VOLTA CHEM

Electrification of the Chemical Industry

The global competitive landscape of the chemical industry after the energy transition

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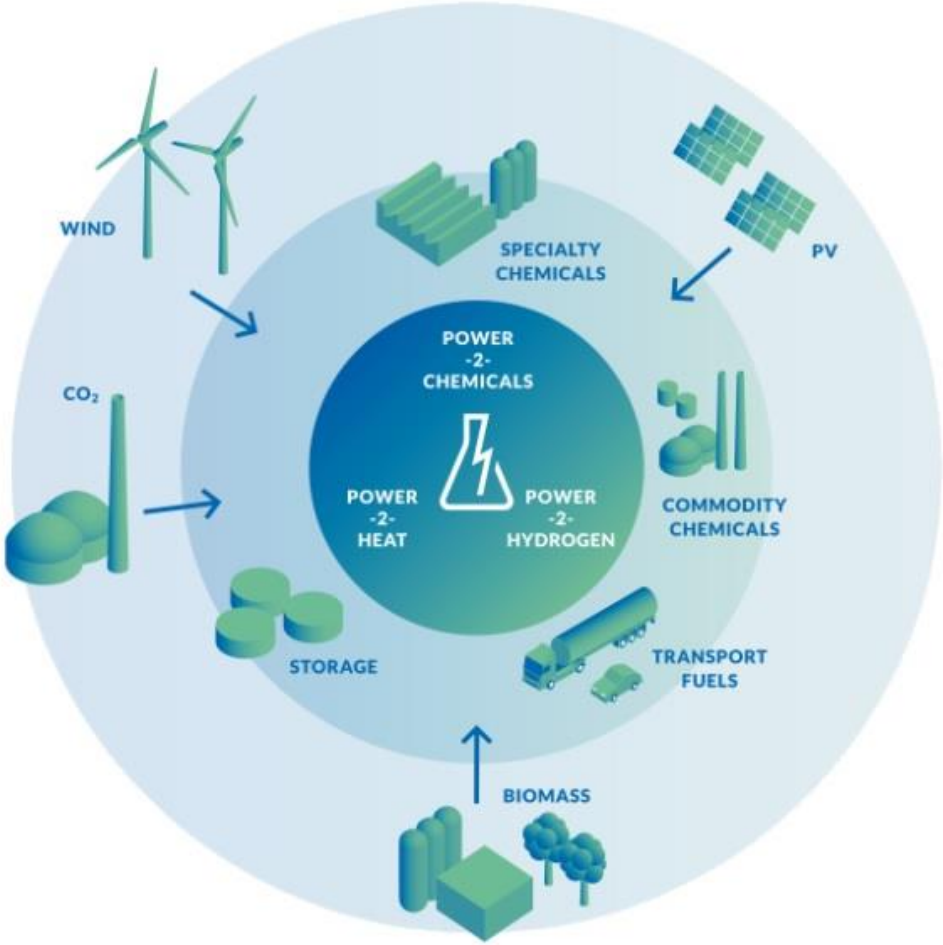
Voltachem Annual Event, 13 December 2018

Brightlands Chemelot Campus, Geleen, the Netherlands

Powered by: TNO innovation for life ECN

VoltaChem in 1 slide



- Public-Private ***Shared Innovation Program*** of 6M/year initiated in 2015 by TNO, ECN and Topsector Chemistry.
- *Accelerate innovation and implementation* of ***electrification for achieving decarbonization*** in chemicals.
- Initiate and facilitate ***collaborative development*** *of technology and associated business models*.
- Addresses both the *indirect and direct use of electricity* within the chemical industry, involving stakeholders from ***chemicals***, ***energy & equipment supply***.

The big effort ahead of us

- A colossal transition
- Reduce greenhouse gas emission by 90% by 2050
- From our own processes *and* from our products *and* from what we buy in
- A *complete* redesign is required

We need guidance !

- Investments are huge
- Time is *VERY* short
- no time for mistakes,
- no money for dead-end stop-gaps

- We need the point on the horizon
  - For energy and raw materials and their logistics
  - For products
  - For technology

A new energy and raw material map

- Today fossil carbon is both energy source and raw material, and can be transported efficiently
- Great freedom to locate either close to sources or close to markets
- Energy and raw materials will be decoupled and part of the logistics will change

A new product map

- 80% of refinery output goes to fuels and to immediate emission of fossil-GHG. This will END
- A large part of the chemical industry output (600Mtpa) ends up as delayed emission of fossil-GHG. This will END
- Examples:
  - Chemelot: footprint = 6Mtpa CO2-eq, handprint = 10
  - Port of Rotterdam: footprint = 16Mtpa CO2-eq, handprint = >150

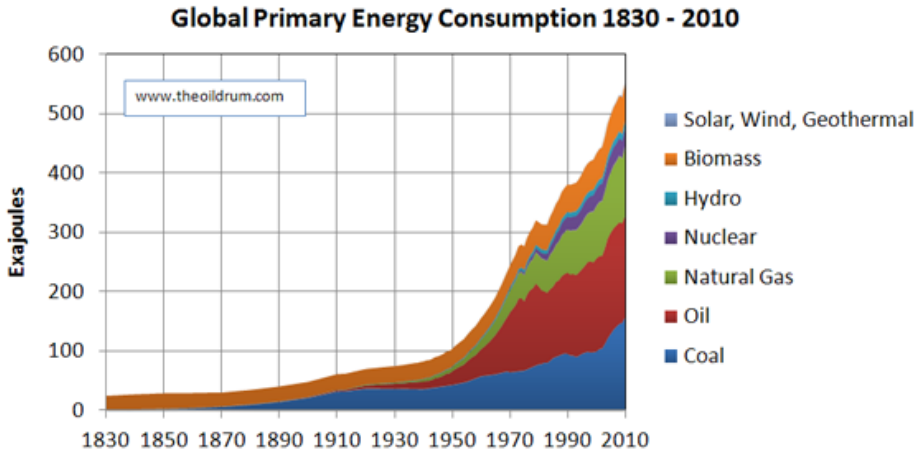
Scope and questions

- What will be the global energy picture ?
- What will be the raw material picture ?
- How will major chemical processes be run in the future ?
- Which new technologies need to be developed ?
- How will the global competitive landscape look like ?
- What will happen to NW-Europe ?

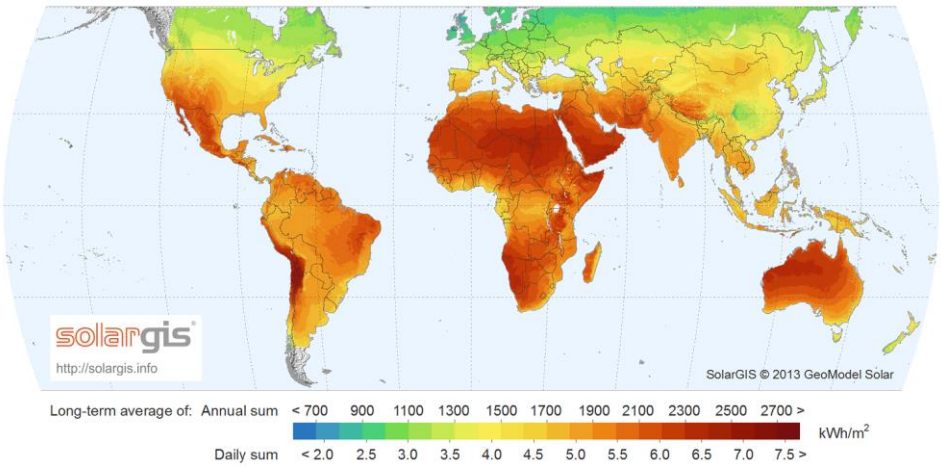
- Today's focus: petrochemistry (not: metallurgy, cement)

1. energy: the future looks electric

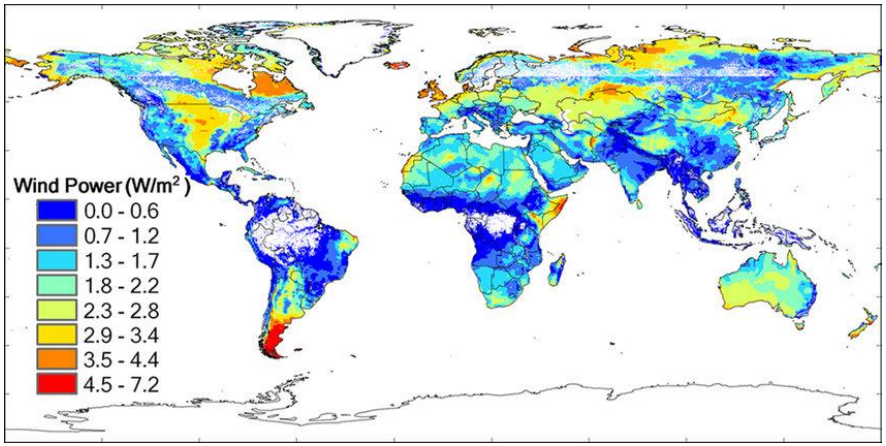
- Biomass cannot make it
  - Global energy consumption: 158000 TWh/567 EJ (2012)
  - Global biomass: 1btpa of carbon, 210000 TWh, about right in theory…
  - Solar: 1500000 EJ…



Electric energy hot-spots: solar and wind



Nuclear is the wild card !



Energy perspective NW-Europe, case NL

- We have wind !
- Theoretical NL North Sea potential (50k km2, 4W/m2) 200GW
- Estimated NL North Sea potential (PBL): 75GW installed = 35GW average = 330 TWh = 1200 PJ
- Current NL demand: 2000 PJ. Add 10% for solar and onshore wind
- Abundant wind power is fake news !
- Our neighbours may want some of it….
- Don’t think of inefficient uses !
- Reducing energy need is a priority (electric driving, heat pump heating, stopping certain industries ?)

Transporting electric energy

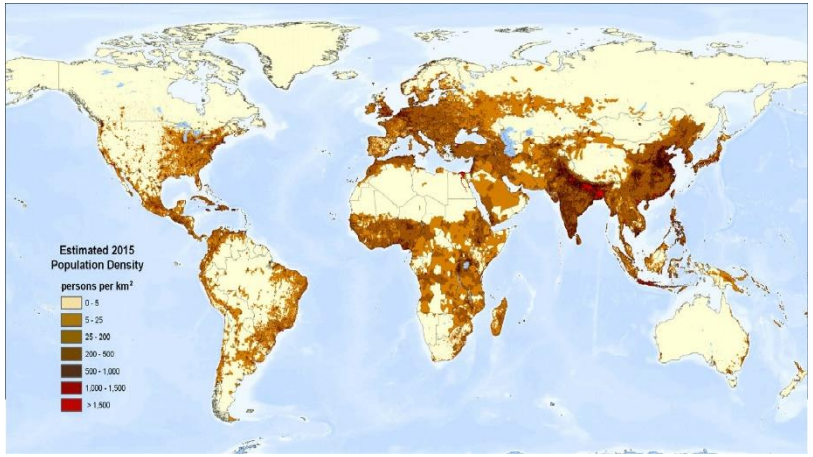
- There is enough solar elsewhere (potential per m2 can be 100x that of North Sea wind)
- HVDC by cable
- As hydrogen by pipe
- As ammonia by boat

2. Raw material

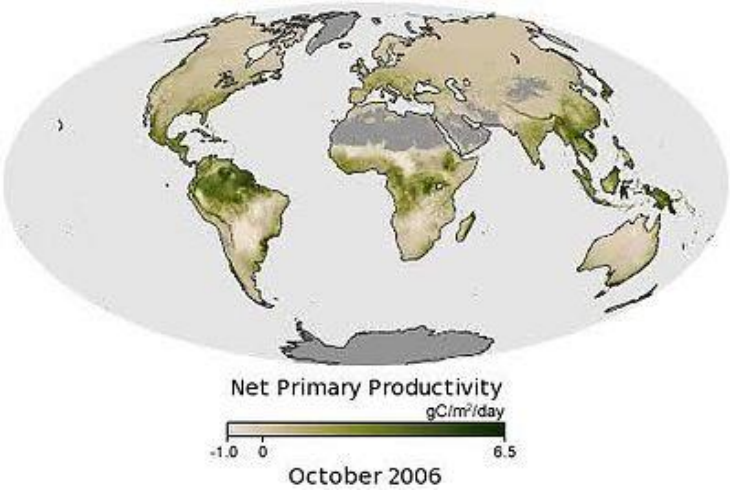
- Recycled
- Biomass
- fossil

Raw material hot spots

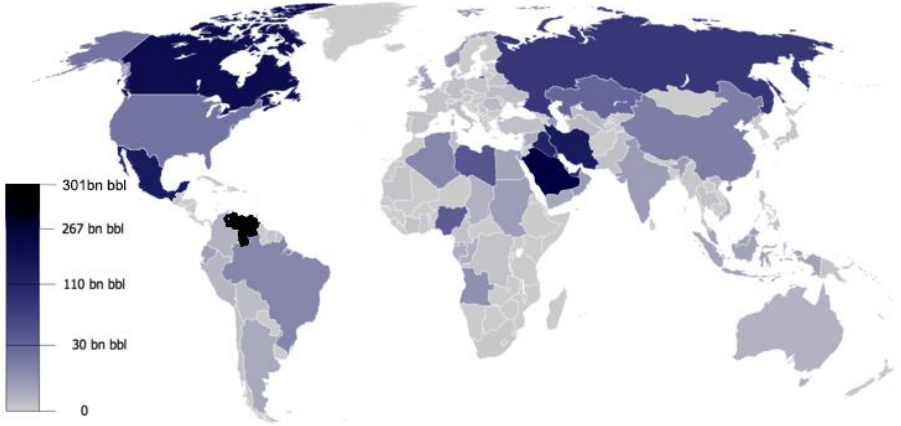
Recyclable waste



biomass



fossil



Raw material perspective NW-Europe, case NL

- We have waste !
  - Fossil origin
    - Total input: 1-2Mtpa of plastic waste (production is much higher).
    - Recovered: from households, 170ktpa of packaging plastics
    - recycled: today 300ktpa is recycled, rest is mostly incinerated
  - Biomass origin
    - Mixed biobased: 3.7Mtpa from households (incl.paper, about one third)

Waste as raw material: it moves….

GPCA '18: SABIC plans demo plant to convert plastics waste into cracker feedstock
Source: ICIS News
2018/11/28
DUBAI (ICIS)--SABIC is planning to build a demonstration plant in Europe to transform waste plastic into feedstock for its crackers as part of the company's strategy to further advance its circular economy model for the business, a senior company executive said on Wednesday.
The new demonstration plant is intended to be built at its Geleen manufacturing site in The Netherlands, according to Abdulrahman Al-Fageeh, SABIC's executive vice president, petrochemicals.
The plant would target the chemical recycling of low quality, contaminated mixed plastic waste streams into a feedstock suitable for the company's crackers in Europe.
The feedstock, known as pyrolysis oil, is created by converting the plastic waste that would otherwise by incinerated for energy recovery or ends up in landfills.
The feedstock will then be refined and upgraded at the new demonstration plant.
“We are supporting greatly the mechanical recycling of plastics but we believe that the long term sustainable circular economy will lie in chemical recycling,” said Al-Fageeh.
“We are in the process to make sure we have the right technology [for the demo unit], the right process and of course you have to depend on the value-chain of the business."
The SABIC executive spoke to ICIS on the sidelines of the 13th Gulf Petrochemicals and Chemicals Association (GPCA) Annual Forum.
Such units could be an integral part in the circular economy model as it helps to create new feedstock supply while at the same time protecting the environment, Al-Fageeh added.
“We are really one of the pioneers for supporting and encouraging for the change of the model from a linear to a circular economy,” he said.

07 december 2018|Nieuws
SABIC is het eerste petrochemische bedrijf dat een investeringsproject uitvoert voor de chemische recycling van moeilijk verwerkbaar plastic afval naar de oorspronkelijke kunststof.
Sabic, wereldleider in de chemische industrie, is het eerste petrochemische bedrijf dat een project implementeert dat vuil en gemengd plastic afval via chemische recycling terugbrengt naar de oorspronkelijke polymeer. SABIC heeft hiervoor een memorandum van overeenstemming ondertekend met Plastic Energy in Londen, pionier in chemische recycling van kunststof afval.
Sabic en Plastic Energy willen de eerste commerciële fabriek in Nederland op het chemisch industriepark Chemelot bouwen voor de productie van ‘Tacoil', een gepatenteerd product van Plastic Energy dat wordt geproduceerd door de recycling van gemengd plastic afval van lage kwaliteit. Dit materiaal wordt anders verbrand of gestort. De fabriek zal naar verwachting in 2021 in bedrijf gaan en is een mijlpaal voor Sabic in het licht van de circulaire economie en de duurzaamheidsdoelstellingen van de onderneming.

Raw material transport options

- Plastic waste:
  - MUST be recycled if landfill/burning not allowed
  - costly to collect, cheap to transport, good composition
- Biomass waste
  - costly to collect/transport, poor composition (low carbon)
  - Alternatives: incineration, composting, biogas
- Virgin biomass
  - Affordable to collect/transport, poor composition
  - Lignin is an interesting exception
- Fossil
  - In principle limited: to expand volume in closed loops or in combination with carbon storage
  - Existing logistics stay valid

3. The global competitive scene

Privileged regions in a carbon-neutral world

	waste	**biomass**	**Fossil (only in combination with recycling or CCS)**
Wind power	NW Europe	NW Europe	
Solar power	India, Nigeria	Thailand, Brazil	Middle East, US-Gulf

4. Thinking beyond the energy transition: Model products

- High volume, high carbon footprint
- Polyolefins
- Ammonia
- High-density energy carriers
  (fuel for aviation, shipping and heavy equipment)

5. Processes, raw materials and logistics after the energy transition: ammonia

- Hydrogen by
  - Electrically heated steam-reforming of methane, storage of CO2
  - Decarbonization of methane to hydrogen + carbon,
  - Electrolysis of water
- Final step is always optimal Haber-Bosch synthesis
- Transport as liquid

5. Processes, raw materials and logistics after the energy transition: polyolefins

- depolymerization by:
  - Pyrolysis of plastics, treatment of pyrolysis oil, conventional steam cracking. All heating electric, hydrogen green
  - Milena gasification of plastic/organic waste to olefins/aromatics. Heating electric (Milena)

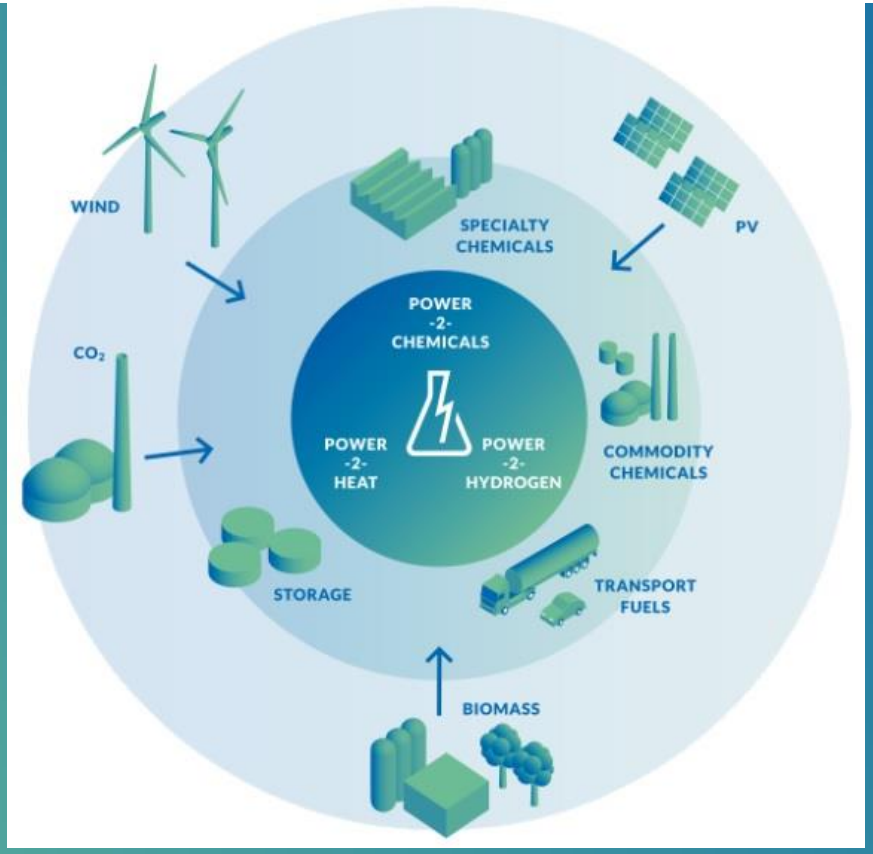
5. Processes, raw materials and logistics after the energy transition: high-density energy carriers

- products:
  - Shipping: ammonia ?
  - Aviation: Carbon-dense. Biobased ?
    - lignin oil (methanol solvolysis),
    - kerosene from carboxylic acids (fermentation/dimerisation/isomerisation),
    - biodiesel-types (RVO, FAME, HVO)

Conclusions

- There will be a fundamental scarcity of renewable energy in NW-EU, so we have to reduce demand and, above all, make choices
- Electricity will be, mainly, produced from wind in NW-EU and imported as energy carrier (HVDC, H_2, NH_4) from regions with abundant solar
- Conversion of electricity into hydrogen in NW-EU other than for buffering is a waste (loss of profit)
- Circular use of carbon powered by electricity from wind puts NW- EU on pole position

Let’s energize innovation together!



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Back-up

Ammonia

- Production of ammonia will mostly happen where sunny deserts meet the shore: Australia, West Africa (Combination of abundant solar power and sea water, omnipresent nitrogen, transport options)
- Limited electricity availability will make it unattractive in NW-EU
- Shipping ammonia is OK
- Ammonia could even become a storage and transport medium for renewable energy
- Will there be niches for NW Europe ? (linked with chemical uses in caprolactam ? And with raw materials like waste or cracker off-gas ? Technologies like decarbonisation or gasification ?)
- How will we in NWEU respond ?

Polyolefins

- Polyolefins and other plastics production will grow a lot because their use supports sustainability (light-weight in mobility, reduction of food waste, recyclable alternatives for metal and concrete)
- Production of polyolefins will be based on recycled waste (plastic + biomass) close to large concentrations of consumers, with some make-up from fossil sources
- What will we have to do in NWEU ?

Possible theses for discussion: high-density energy carriers

- Aviation fuel will be based on biomass
- Shipping fuel could be a mix between electricity (rivers, coastal, ferries), and biomass/ammonia (deep sea)