

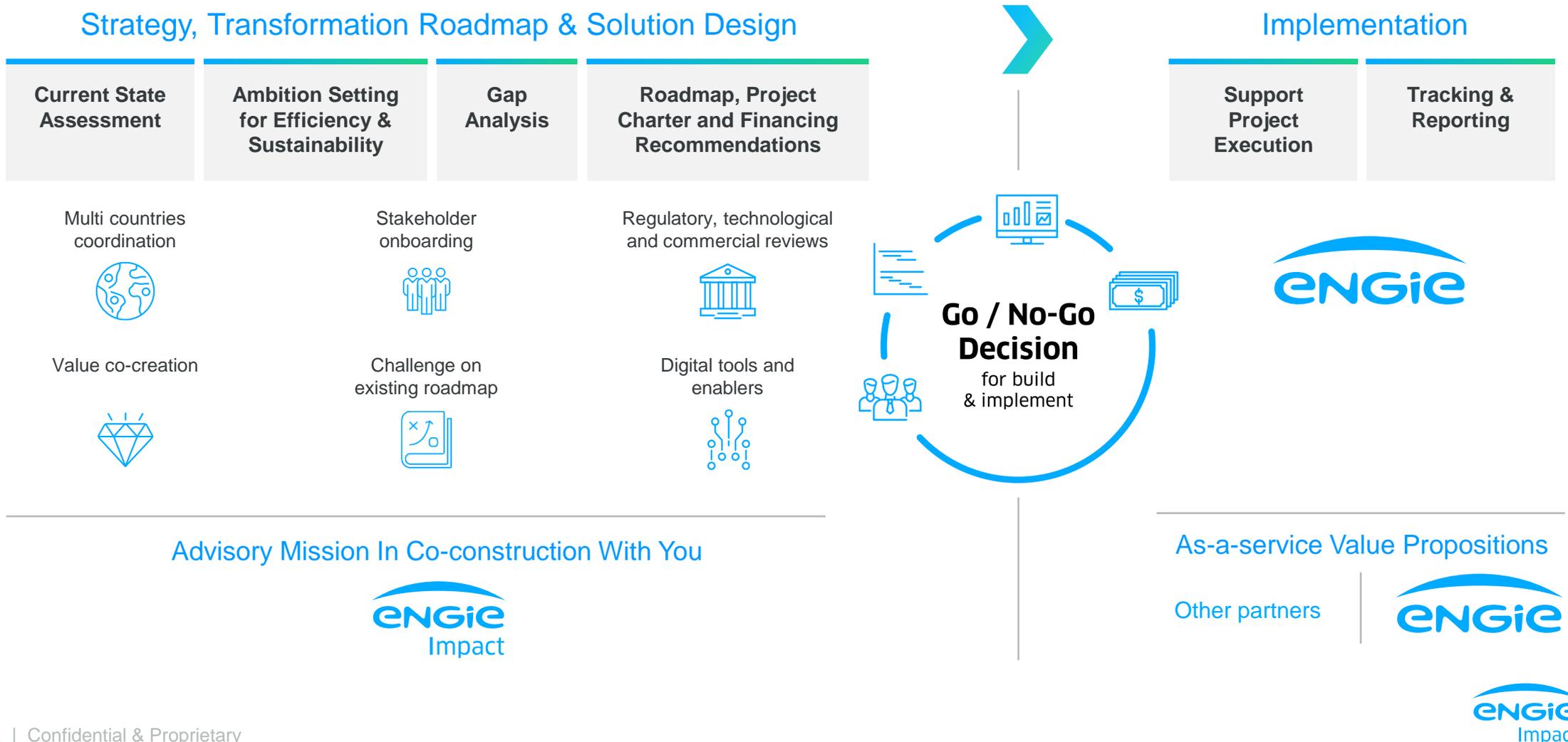
ENERGY AND MINES AFRICA VIRTUAL SUMMIT RENEWABLES FOR MINES

**Towards Zero-Emissions Mining:
How and When to Integrate
Hydrogen?**

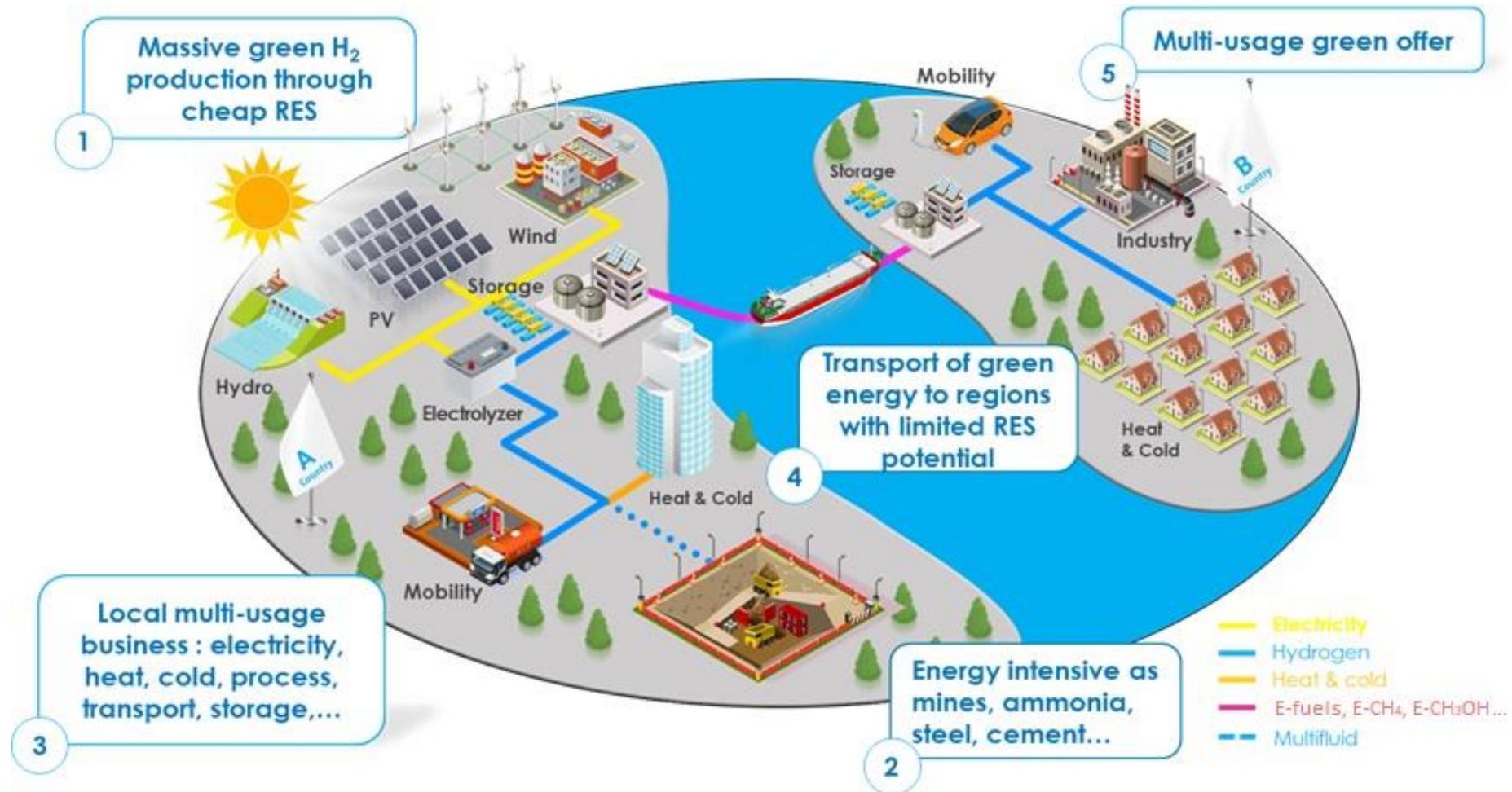


**Jasper Schrijvers
Consultant ENGIE Impact**

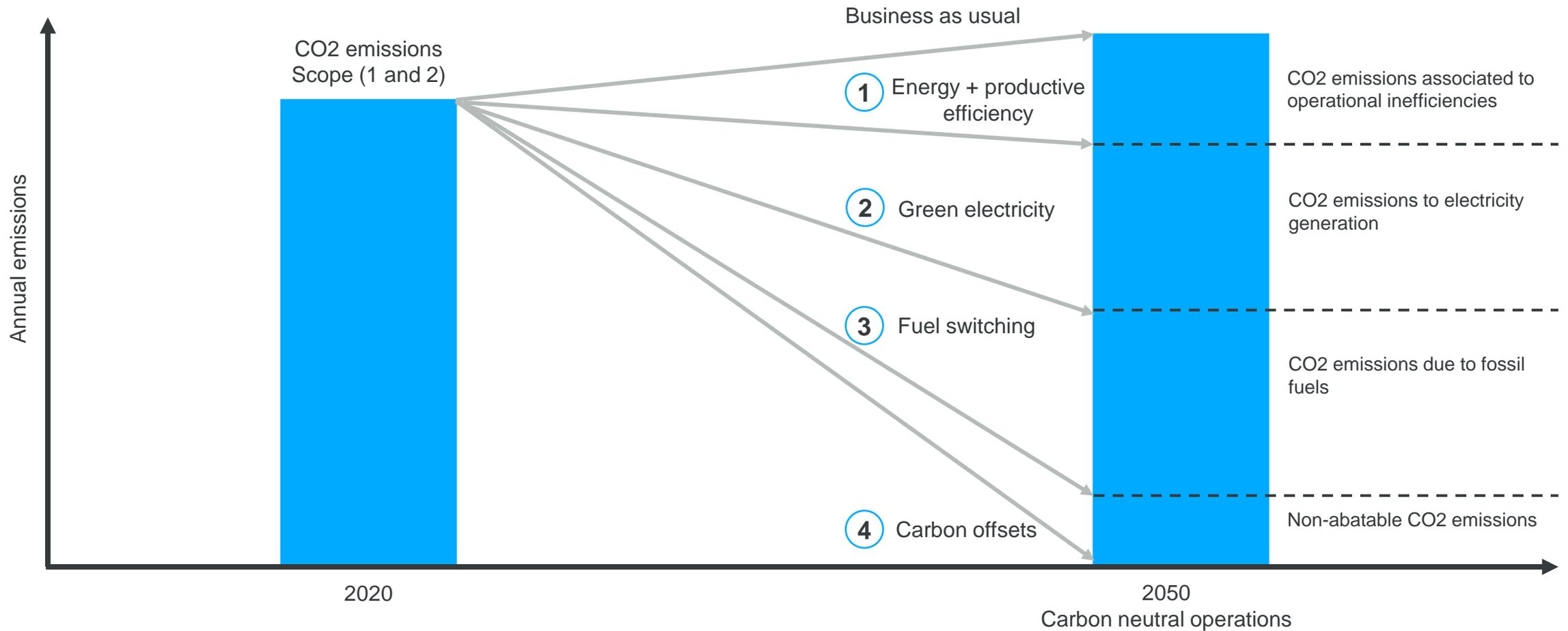
ENGIE Impact teams design decarbonization roadmaps with an open, flexible, end-to-end approach



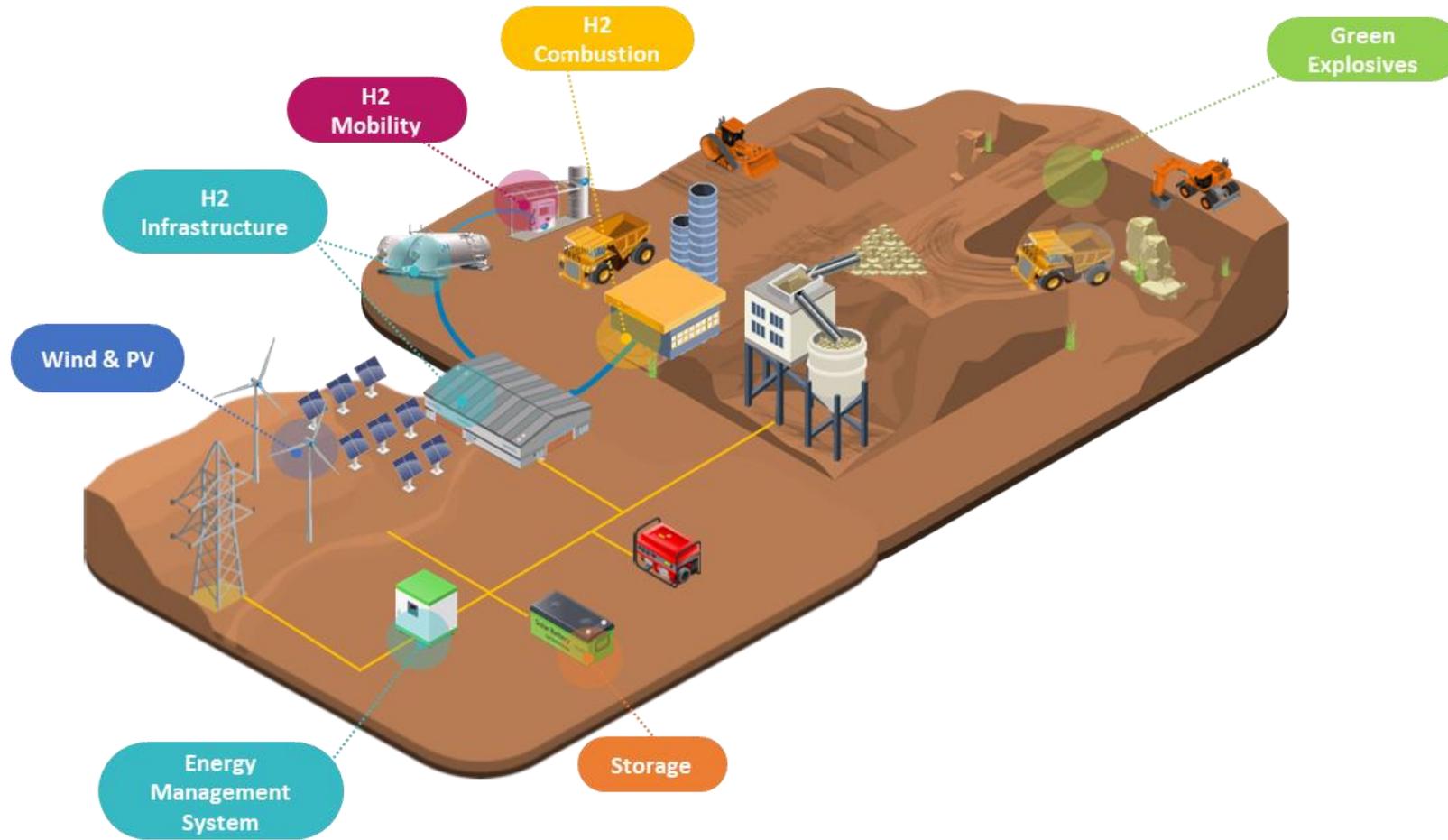
ENGIE has a separate H2 business unit with its own view on the future H2 economy



Within the road to net-zero mining H2 plays an important role in green electricity and fuel switching

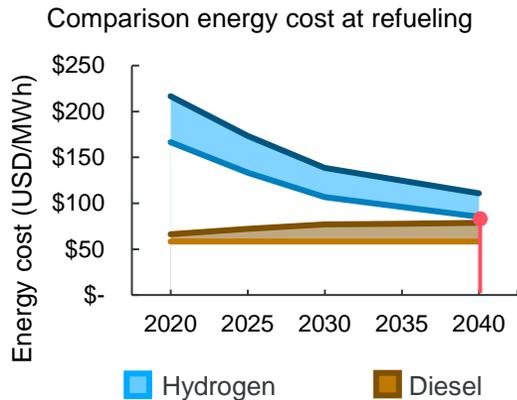


H2 has different mining applications and is an enabler for on-site renewables



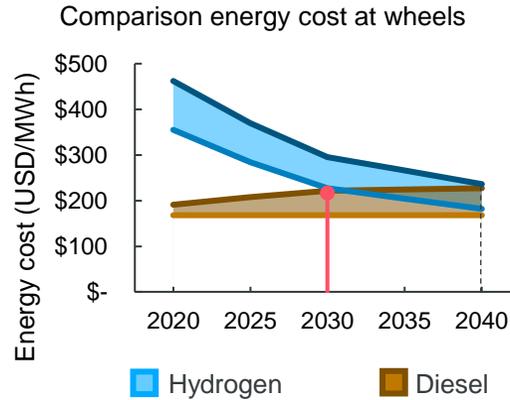
TCO for mining trucks can become competitive before 2030 due to higher efficiency and runtime, in addition to CAPEX & LCOH decrease

Even though the **energy cost parity** at refueling is unlikely to be achieved before 2040...

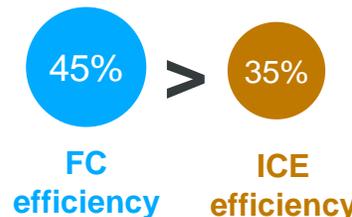


- Hydrogen technology costs are expected to **decrease in both CAPEX and OPEX**.
- The electrolyzer market is supposed to grow sharply from 2025.
- Energy cost parity is expected to be achieved by 2040 in a favorable scenario.

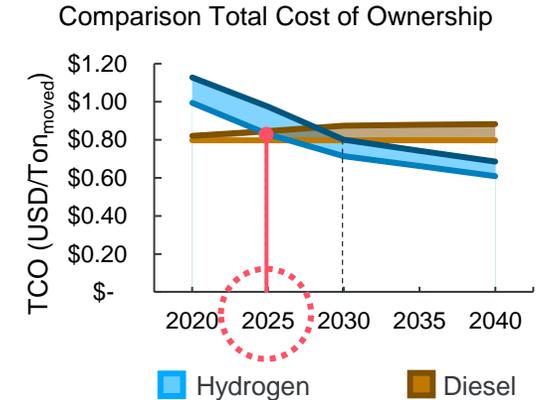
... the **efficiency** of a fuel cell is higher than the internal combustion engine...



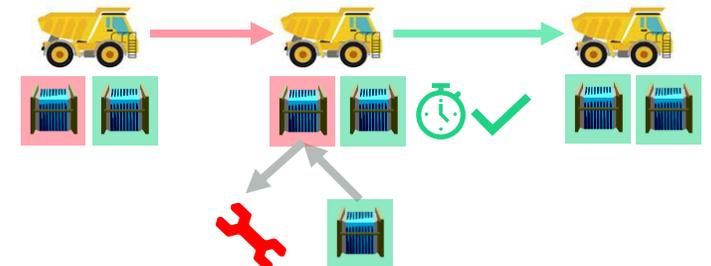
- The **average efficiency** of a Fuel Cell (FC) module is around 45%, while an Internal Combustion Engine (ICE) is below 30%.
- Regeneration** of energy going downwards in battery.



... and there is an important TCO reduction due to higher **availability & productivity**

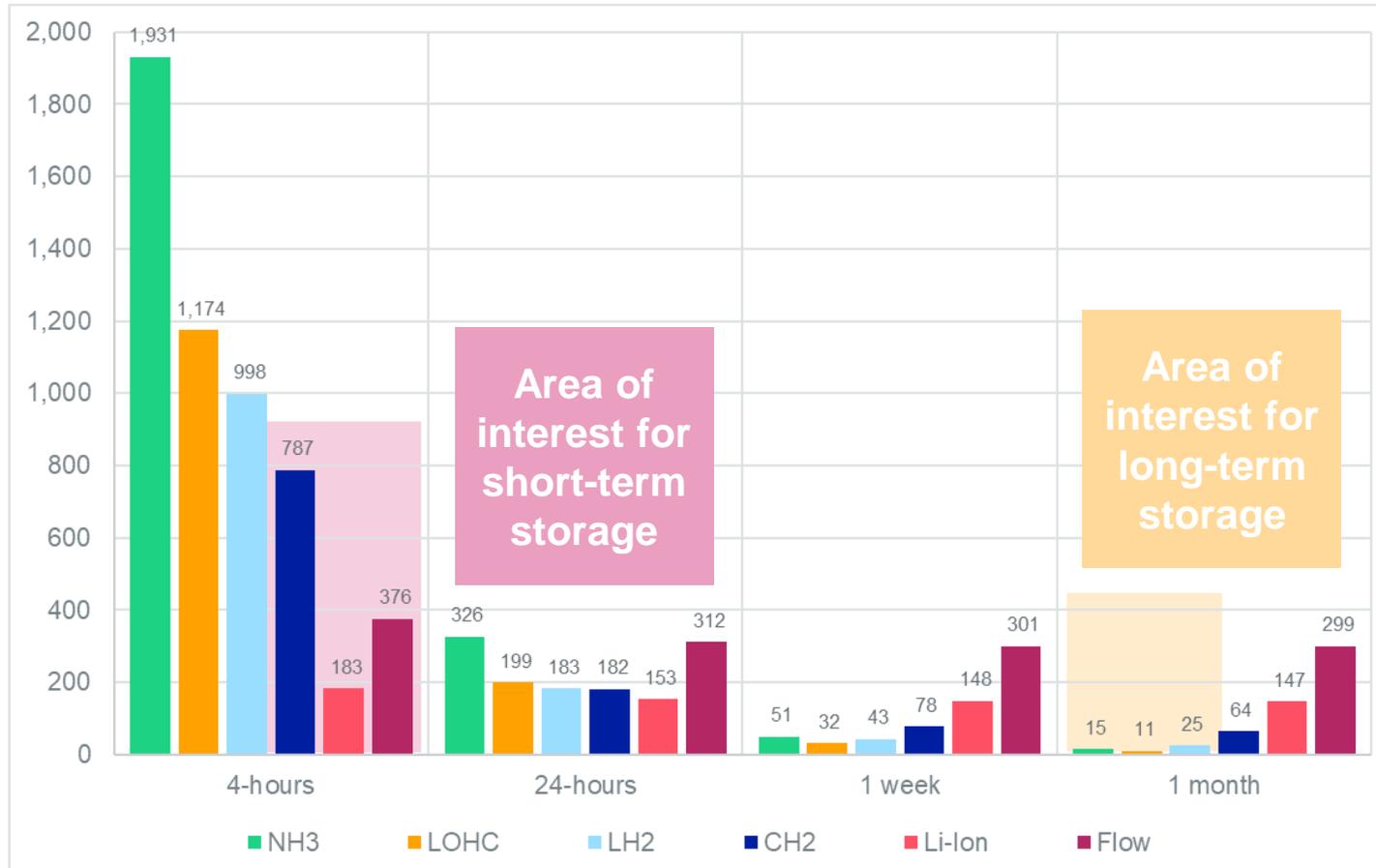


- FC modularity allows **redundancy strategy** and **quick replacement**, increasing the propulsion system's mechanical availability.
- Increase in mechanical availability **increases runtime** and **decreases fleet size**.



H2 is the ideal technology for long term energy storage while batteries are the best for short term storage

Storage cost for different storage time (\$/kWh_el)



NH3- Ammonia, LOHC – Liquid Organic Hydrogen Carrier; LH2 – Liquid Hydrogen

- **Li-ion batteries** are the most cost- competitive **short-term electricity storage** option.
- **Compressed hydrogen** is the most cost- competitive **short-term hydrogen storage** option.
- However, **hydrogen- based storage technologies** are more cost-competitive for **long-term energy storage**.
 - **LOHC** is the **most cost-effective** option
 - **On-site NH₃ production** is the **second most cost-effective** option, as the high relative cost of small-scale ammonia production offsets the low cost of ammonia storage.
 - **LH₂** is the **least cost-effective** option, as its technological and commercial maturity does not compensate the **high relative cost**.



Let's continue the journey together

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