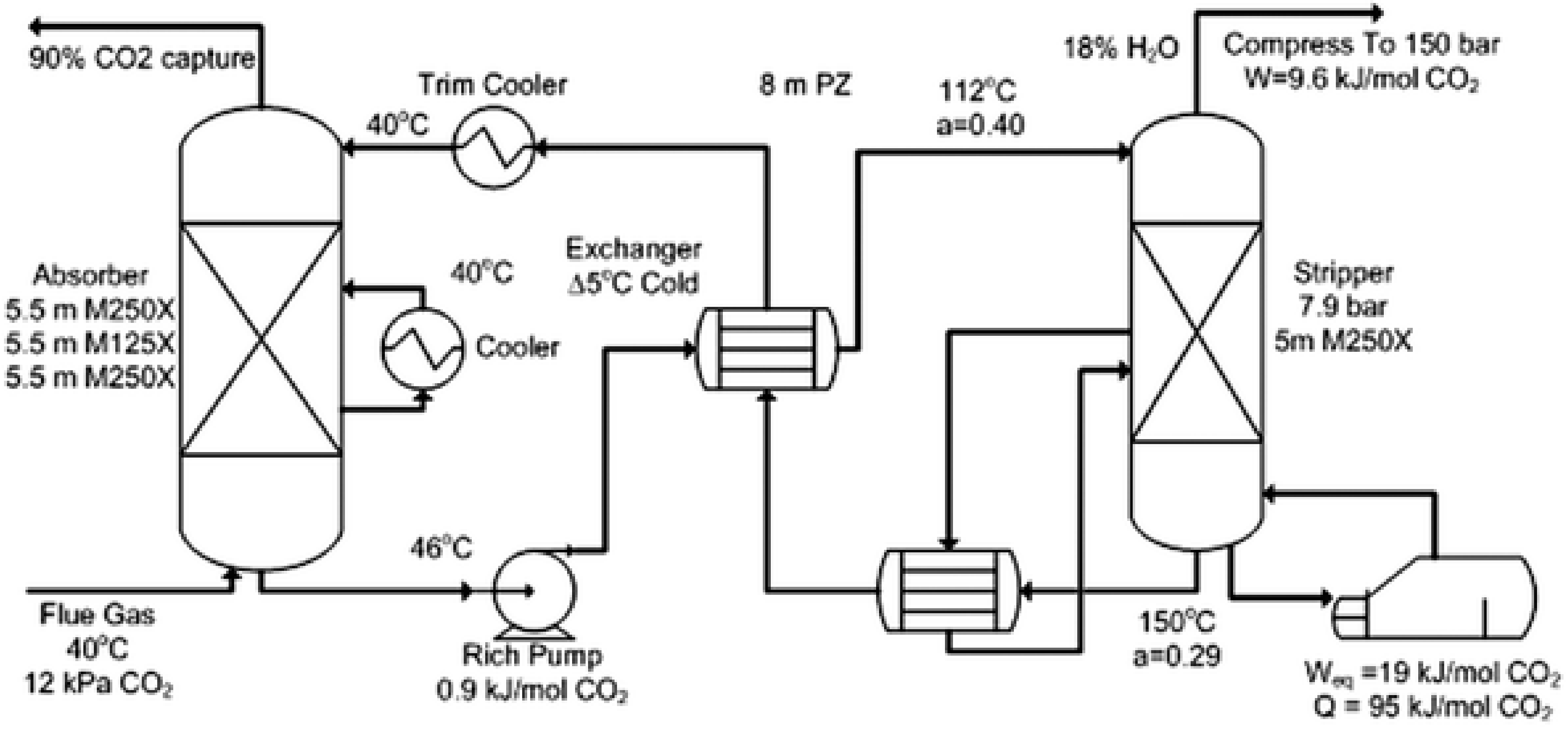
- Fermentation off gas (95% CO_2 in the feed stream); uses activated carbon and then direct compression
  - old technology; worked on such a plant in 1985!
- Gasification or steam reforming/shift gas/rectisol (50% CO_2)
  - water gas shift reactor, used by AECI for ammonia synthesis; worked there in 1978!
- Flue gas (20% CO_2); to date only amine absorption
- See https://co2re.co/FacilityData
  - There are no flue gas CCS facilities presently operational at scale
  - Most countries are unprepared for deployment of CCS (see the Readiness Index on this site)

Blue Hydrogen CCS

- Two CO_2 ‘sources’
  - product of steam reforming
  - flue gas (from boilers necessary to raise the steam!)
- It’s not just a rectisol problem!

The Basic Elements of Flue Gas CCS

- Absorption with amines is the main capture technology



Technology Problems for Blue Hydrogen/CCS

- Grey hydrogen production through steam reforming is well established
- BUT CCS is still under development with big issues
  - Efficiency limit about 87% (13% release of carbon)
  - Release of fugitive methane
  - Expensive
  - Where can it be stored?

Carbon Collection and Storage

- Expensive!
- "non-trivial engineering problem of how to collect the CO_2 from highly variable and geographically distributed emitters, and then transport it to a subsea depository"

Potential Sites (SACCCS)

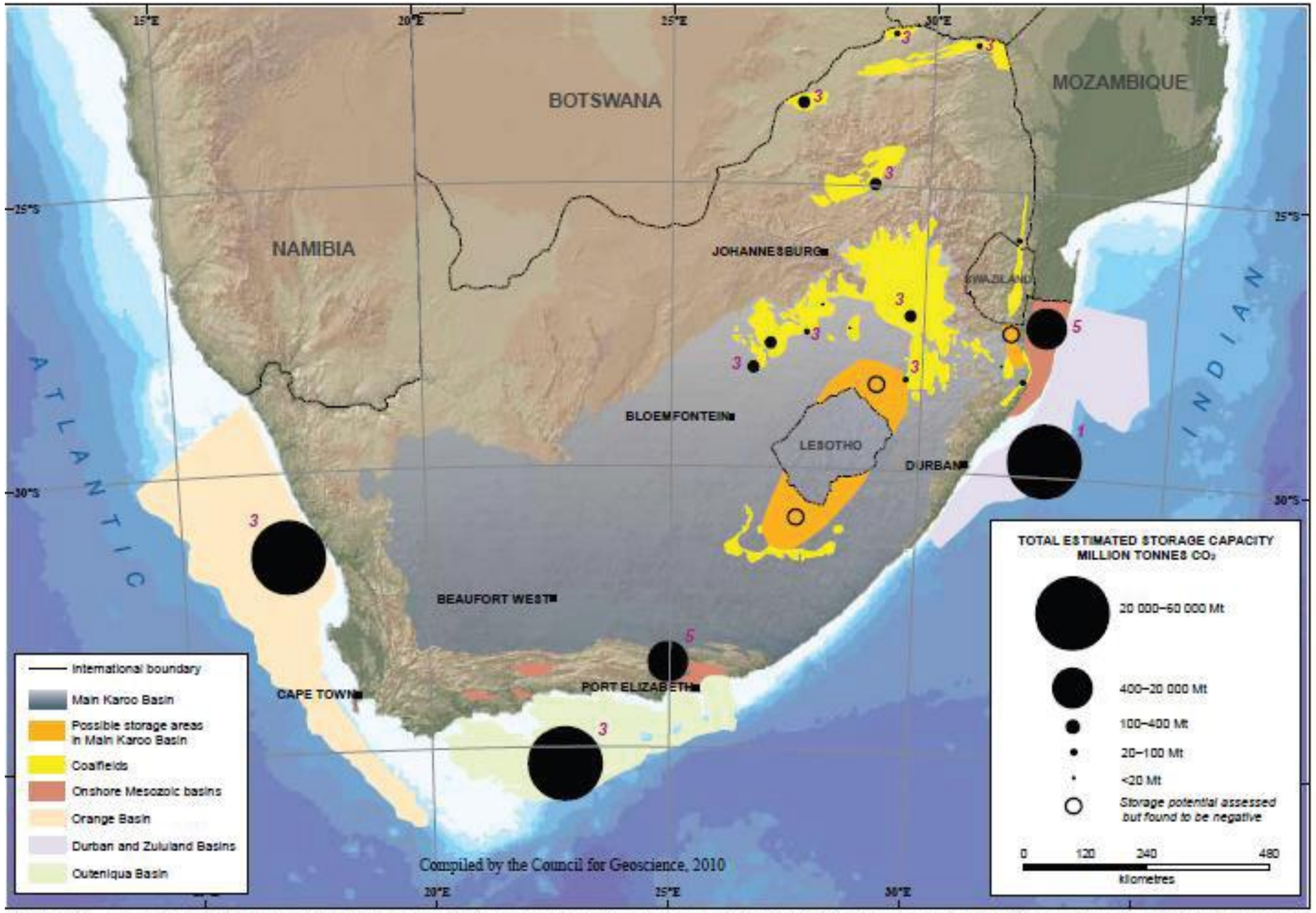


Figure 10.1 Possible deep saline formation storage opportunities onshore and offshore in Mesozoic basins along the coast of South Africa and for the deep coal fields of the Karoo Basin. Storage capacity of the basins and coal fields are indicated by round symbols (black) and data confidence by purple figures (cf. Table 4.10).

From Boot-Hanford

- Safe and secure CO_2 storage has been demonstrated with multi-year injections of around 1 Mt per year at a number of sites. Total CO_2 storage capacity is also being proven, but will be sufficient for many years of CO_2 emissions.
- CO_2 is regularly transported safely in pipelines across large parts of the USA and Canada.
- A number of technologies have been proposed which would potentially allow CO_2 to be captured directly from the air. Extreme care should be exercised when evaluating the climate benefits and scalability of such processes.
- Boot-Handford, M. E., Abanades, J. C., Anthony, E. J., Blunt, M. J., Brandani, S., Mac Dowell, N., Fernández, J. R., Ferrari, M.-C., Gross, R. & Hallett, J. P. 2014. Carbon capture and storage update. *Energy & Environmental Science,* 7(1), pp 130-189.

Levelised Cost of Hydrogen (LCOH)

- Many TEA approaches; simplest (and most common) is the LCOH

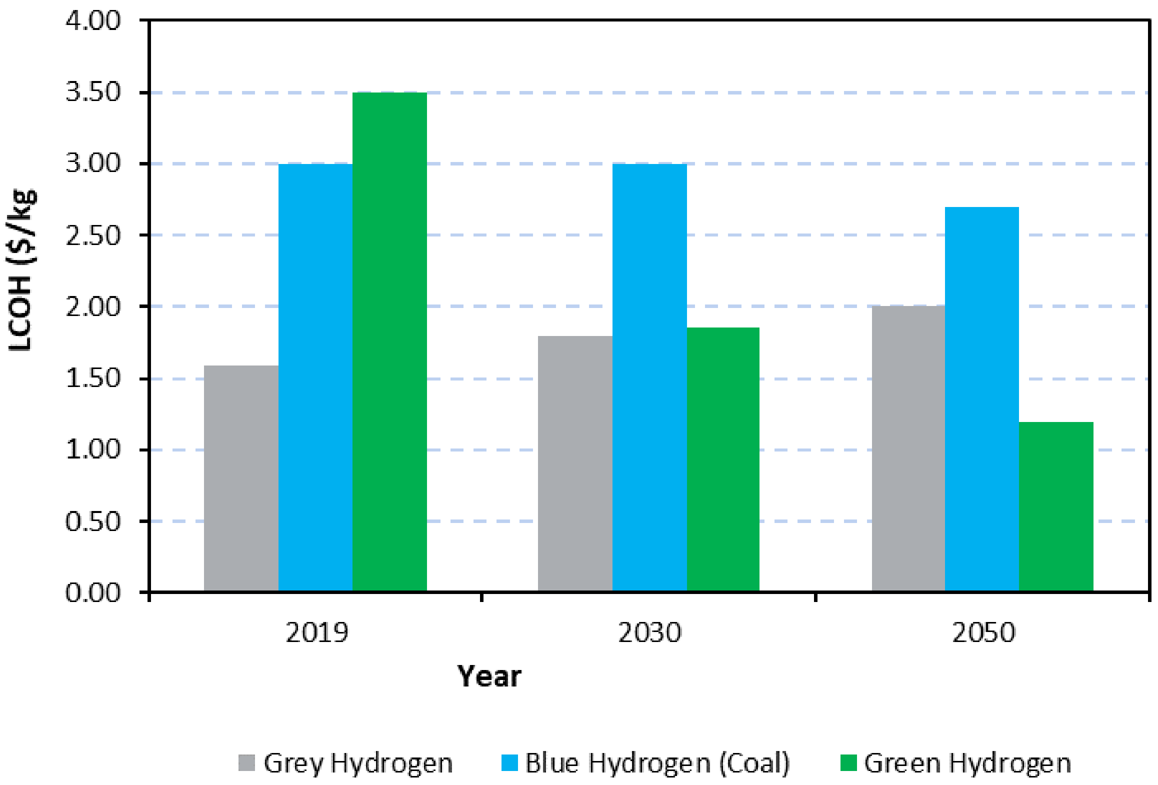
$$LCOH = \frac{Sum\ of\ Discounted\ Costs\ over\ Lifetime\ of\ System}{Sum\ of\ Discounted\ Value\ of\ Hydrogen\ Produced\ over\ Lifetime}$$

$$= \frac{\sum_{t=1}^{n} \frac{I_t + O\&M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{H_t}{(1+r)^t}}$$

where:

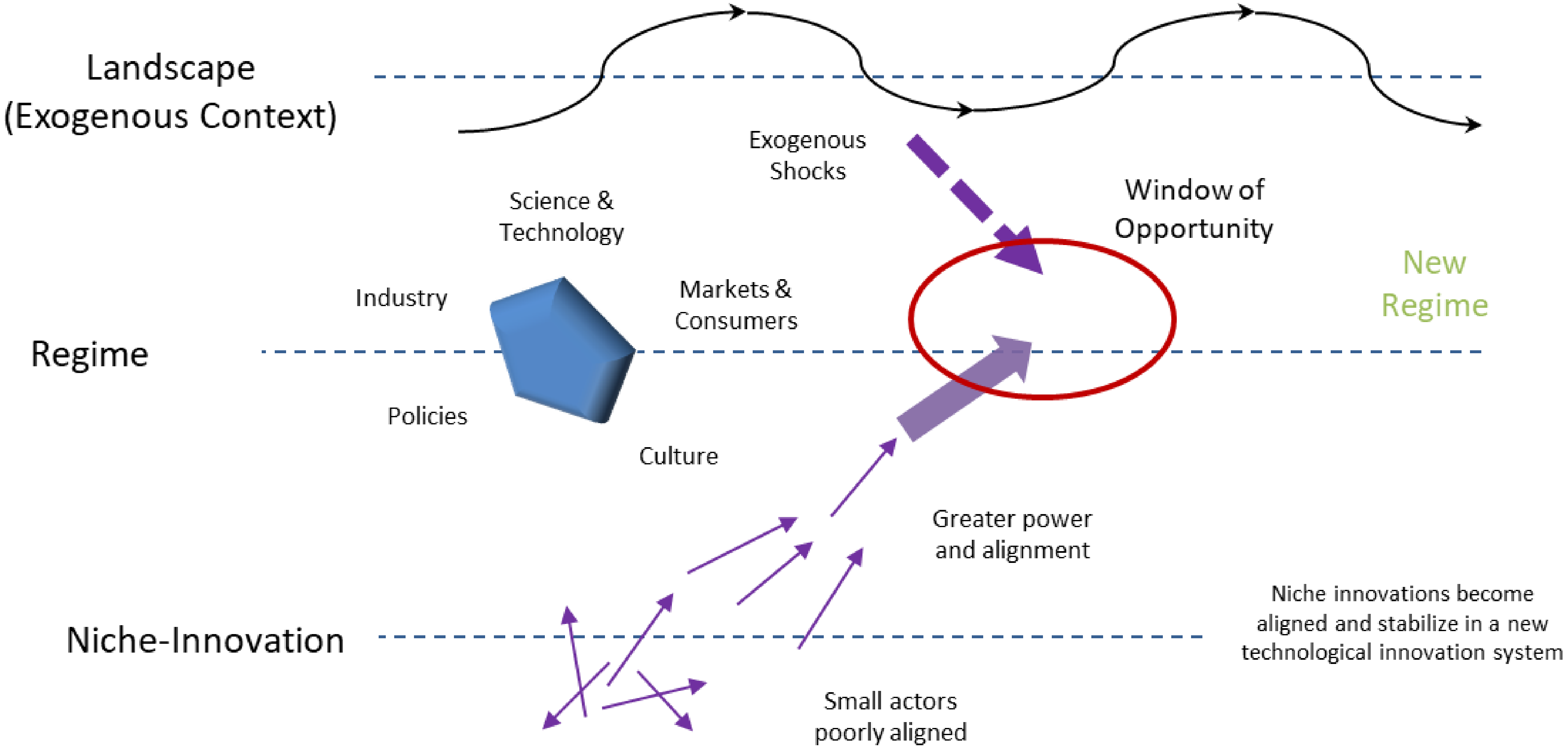
I_t	= investment expenditure in year t ($)
$O\&M_t$	= operational and maintenance cost in year t ($)
F_t	= fuel cost in year t ($)
H_t	= hydrogen output in year t (kg)
r	= discount rate (%)
n	= expected lifetime of the system (years)

LCOH by Colour



Noussan, M., Raimondi, P. P., Scita, R. & Hafner, M. 2021. The Role of Green and Blue Hydrogen in the Energy Transition—A Technological and Geopolitical Perspective. *Sustainability*, 13(1), pp 298

Insights from the Multi-Level Perspective



Summary - Arguments For and Against

- For
  - Retention of coal mining jobs in the short t
  - In the short term, it may be a quick
  - Meets some of the JT concer
- Against
  - New pathwa
  - New se who will be difficult to dislodge
  - Ongoing emissions
  - High tech ical risk
  - Likelihood of sunk investment and lock-in to high LCOH

Coal is not the bedrock of our economy;
it is the nemesis!