Cointegration:

Optimal Carbon Capture, Utilization and Storage and the Urgent Need for Sustainable Energy

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Carbon Recycled Energy

10th Session of the Group of Experts on Gas

24 March 2023, Palais des Nations, Geneva

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Three challenges to respond to customers need for affordable energy:

1. **Integration of the energy system as a whole in order to make it resilient and sustainable. Volatile energy demand and intermittency highlight that only co-integration is realistic.**
2. **Industry (*still*) needs a long-term perspective *NOW* in order to invest into new assets and bring resources to the market.**
3. **Elasticity of supply to customers and utilization of existing infrastructure needs to improve *NOW* in order to underwrite strong returns on assets and moderate prices.**

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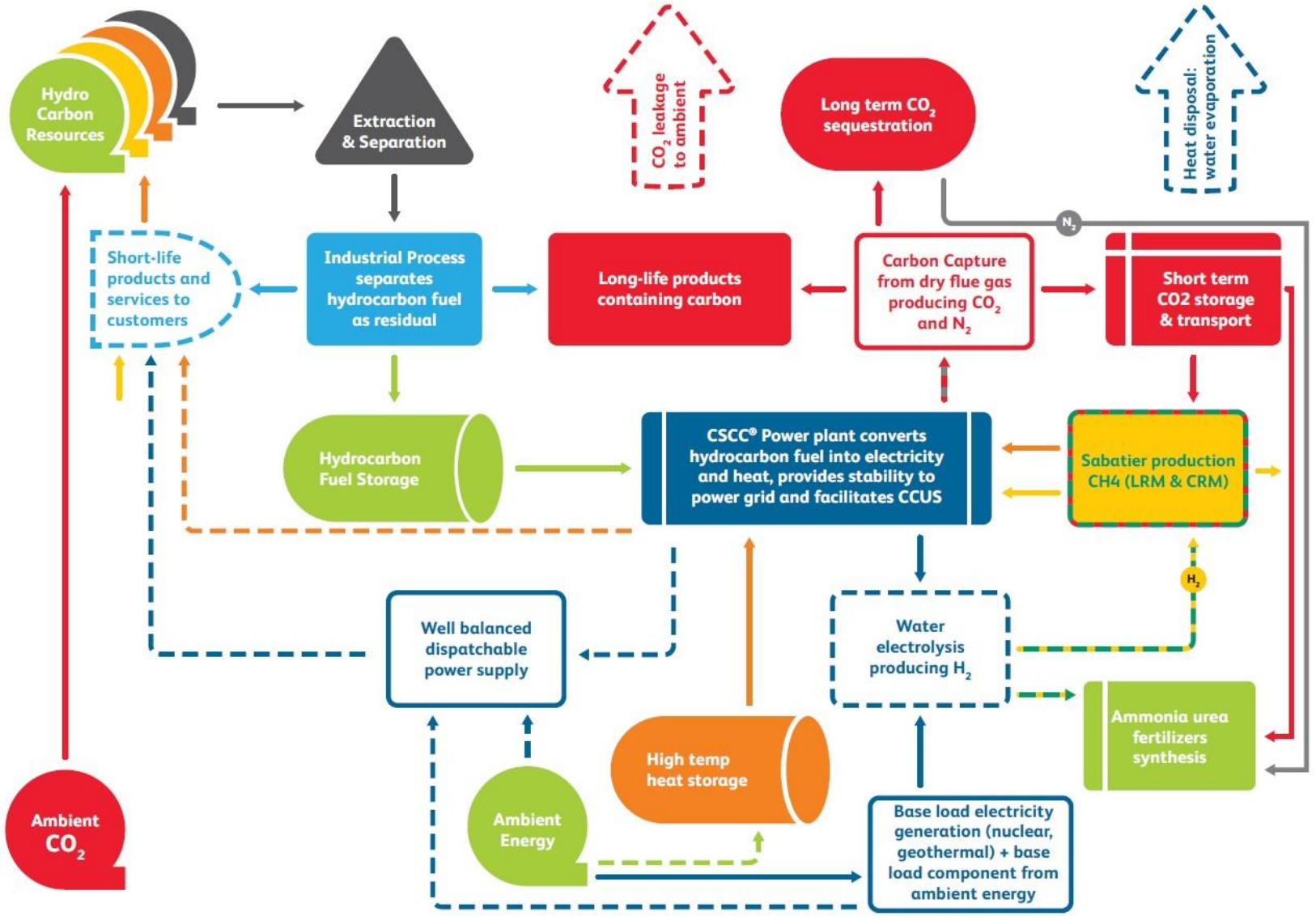
Cointegrated Steam and Compression Cycle (CSCC®) Power plant (BioFlex®) is *a tool* to deliver:

- Dispatchable electricity
- Stability to the grid
- District heating services
- Low cost biogenic bCO_2



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+ Biogenic bCO_2

(production, transmission and storage)

+ *Hydrogen from water electrolysis made by sustainable electricity blend*

=

Renewable Methane (LRM or CRM)

+ Industrial grade heat

+ oxygen

Fuel	Energy transit by equivalent gas pipeline compared to natural gas equivalent
Hydrogen	0.303 x
Methane derived from LRM or LNG	1.15 x
CO_2 (used for methanation with H_2)	**1.84 x**

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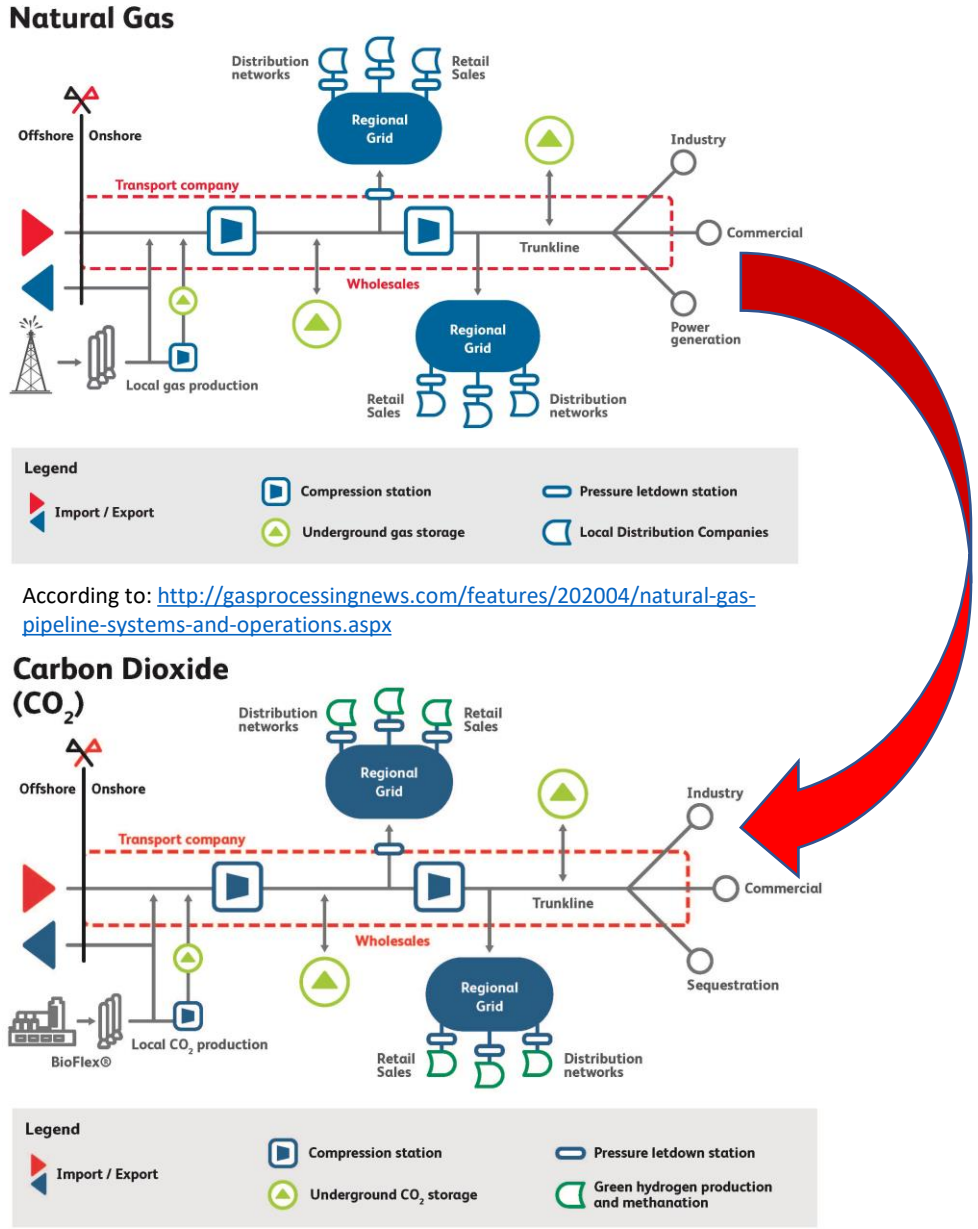
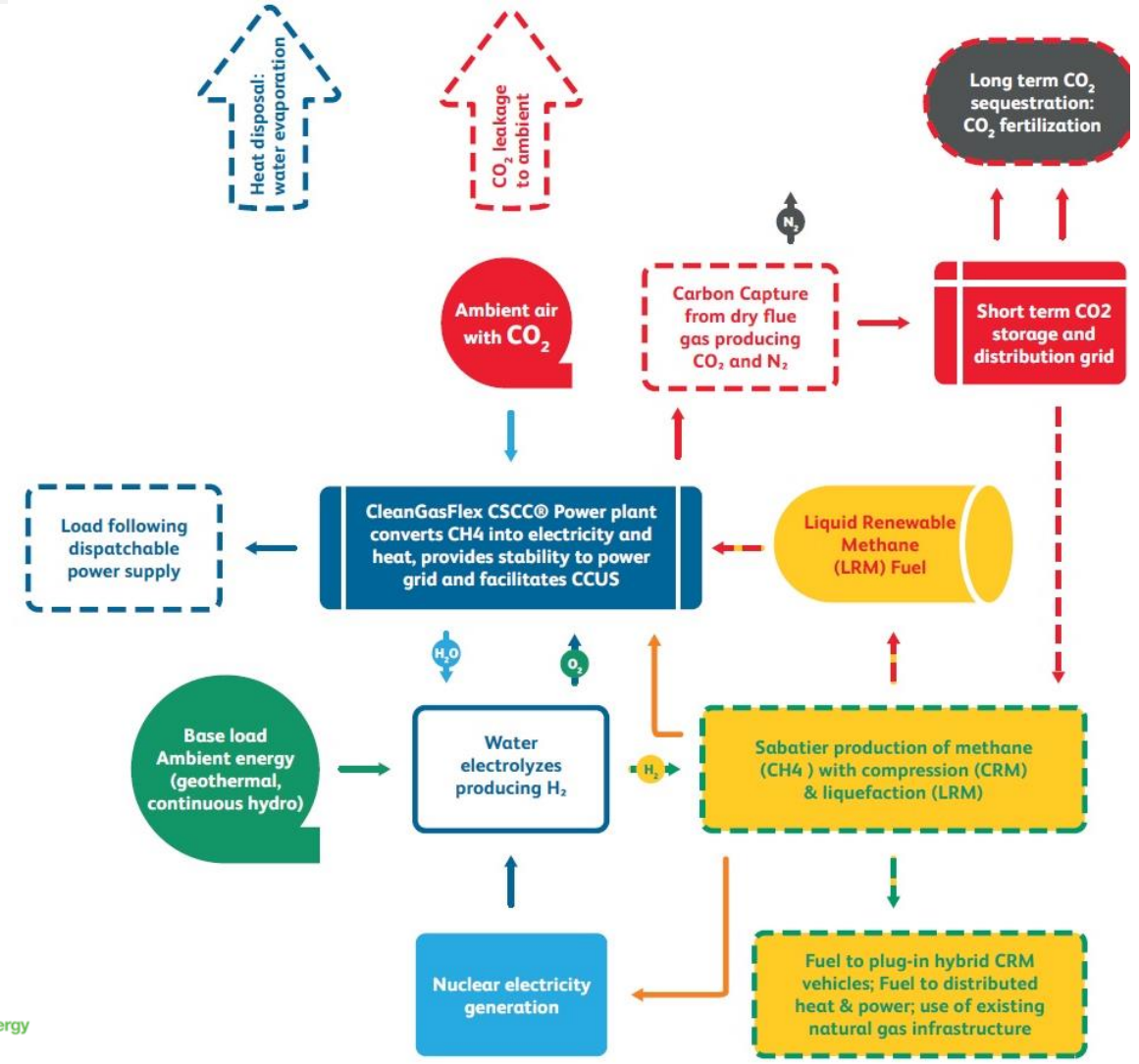


According to: http://gasprocessingnews.com/features/202004/natural-gas-pipeline-systems-and-operations.aspx

Infinite recycling of CO2 from power generation and marine propulsion allows economic use of green hydrogen

Recycling and storage of CO_2 enables production of Liquid Renewable Methane (LRM) with green hydrogen made by sustainable (carbon neutral) electricity to maximize utilization rate of electrolyzes.

LRM is suitable to use in standard LNG and to re-gas into standard gas infrastructure.



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Simple quantitative sustainability criteria and economic outlook

Biogenic $_{b}CO_2$ captured and used for LRM production	=	CO_2 emitted into atmosphere from moveable and sources where carbon capture is difficult
CO_2 from fossil fuel combustion that is not recycled	=	CO_2 to long term sequestration
Green hydrogen price of 1.5$/kg	→	LRM from 8-14 $/mmBTU or LRM from 25-40 €/MWh

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Available biomass and wind resources in EU27 sufficient to deliver sustainable energy for heat, power and mobility

- **2500TWh** of sustainable biomass suitable for BioFlex® combustion per year;
- Generating ***1211TWh*** *of electricity* and
- ***537 million metric tons*** of biogenic $_{b}CO_2$, sufficient to mix with
- **Green Hydrogen** produced annually by **1610TWh of carbon neutral electricity**
- Producing ***2750 TWh*** of **LRM** or **CRM** for transport.

- In 2019, coal, gas and petroleum produced only **1072TWh** of electricity
- As plug-in hybrid compressed renewable methane (CRM) vehicle is about 16% more efficient than diesel vehicle, **2750TWh** of CRM replaces **3190TWh** of fuels consumed in road and inland waterway transport that emit >70% GHG from transport.
- Readily available waste heat is equivalent of over **90BCM** of pipeline gas during heating season

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1. **Co-integrated Steam & Compression Cycle (CSCC®) principle is a tool to co-integrate energy system including electricity, heat and mobility**

2. **Perspective to repurpose conventional gas infrastructure to CO_2 and pure methane in the future, enables investments *NOW*; co-integrates the energy system; increases returns and facilitates sustainability**

3. **That disarms energy as a political weapon and enables the integration of modern commodity markets across UNECE area**

NOTE: ***There is an accompanying White Paper, "Co-intearation" which will be made available to the Secretariat for distribution.***

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