European Hydrogen Week

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euhydrogenweek.eu

Carbotopia

Session 12: Waste to Hydrogen Production

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Introduction: Stefan **Petters**
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Speakers: Vjekoslav **Majetić**, Indeloop; Nadia **Romdhane**, Green Hydrogen Technologies; Matti **Malkamäki**, HyCamite; Christian **Bestien**, Haffner energy

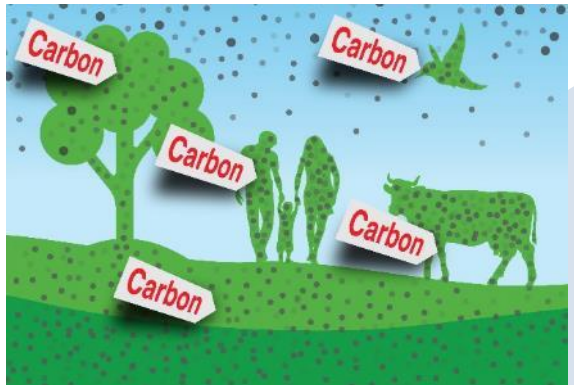
Did you know, waste comprised of various moisture ligated end of life Carbohydrates and Hydrocarbons has an average atomic Ratio of intrinsic compounded with moisture's Hydrogen to Carbon Ratio of $\geq$ 2:1?

This means that for Molecule2Molecule transformations Waste is as good a feedstock alike Methane [CH_4]! This is 2.25 times the H_2:C-Ratio of Oil! So, why drill Oil for what we can make from our Wastes?

How SMART is co-incineration of Waste - combustion fuel together with its extinguishant Water, for inefficiently destroying Molecules2Electrons? Transforming Waste-Molecules2Molecules of new Energy Carriers at 37% the CO_2 intensity of their production from Oil?

Why squander our Wastes' CH_4-like total Hydrogen : Carbon Ratio?

Hydrogen can be dissociated from its Carbon-bonds and out of Water



H_2:C=1.2+50% H_2O

∑ 2.0H_2/C → 0.2CO_2/H_2

H_2:C=1.6+40% H_2O

∑ 2.2H_2/C → 0.14CO_2/H_2

- Why co-fire Fuel with extinguishing agent → Water?

H_2:C=0.9 → 0.5CO_2/H_2

- We can build wealth from what we pay to be burned!

- **Waste Transformation into new energy carrier Molecules can come at just 37% the CO_2-intensity of Oil!**

Just for you to experience the discrepancy in Efficiencies, let me touch your emotions by basing comparisons on the mobility application of achievable outputs, not necessarily suggesting to use all for fueling cars!

Typically incinerated Household Waste of ~160 000 citizens requires a plant for 43MW_{chem} and could turn out 9MWh^{-1} Electricity. According to EIT Europe Statistics such 72GWh/yr would need 20 3MW Windmills.

This amount of Electricity could charge 10 000 BEV for 100km/d each. Transforming the Electrons2Molecules in Electrolysis Hydrogen though only 3 600 HFCV for the same range. In contrary transforming Waste-Molecules2Hydrogen could refuel 12 500 HFCV for 100km/day (3.5 x)

Resource-Efficiency [SDG12] of Waste versus W2E equiv. onshore Wind

measured in № E-Vehicles 100km/day refueling

1 plant per 160 000cpt

43MWh$_{chem}$

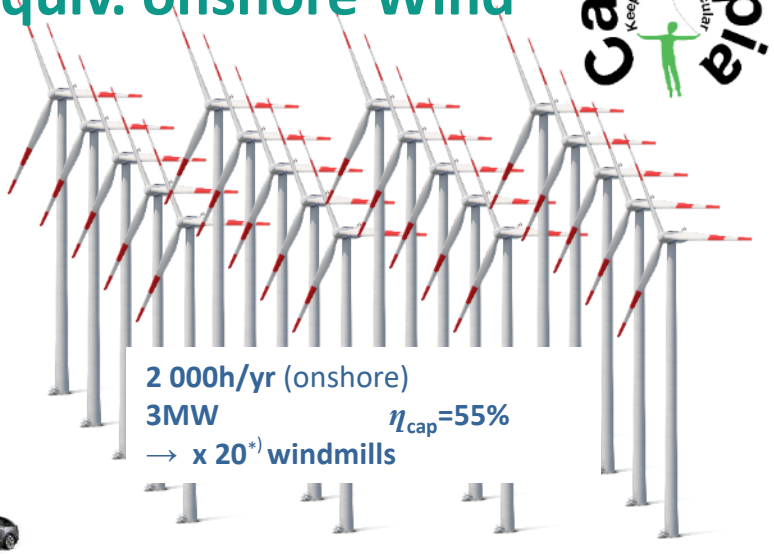
24/365 @ η_{avail} = 90% **Waste incineration**

50km Radius
EU27 ø1mln capita

9MWh$_{electric}$

equivalent

10 000 BEV



2 000h/yr (onshore)
3MW η_{cap}=55%
→ **x 20**[*)] **windmills**

9MWh$_{electric}$

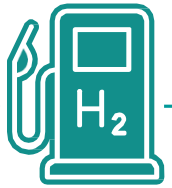
1 300tpy ← 60MW ✚

12mln Liter auxiliar **H₂O** ??

3 600 ←

refine

from intrinsic
H_2:C ratio incl. H_2O
✚ **10mln Liter** auxiliar **H_2O**



12 500 HFCV

W2H₂ η_{chem} = 50% → **4 500tpy**

*) EIT Europe Statistics

Often emotionally discussed E-Fuels from $_{gn}$Hydrogen & CO_2 Synthesis would bring the Electricity's Usage-value down to just refill 870 ICE cars for 100km/d, which is less than 9% of BEV's range.

Transforming Waste-Molecules2Molecules for a Fisher Tropsch Synthesis Fuel on the other hand could fill up 5 400 ICE Vehicles for 100km/d and would suggest itself as a 6 times more efficient alternative to E-Fuels.

In this point I propose to bare the comparison in mind, when rather talking of aviation than road-vehicles, I have only chosen exemplarily here to make it easier for everyone to relate to the results.

Resource-Efficiency of waste derived Syngas versus W2E equiv. E-Fuel

measured in № ICE-Vehicles 100km/day Synthetic Fuel fill-ups

1 plant per
160 000cpt

100 000tpy

24/365 @ η_{avail} = 90%

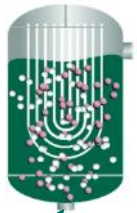
43MWh$_{chem}$ -1

50km Radius
EU27 ø1mln capita

Syngas Platform
Vienna at MA48
1110 Pfaffenau

from intrinsic
H_2:C ratio incl. H_2O
5mln Liter auxiliar **H_2O**

Fischer Tropsch Synthesis

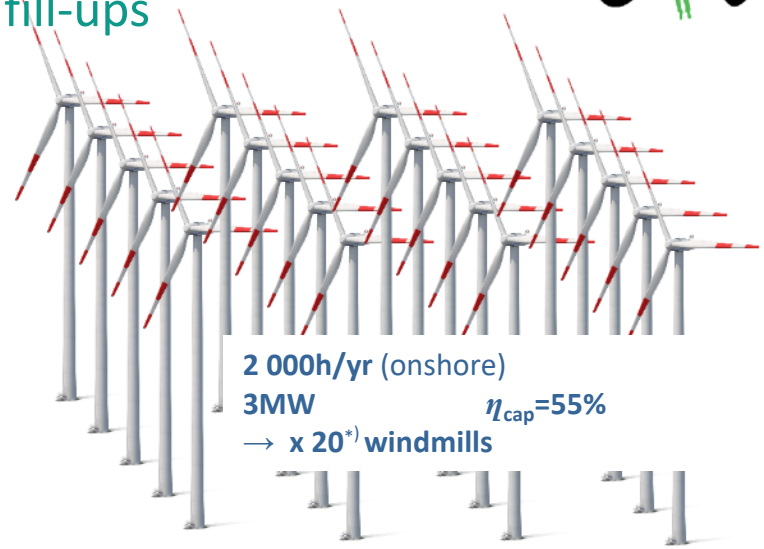


→ **13.7mln Liter/yr**

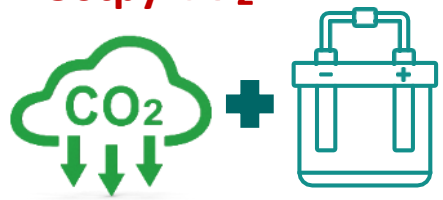
→ **5 400**

ICEV

W2E$_{lectricity}$
equivalent



1 300tpy H_2 ← **60MW**
7 150tpy CO_2



12mln Liter
auxiliar **H_2O**
??

870 ← **2.2mln Liter E-Fuel/year**

*) EIT Europe Statistics

Well, the Future is already among us, just not distributed easily perceivable yet! While the so far discussed options still relied on CO_2-neutrality of Waste, there already exist several Technologies to become CO_2-negative!

Nature's sole heir of residual energy from ceased matter is CH_4. So, all Technologies for accelerated transformation of carbonaceous residues into Energy rich Gases can use the natural equilibrium reaction into CH_4 to be split into molecular Carbon and so-called Turquoise Hydrogen colloquially referred to as Methane Pyrolysis.

Applying such a process-flow directly derivable Hydrogen can refuel 9 000 HFCV plus a Synthesis of Water Gas - partial Shift off the Carbon enables refilling 3 500 ICEVs in addition for 100km/d each.

Resource-Efficiency by waste Methanization combined with CH_4 Pyrolysis

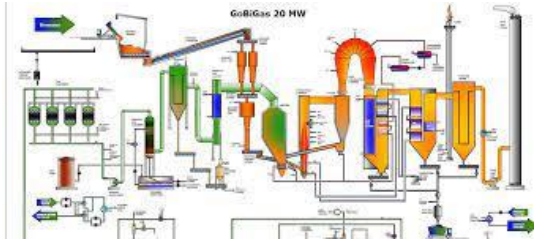
derived Synthetic Fuel № ICEVs plus HFCV for 100km/day each

1 plant per
160 000cpt

100 000tpy

43MWh$_{chem}$

Wood 2 Methane
Gothenburg

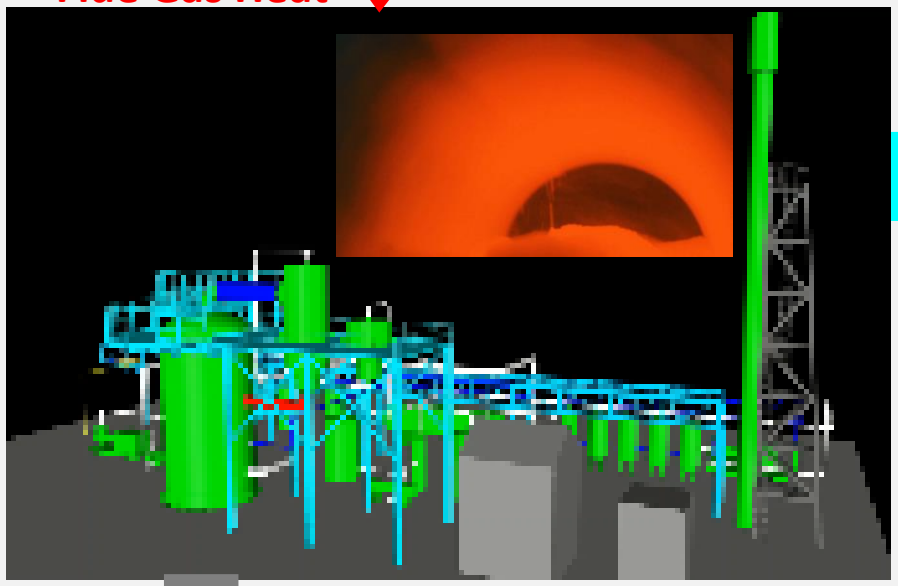


50km Radius
EU27 ø1mln capita

28MWh$_{Bio-SNG}$

3MWh^{-1}
Flue Gas Heat

CH_4 TCD

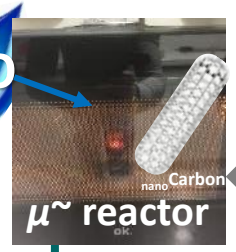


15MWh^{-1} H_2

3 000tpy

12MWh^{-1} Carbon

-4MWh$^{-1}_{RE}$ → + 2mln Liter
auxiliar H_2O



$CO+H_2$

9mln Liter/yr SF → 3 500 ICEV

+

9 000 HFCV

∑ 12 500 Cars

Ranking applied here primarily refers to Use of Energy-Molecules (not direct Use of Electrons)! Batteries of course are Energy storages that can within their cycling capacities store electric charges (in Molecules).

However, for any Energy storage exceeding cycling capacities of batteries Energy carried by Molecules is more practical than in Electrons. Hence, the less Molecules destroyed through transformation processes, the better.

Further, Climate Neutrality requires utmost Carbon- and Water- Efficiency privileging low Water consuming processes that retain Carbon molecular.

Basically, the shown Synthesis of Pyrolysis to Fuel is a kind of E-Fuel, but more economic due to the preservation of molecular Carbon and lower Water-Usage.

The advantages of Moelcules2Molecule over Electrons2Molecules

measured in № Vehicles 100km/day refueling

Waste 2 . . . . . Electricity

→ Hydrogen →

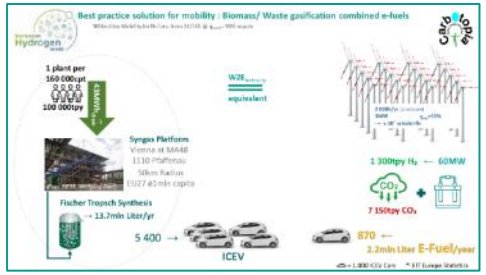
10 000 BEV

≡ 20 x 3MW onshore Wind + 60MW Electro-lysis

- 3.5 times Electrolysis H_2
- @ 22% auxiliary Water
- Adding Value to Waste
- eliminating incinerators' uncovered Cost overruns

Total 12 500 HFCV versus 3 600 from Electrolysis

Waste 2 Synthetic Fuel



→

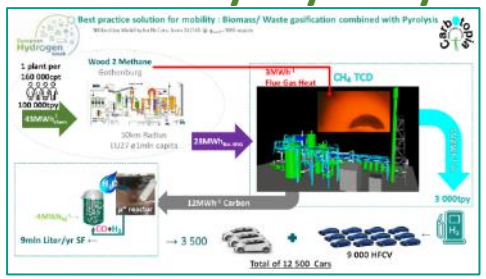
2.3kg CO_2-mitigation per Liter Syn-Fuel

3.25kg CO_2-Use per Liter E-Fuel

- 6.2 times E- Syn Fuel
- @ 6.7% auxiliary Water
- Adding Value to Waste
- Eliminating incinerators' uncovered Cost overruns

Total of 5400 ICE Cars versus 870 from E-Fuel

Waste 2 Pyrolysis Hydrogen & Syn Fuel off Carbon



→

USP n.a. for electric

- Flexible for existing ICEVs
- @ 60% aux. Water of SF
- All European Technology
- supply chain autonomy
- Compatible for Bio- & Hybrid- Gas feedstocks

optional 3 500 ICEV plus 9 000 HFCV, in Total 12 500 Cars or HFCV only

Carbotopia® had Economica Institute analyze the Macro-Economic effects of Waste-Transformation with downstream homogenization of the decomposition-Gas into adjustable chemical synthesis stoichiometries.

The Employment effects from building and operating such bio-refineries showed a 14% Fiscal Return from Employment charges and overheads.

At Zero Feedstock Cost operations are profitable at €5/kg H_2 & €1.6/ltr Synthetic Fuel. Under maintained PPP-Charges' negative Feedstock Costs could subsidize the Hydrogen price 90% at remaining Synthetic Fuel Cost.

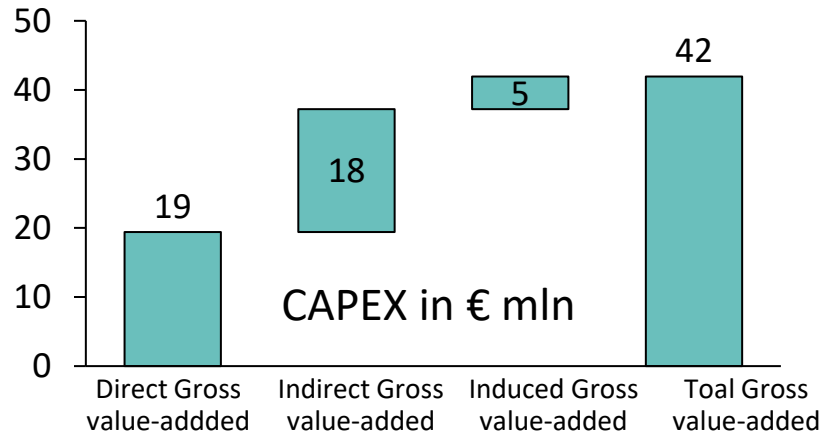
So, the most sustainable solution would also be most economic for all, changing the so far maintained paradigm that doing good must cost more.

Socio-economic value Impact of combined gasification & pyrolysis

Macro-Economics study of a 43MW Carbotopia® Bio-Refinery (Economica Institute)

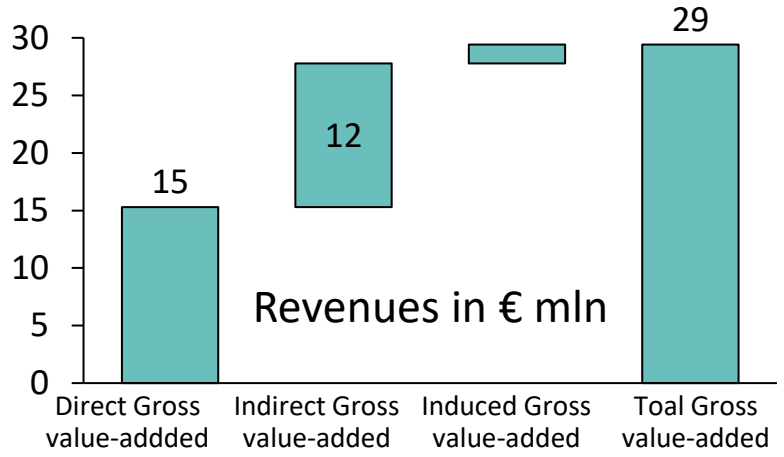
Investment Phase

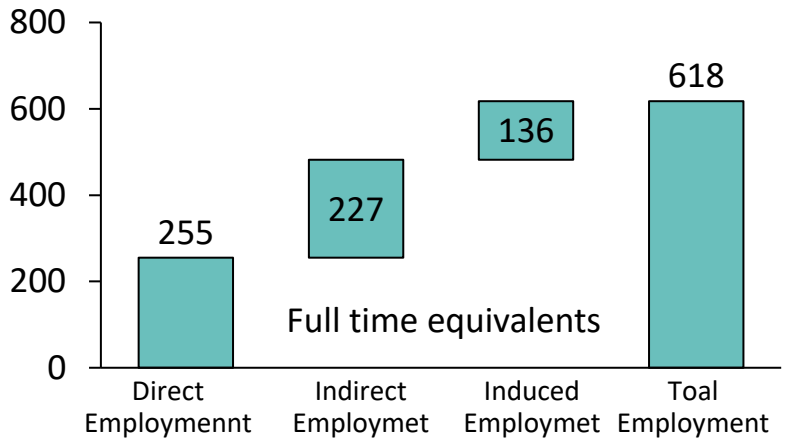
at e.g.:
5 yrs
Amoritzation



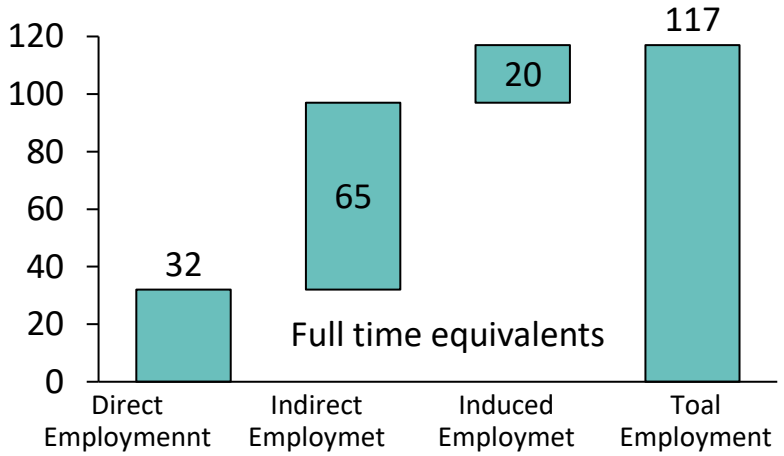
Operations Phase

at e.g.:
1kg H_2 = €5.0
1ltr SF = €1.6
20% Profit





plus
14% Fiscal Return from Employment Charges (in AT)



Source: Economica Institute 2012 for Carbotopia®

EU27-Population of ~450mln at here assumed Waste volumes could employ 2 800 43MW Bio-Refineries. The current target of 10Mt Hydrogen in Europe could be produced by 2 220 plants.

All Technologies for such Bio-Refineries have been developed in Europe and given it being a self-refinancing Waste treatment method can be rolled out to the Rest of World, e.g. under Carbon Trade Financing Schemes.

So far Asset impairment of existing incinerators had been a big barrier. However, Europe still landfills about an equal amount as it incinerates. Most of us have no imagination how much land landfills make unusable! Further, increasing extreme weather events washing out landfills are a major root-cause for maritime litter!

Europe incinerates 26% and still landfills 25% of its Household Wastes

Why not become World Market Leader in Self- refinancing Waste-Valorization?

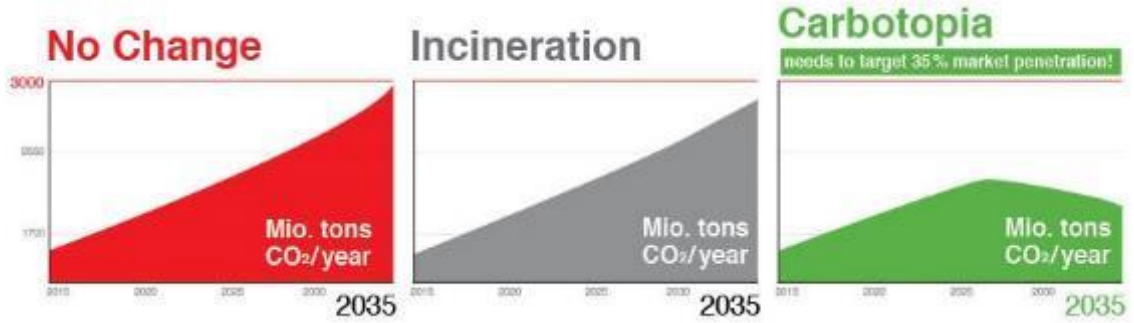
10 Plants versus Landfills:

2.2 Million Tonnes of CO_2 Equivalents/yr

65 Hectares of Landfill Area =

Turning around Climate Impact until 2035

Mio.ton CO_2 / year



4,500 plants until 2035 can save:

cumulated 5 Giga-ton CO_2 equivalents

4.3 km³ less landfill space =

Ramping towards 35% Market Penetration in 2035

Profit from waste-valorization driving roll-out;
€56 bln waste transformation revenues and
€20 bln plant equipment industry from:

4,500 plant licensees

540,000 new job creations

elimination of 1 Giga-ton CO_2 per year

Waste is an available resource and there's still a lot of room for reduction. Technologies are European and realization of outlined concepts are independent of import supplies. In contrary, they support circularity and allow to produce crystalline Carbon for Batteries, Bipolar Plates, electrodes or light weight composites.

Waste can be refined at 3-fold the Carbon- and 5-times Water Efficiency compared to Oil, grace to initially pointed out Hydrogen : Carbon Ratio. Given increasing Water scarcity the consequential Water savings may be the most decisive motive to chose this path in the long run.

Why not start now? See how many have done great preparatory work in this field already among our panel!

Summary

Isn’t Waste-Valorization a must in times of Energy-Supply security concerns?

- Waste is an available resource with a total H_2 : Carbon ratio of ≥ 2 (alike CH_4) that shouldn’t be wasted
- Utilizing waste-2-hydrogen via FCEV and ICE are 25% more effective than BEV (from W2E)
- Hydrogen can be split from and over Carbon at 20-35% of its Energy by pyrolysis or reforming
- Carbonaceous residues can be refined at 3-fold Carbon- & 5 times the Water- Efficiency than oil
- Today’s PPP-socialization of incineration’s uncovered Cost-overruns is like getting someone paid the value of a sellable house to just burn it down – but people don’t know what they’re forced to pay for!
- Why transform Molecules into not-storable Electrons that we lose when not synchronously used
- Water is an increasingly scarce resource and shouldn’t just be co-fired with biomass or trash

Panel Debate

Let’s just explore some of the numerous solutions so far politically suppressed

Vjekoslav Majetić, CEO, Indeloop

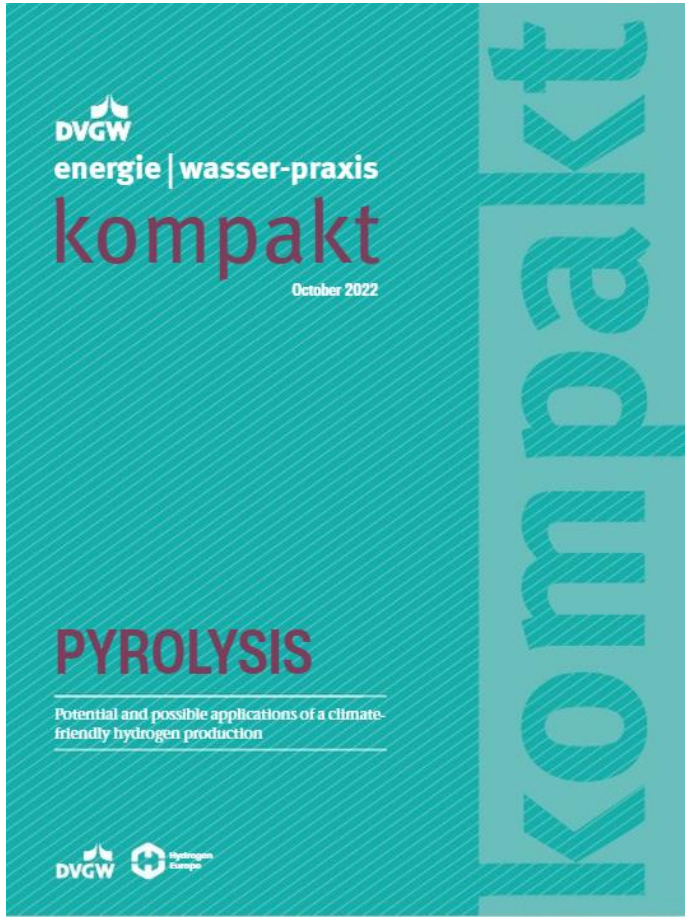
Nadia Romdhane, Head of Process Engineering, Green Hydrogen Technologies

Matti Malkamäki, Chairman of the Board, HyClamite

Christian Bestien, Director, Business development, Sales and Marketing at Haffner energy

Stefan Petters, guo – Business Development Consult

State of the art of pyrolyse and project descriptions in a brand-new joint DVGW – HE broschure



We must use all options!

An introduction to the perspectives for transforming the energy supply by **Prof. Dr Gerald Linke**, Chairman of the Board of DVGW e. V. and **Jorgo Chatzimarkakis**, CEO of Hydrogen Europe.

Source: DVGW

Source: Hydrogen Europe

Europe's energy supply is to become independent, diverse and climate-neutral - and that in just a few years. While the climate goals are to be achieved quickly in order to minimise the consequences of climate change, geopolitical risks due to dependence on energy imports from a few supply countries must be taken into account in parallel and the energy supply must be placed on a broad basis.

DOWNLOAD:
https://wvgw.de/dyn_pdf/ewp/2022/kompakt_Pyrolysis/

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