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Diving deep and looking high

Key issues in doing a practically useful climate roadmap for the chemical industry

Presentation for MAI/Israel on 27 January 2021

DR. PETRI VASARA, VICE PRESIDENT, AFRY MANAGEMENT CONSULTING

1. Briefly about AFRY
2. Climate roadmaps in Finland
    1. Why?
    2. How?
    3. What?
3. Takeaways

Who are we, AFRY?

Briefly about AFRY: since 1895

In 2019 ÅF and Pöyry became AFRY

– **1895 + 1958 = 2019**
  In February 2019 ÅF (since 1895) and Pöyry (since 1958) joined forces in order to become an international engineering, design and advisory company, driving digitalisation and sustainability for the energy, infrastructure and industrial sectors all over the world.

– **More than sum of its parts: ÅF + PöyRY < AFRY**
  In November 2019 ÅF Pöyry launched a new common brand, AFRY. The name is a combination of the letters in ÅF and Pöyry: AF+RY [eɪːfɹi]

– With a strong focus on sustainable solutions we bring the best from ÅF and Pöyry into the new brand AFRY.

INDUSTRIAL & DIGITAL SOLUTIONS

Advanced Automation
Automotive R&D
Connected Products
Experience Design
Food & Pharma
IT Solutions
Specialized Tech Services
Systems Management

ENERGY

Thermal Heat & Power, Renewables & Energy Markets
Hydro
T&D
Nuclear
Contracting

INFRASTRUCTURE

Transportation
Buildings
Project Management
Water
Environment
Architecture & Design

PROCESS INDUSTRIES

Bioindustries
Chemicals
Pulp, Board, paper & tissue
Metal & Mining
Smart solutions:
– Health & Safety
– Environment
– Smart Site TM & Digitalisation

MANAGEMENT CONSULTING

Energy Central & Northern Europe
Energy Western Europe & ROW
Capital
Operational Services
Industry
North America
Concept Development

No. of employees: 17,000

Approx. annual revenue: 2 bEUR

Industry
Infrastructure
Energy

Offices in countries: 50

Projects in more than	We speak more than	We are	We are	We are
100	50	4000	27%	73%
countries	languages	employees from young generations	women	men

Nordic base with strong global presence

Our presence

Chemical Convention 2019 as example of broad knowledge base needed

TOPICS CONVERGENCE

- Climate and energy transition across economy
- Climate transition across heavy industries
  - Similar drivers and dynamics
  - Interdependencies crucial
  - (hyped) example: hydrogen

➔Hence, unique leverage of AFRY's
- strong combination of management consulting and engineering
- thought leadership across sectors and industries
- very strong position as one of the leading consultancies in the energy sector's transition
- no.1 position globally in forest industry + bioindustries

"PROOF"

- AFRY leader, Dr. Petri Vasara, demonstrates AFRY's wide knowledge base in his presentation at the Chemical Convention 2019 main event

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AFRY covers the chemical sector from management consulting to designing and implementing chemical refineries

- Example project types include:
  - Extensive engineering works and project services for new assets in petrochemicals and oil refining
  - Pre-feasibility and feasibility studies
  - Strategy and investment projects
  - Optimisation, logistics, revamps, capacity increases,...

Climate roadmaps in Finland: Why, how, what?

Also e.g. in the Netherlands, but not the topic today

How can the Finnish chemical industry project be condensed?

WHY?

PUSH AND PULL: CHEMICAL INDUSTRY PUSH, GOVERNMENT PULL

- The background of this study included both the ambition of Kemianteollisuus ry / The Chemical Industry Federation of Finland and the climate targets declared by the Finnish government.
- In the summer 2019, the Finnish government set a target to become carbon neutral by 2035 and carbon negative thereafter, and asked for industry roadmaps

HOW?

SECTORS FROM CHEMICALS, STEEL, ENERGY, FOREST TO TRAFFIC AND ICT

- In cooperation with other main manufacturing sectors (Technology Industries of Finland, Finnish Forest Industries Federation) and Finnish Energy (ET), a roadmap work where technology-driven scenarios, their requirements and costs iteratively meet the supply of low-carbon energy, forming a holistic, national pathway to 2050. A traffic roadmap was also completed as part of the same whole

WHAT?

COMPATIBLE YET SPECIFIC: SUM UP BUT KEEP DIFFERENCES

- The goal was to identify the means and to provide a realistic roadmap towards carbon neutral chemical industry in Finland 2045.
- On top of GHG scenarios, the study focused on raw materials, technology and energy breakthroughs, R&D&I and investment needs, policy needs, export potential and many more aspects of chemical industry.

*Available at https://kemianteollisuus.studio.crasman.fi/file/dl/i/W03X2Q/yulYl_o2iB7IOGSXBKBNSw/Kemianteollisuusroadmapandexecutivesumm ary.pdf

Why?

Roadmaps follow from government target and query – Finnish chemical industry was a forerunner already before those

FINNISH CHEMICAL INDUSTRY PIONEERING

– Even prior to Finland or EU net-zero targets: The Chemical Industry Federation of Finland published own targets

GOVERMENT TARGETS IN JUNE 2019


Ympäristöministeriö
Miljöministeriet
Ministry of the Environment

Front page | Areas of expertise | News | Projects and legislation | Publications

- Climate
- Housing
- The EU and international cooperation
- Carbon neutral Finland 2035
  Government's climate policy
- Nature and water
- Building and land use
- Research and development

EN / AREAS OF EXPERTISE / CARBON NEUTRAL FINLAND 2035

Government's climate policy: carbon-neutral Finland by 2035

According to **Sanna Marin's** Government Programme in 2019 Finland will be carbon-neutral by 2035, and the world's first fossil-free welfare society. This requires faster emissions reductions in all sectors and strengthening our carbon sinks.

Source: Kemianteollisuus, Ministry of Environment websites

How?

Progress is only possible, if …

The basic condition for success in all sustainability/low-carbon roadmaps was a competitive, viable industry.

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Aiming at a coherent whole, scenarios built on industry-wide analysis, and reflecting the reality, views and ambition of different sectors

Scenarios! Not forecasts
A forecast looks for the likeliest outcome, a scenario looks for ways to do one's best towards a given goal

The sector, not individual companies
Staying away from pointing out individual companies' actions (even though, obviously, in the work high consciousness of what could be done). No speculation on non-public investment plans

Baseline as comparison
Baseline a comparison with no notable initiatives: Business As Usual but without ambition

Sectoral ambition
Scenarios reflecting sectors' will to implement Paris agreements and other EU/Finnish goals

Compatibility
Without ”tight” logical discipline, different sectoral roadmaps might not be compatible. Now, they were.

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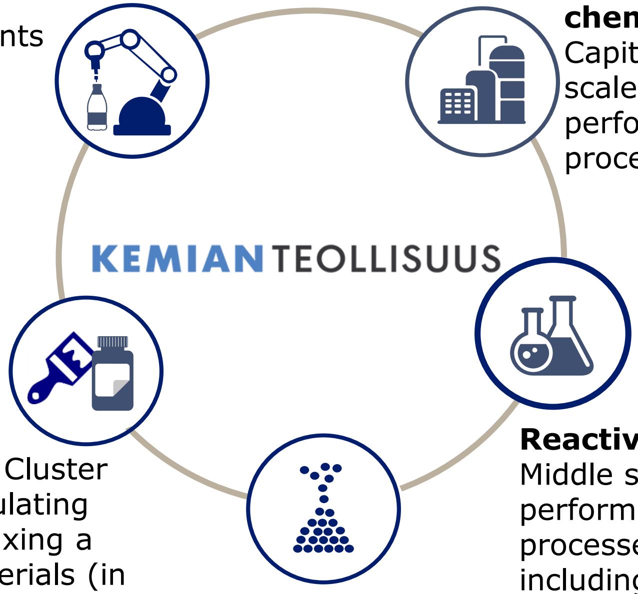
For chemical industry’s complex whole, a classification of companies was made – this one applies to the Finnish industry and is adapted to the focus

- 400 companies into 5 clusters
- Heterogenous industry
- Shared and specific solutions to reduce GHG emissions
- Confidentiality of companies
- Input for process: companies, association, consultants and government



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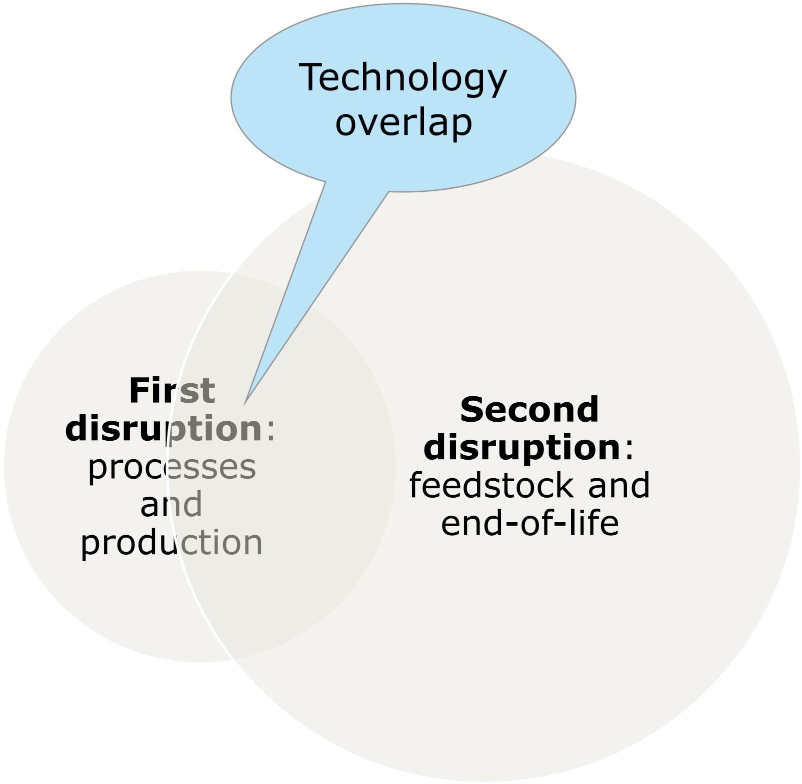
For chemical industry, there are two disruptions: greater focus on first, but second also included

– **The road**
The route to *carbon neutrality* cannot be simple, when even the term needs explanation. There are two disruptions on the way, which have something in common – an increase in energy use.

– **The first disruption:** *processes and production.*
To decarbonise processes and production (Scope 1 and 2), a toolbox of technical solutions is needed. Some exist, others need to be developed. Together, they have the potential to positively disrupt chemical production – at the expense of an *increase in energy use and costs*.

– **The second disruption:** *feedstock and end-of-life.*
To *remove fossil feedstock (*Scope 3) is the second, larger disruption. The demanded change is much more extensive, meets problems in alternative feedstock availability – and may even increase process emissions to begin with. The increase in energy use overall would be *significantly higher*, likewise the cost, compared to the first disruption.



What?

Main export industries in Finland: chemical, forest and technology industries, all studied separately but together

Forest industry

- Pulp
- Paper, packaging, tissue
- Bioproducts

Chemicals

- Oil refining
- Basic chemicals
- Specialty chemicals
- Minerals and fertilisers
- Plastic and rubber products
- Pharmaceuticals

Teknologiateollisuus

- Mining
- Metal industry
- Machinery and equipment
- Electrical and electronics
- ICT
- Design and consultancy

Sector-specific and common solutions and prerequisites in the low-carbon transition, connected to the energy sector

WHAT: NATIONAL ANALYSIS, MINDING THE GLOBAL NATURE OF THE PHENOMENA

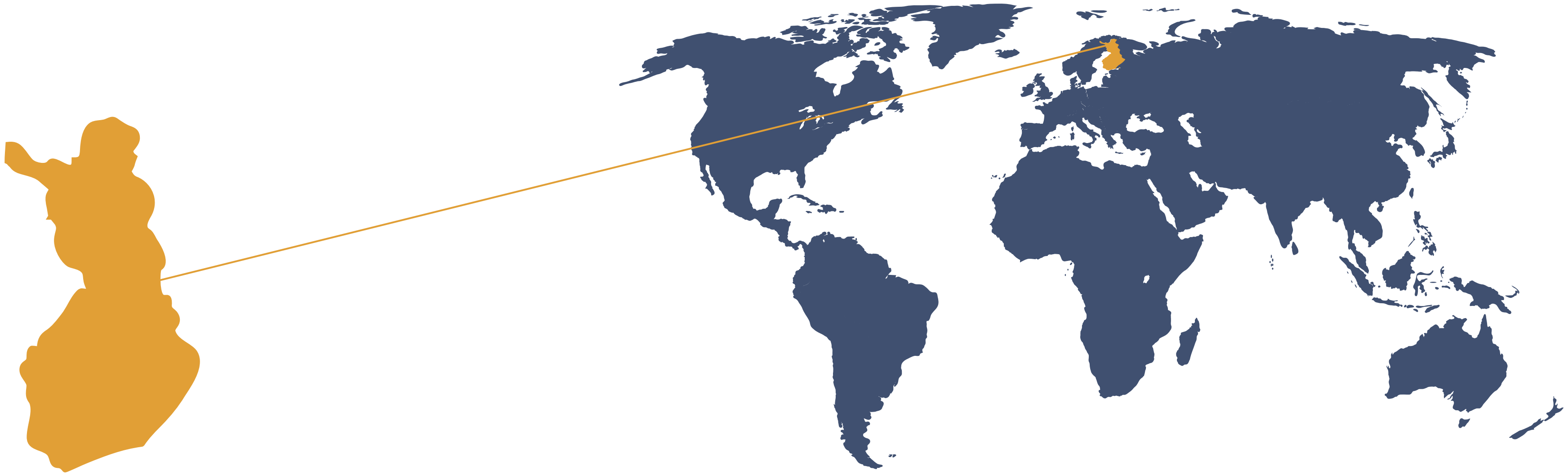
National and global perspectives on e.g. trade, markets, technology, policy

NATIONAL

- Knowhow, innovations
- Promoting exports
- Industrial and technology policy
- New business models

EUROPEAN / GLOBAL

- EU regulation, Green Deal
- International climate politics
- Trade politics
- Broader Sustainability Agenda



Chemical industry roadmap combines many dimensions into multi-use package

TECHNOLOGY: A menu of options to reduce emissions

SCENARIOS: Direct emissions, purchased energy and sensitivity to circumstances

SCENARIOS EXPANDED:
A feedstock (r)evolution of defossilisation

TOOLBOX FOR CHANGE:
Chemical clusters and example action plans

HANDPRINT, EXPORT POTENTIAL AND KNOWLEDGE:
The global imprint of the Finnish chemical industry

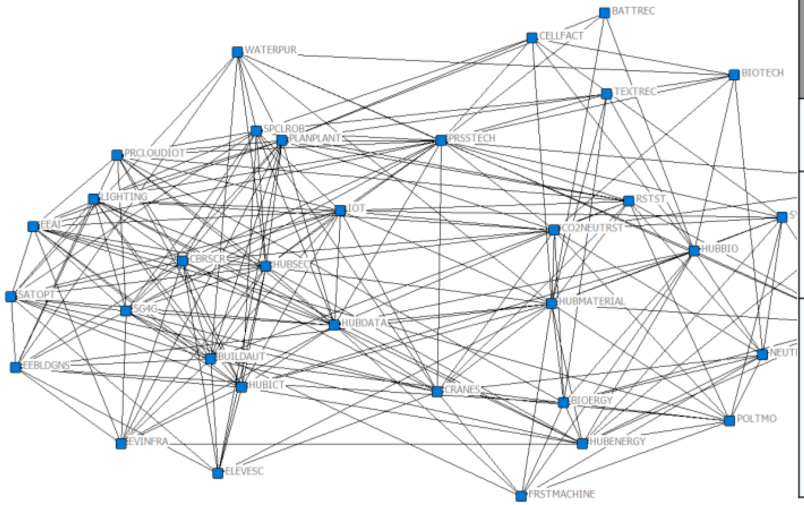
CONCLUSIONS AND CONDITIONS:
The outcome and the preconditions

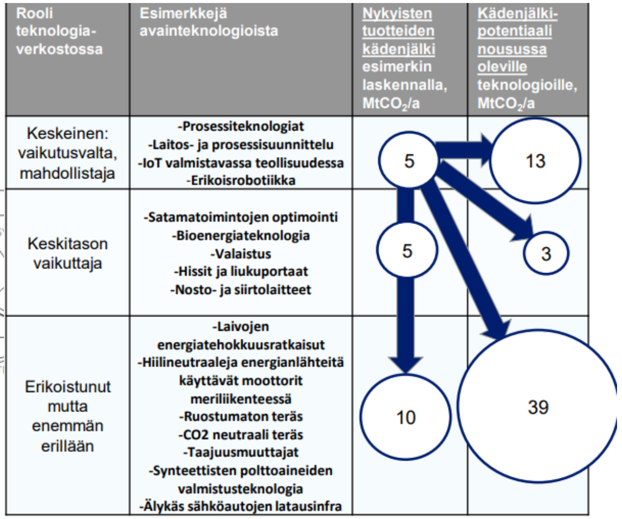
Potential benefits/uses

- Information and data input into e.g. government strategy processes
- Communicative tool for companies
- Advocacy: what is needed, what are the benefits?
- Thought leadership
- Commitment of different stakeholders (also politics)

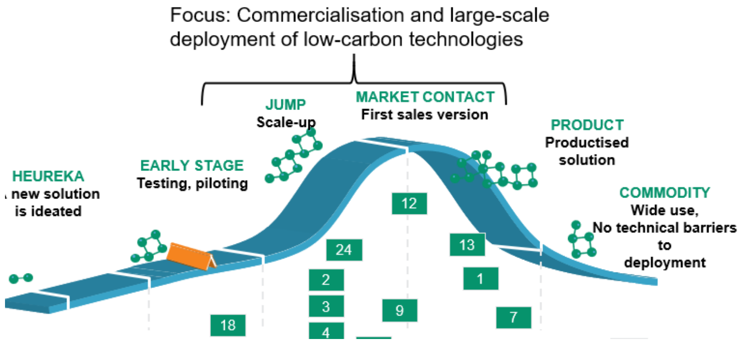
Topics covered in sectors' roadmap work range wide, and reach deep and far

- Technology networks
- Finnish cluster analysis
- Export potentials
- Handprint potentials and future technologies
- Research and innovation needs
- Biomass needs
- ICT (e.g. 5G, data centres) development supporting e.g. chemicals





Rooli teknologia-verkostossa	Esimerkkejä avainteknologioista	Nykyisten tuotteiden kädenjälki esimerkin laskennalla, $MtCO_2/a$	Kädenjälki-potentiaali nousussa oleville teknologioille, $MtCO_2/a$
Keskeinen: vaikutusvalta, mahdollistaja	-Prosessiteknologiat -Laitos- ja prosessisuunnittelu -IoT valmistavassa teollisuudessa -Erikoisrobotiikka	5	13
Keskitason vaikuttaja	-Satamatoimintojen optimointi -Bioenergiateknologia -Valaistus -Hissit ja liukuportaat -Nosto- ja siirtolaitteet	5	3
Erikoistunut mutta enemmän erillään	-Laivojen energiatehokkuusratkaisut -Hiilineutraaleja energianlähteitä käyttävät moottorit meriliikenteessä -Ruostumaton teräs -CO2 neutraali teräs -Taajuusmuuttajat -Synteettisten polttoaineiden valmistusteknologia -Älykäs sähköautojen latausinfra	10	39



COMPLEMENTING PRESENTATION BY KEMIANTEOLLISUUS RY

Lifting out five points

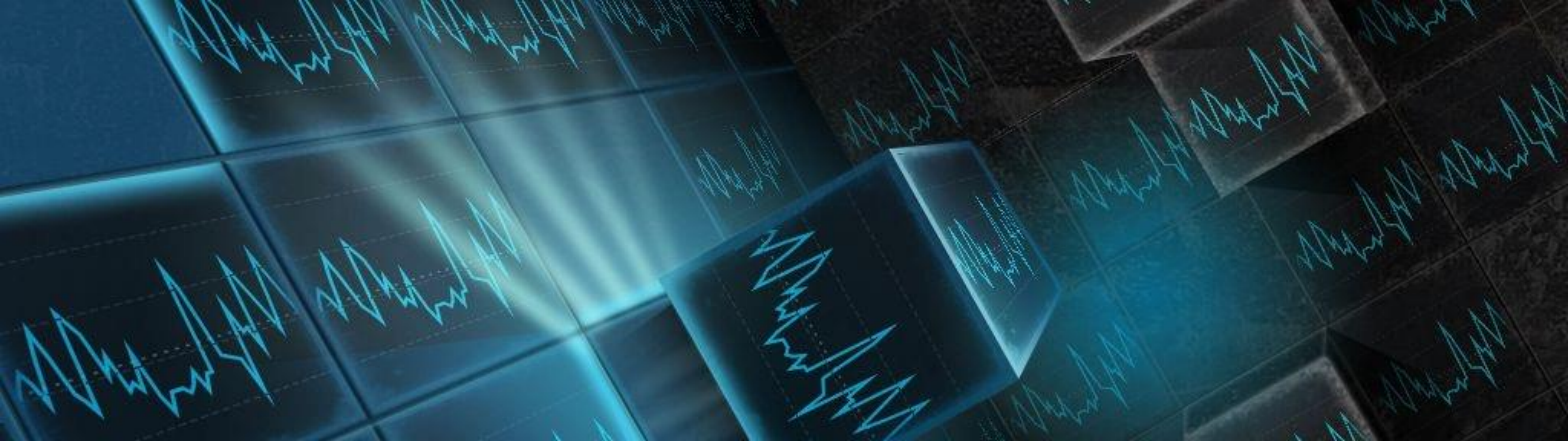
01 Investments in end-of-life/feedstock

02 Steps to most efficient reduction plan

03 Technology "jump curve" – crossing the hump with synergies

04 Technology clusters and profiles

05 Technology networks: where to get the biggest impact?



1. Investments in end-of-life/feedstock

Considering also water efficiency and other relevant aspects

SCENARIO: ”EUROPEAN RECYCLING VALLEY”

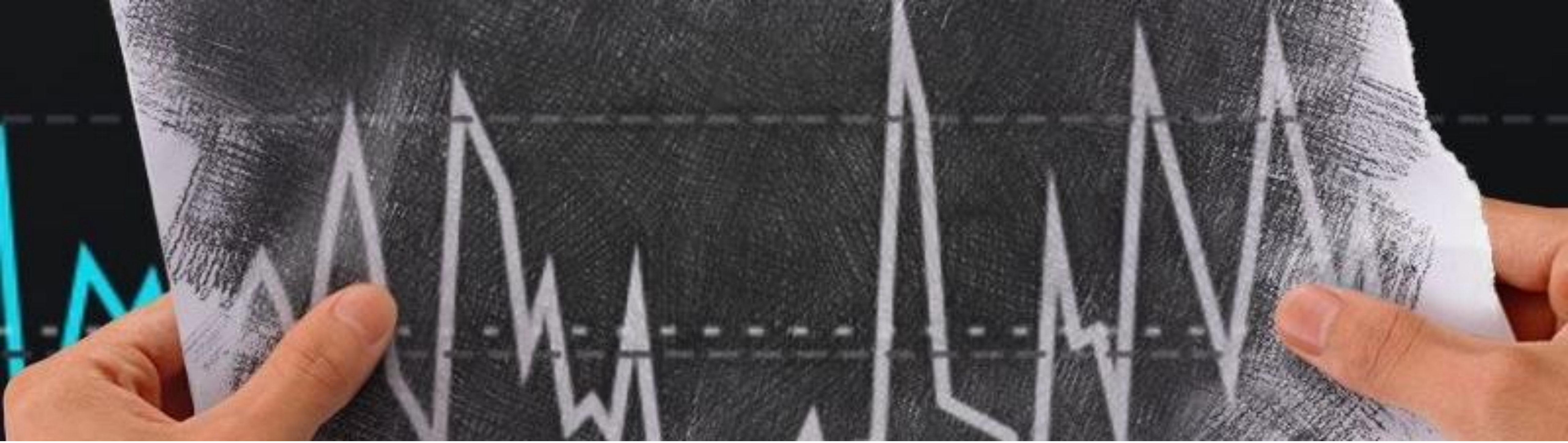
FEEDSTOCK: WASTE AND IN PARTICULAR PLASTIC WASTE RISING UP – AND ISRAELI ROLE?

- European technology has evolved the furthest, pushed and incentivized by ambitious legislation
- Europe is covered by a network of 10 large-scale chemical recycling facilities and smaller, decentralised units
- The large units are placed in population-rich, dense ”megaregions” (see picture), especially where synergy with chemical industry existing facilities, plastics users and functioning collection systems exist

Question: The best fit for Israeli chemical and related industry including biotechnology for residues as part of ”Recycling Valley”?

EUROPE IN THE LEAD, KEY ”RECYCLING VALLEYS”

”Megaregions”

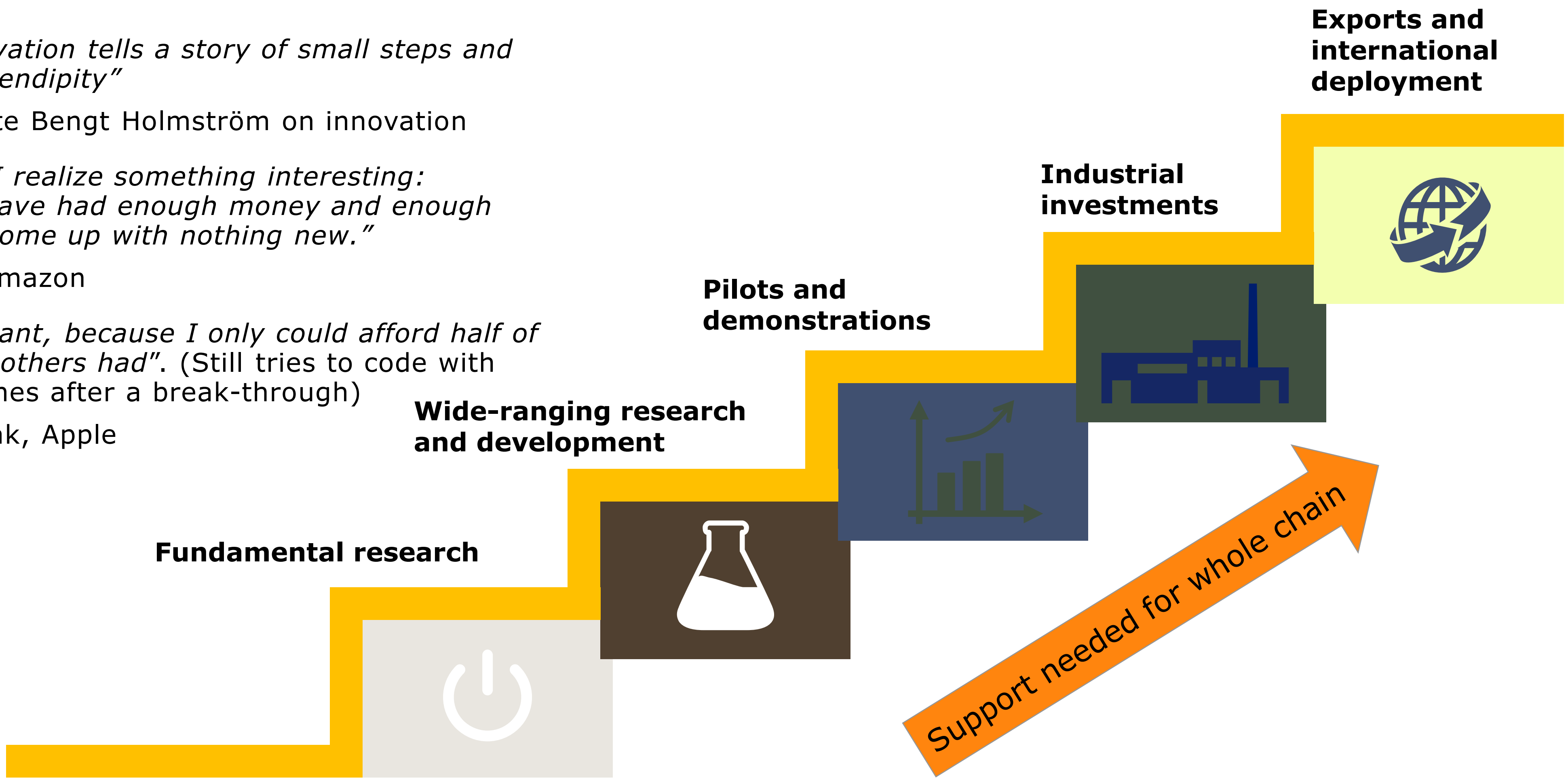


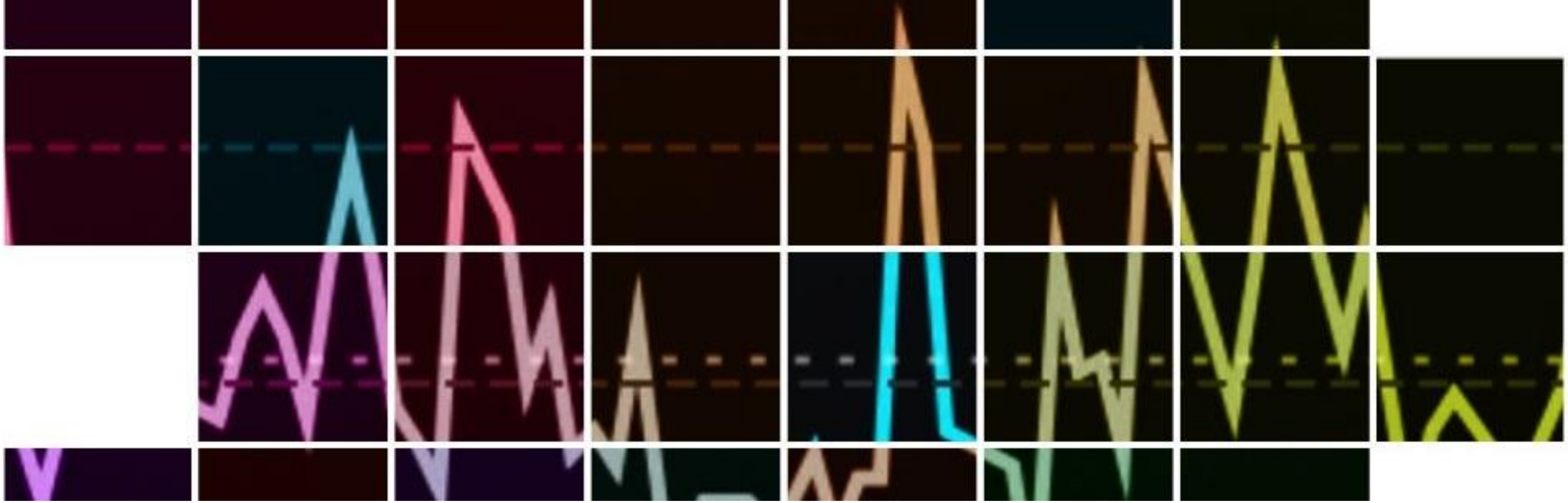
2. Steps to most efficient reduction plan

Plan with relevant technologies coming on-line

Stepwise progress to reach low-carbon markets

- *History of innovation tells a story of small steps and "disciplined serendipity"*
  - Nobel laureate Bengt Holmström on innovation
- *"Looking back I realize something interesting: whenever we have had enough money and enough time we have come up with nothing new."*
  - Jeff Bezos, Amazon
- *"I became brilliant, because I only could afford half of the transistors others had".* (Still tries to code with half as many lines after a break-through)
  - Steve Wozniak, Apple



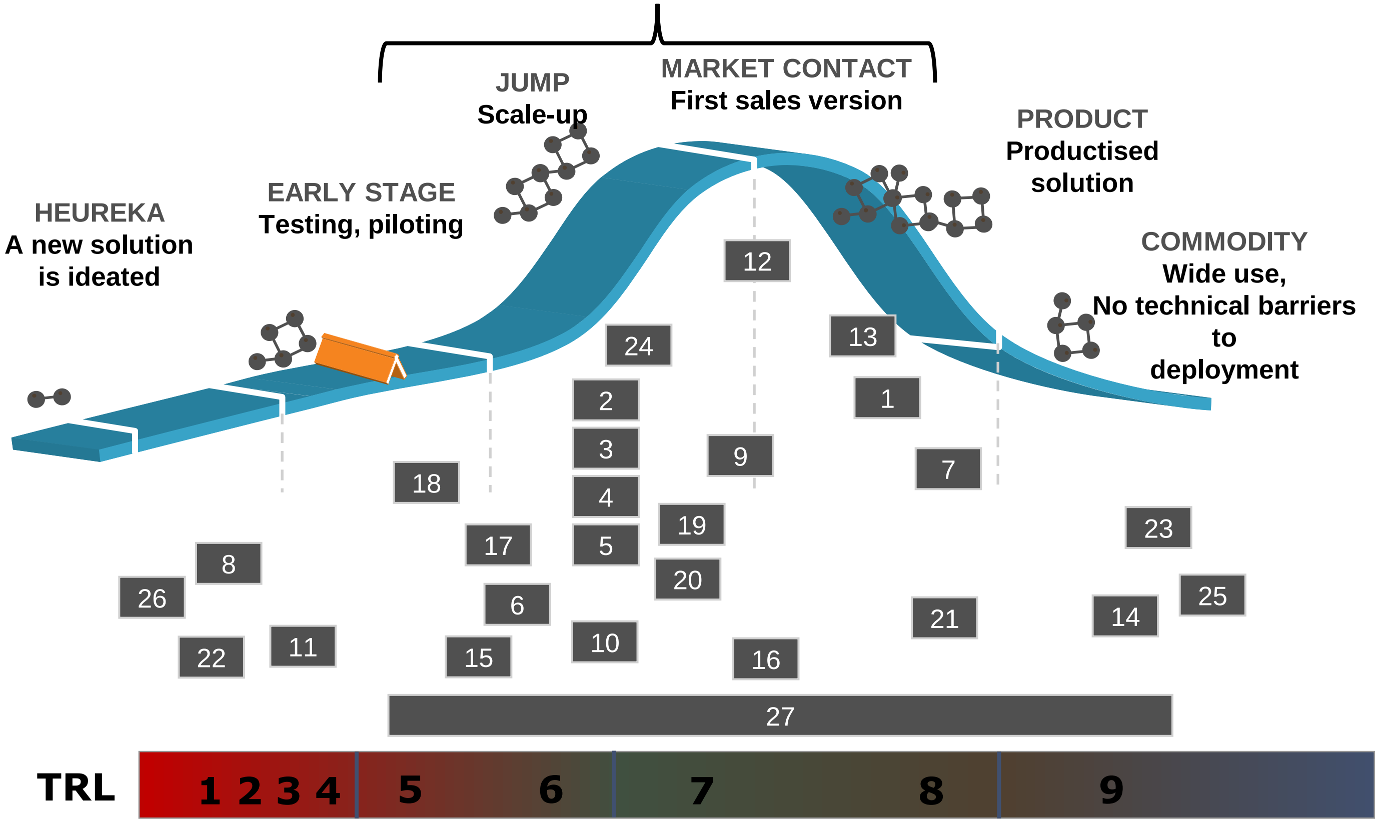


3. Technology “jump curve” – crossing the hump with synergies

Considering also water efficiency and other relevant aspects

"Activation energy" needed to overcome the barrier into new technologies – catalysts of commercialisation in dire demand

Focus: Commercialization and large-scale deployment of low-carbon technologies



Power-to-chemicals

1. Power-to-H2
2. Power-to-methanol
3. Power-to-olefins
4. Power-to-BTX
5. Power-to-ammonia

Raw material and product portfolio changes

6. Biomass to methanol
7. Biomass to bioethanol
8. Biomass to BTX (lignin-based)
9. Bionaphtha to olefins
10. Biomass to olefins
11. Hydrogen via methane pyrolysis
12. Biohydrogen
13. Biobased diesel (HVO)
14. **Energy efficiency**

CCU/CCS

15. Pre-combustion
16. Post-combustion
17. Oxyfuel combustion
18. CO2 mineralisation

Electrification & fuel switch

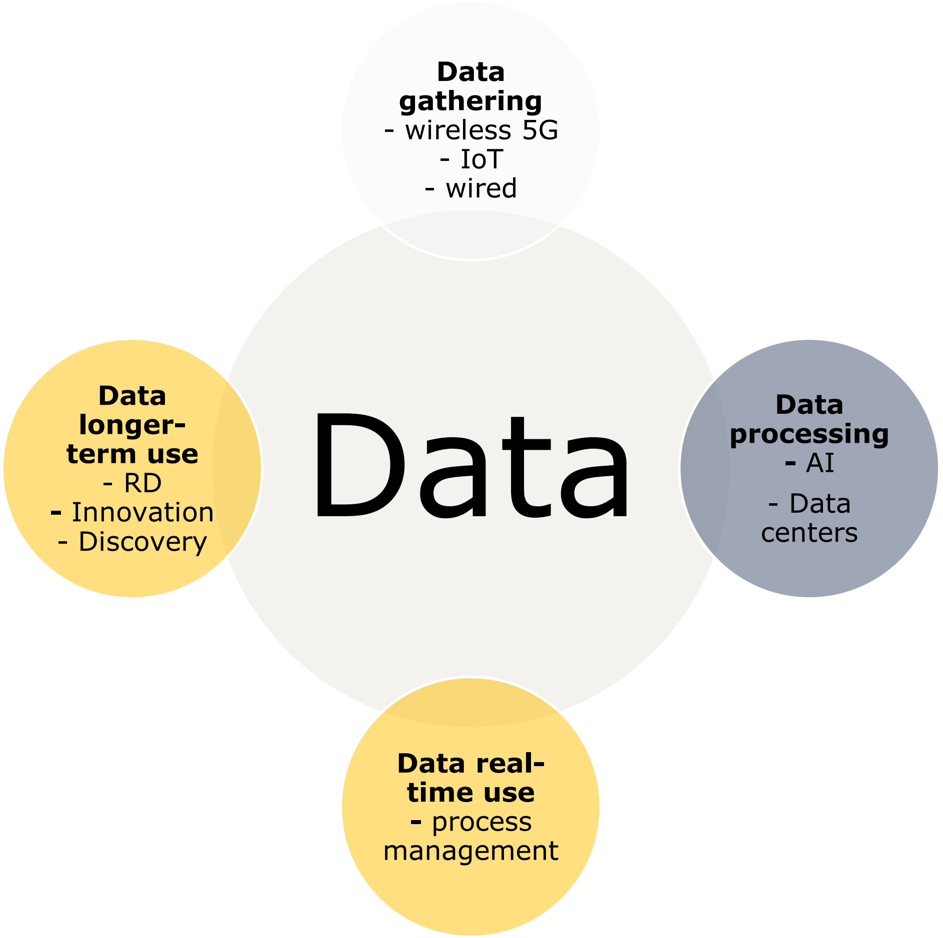
19. Steam production by electric/hybrid boilers
20. Steam production by electric furnaces
21. Coal to natural gas to biogas
22. **Synthetic biology & biochemistry**

Circular economy

23. Mechanical recycling
24. Chemical recycling
25. **Process development**
26. **Bubbling under technologies**
27. **Digitalisation**

It’s all about the data and what the chemical industry does with it - “circular data economy for chemicals”

The **”circular data economy” for chemicals** notes that
- data has a lifecycle with also resource impacts along with handprint.
- data has a source
- it is processed
- the product, insight, is used for control and innovation.
- data needs an end-of-life solution.
- after that and during the cycle, new data gathering begins or
is ongoing.



4. Technology clusters and profiles

The right tools for the right problem

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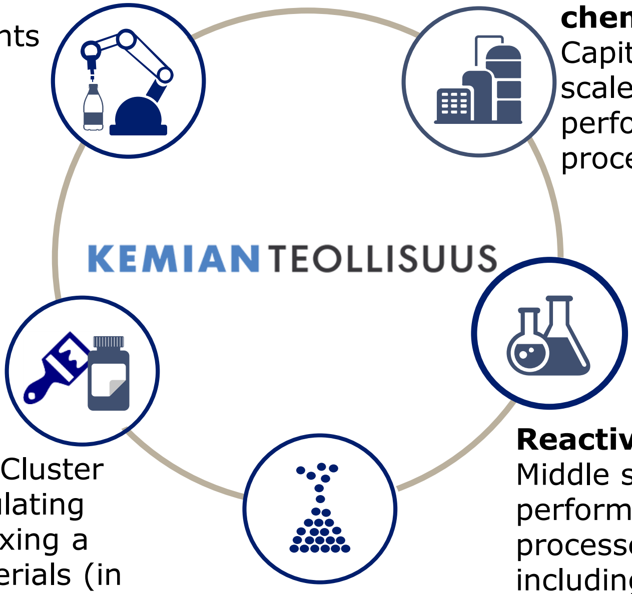
For each chemical industry cluster, a toolbox of concrete solutions was proposed

CLUSTERING

Converters: Cluster of plants that manufacture consumer products

Energy-intensive chemical industry: Capital intensive large scale infrastructures performing complex processes



Formulating: Cluster of plants formulating products by mixing a set of raw materials (in the presence of a reaction or not)

Inorganic chemistry: Cluster of plants specialised in inorganic chemical products

Reactive chemistry: Middle scale infrastructure performing complex processes, products including speciality chemicals and advanced materials

”TOOLBOX OF SOLUTIONS”, TAILORED TO CLUSTERS

EXAMPLE COMPANY:
ENERGY-INTENSIVE CHEMICAL INDUSTRY
A profile that may not exactly match a real company, but represents the cluster

Description

Average company

- **620 ktCO_2** GHG Scope 1 (direct emissions)
- **190 ktCO_2** GHG Scope 2 (purchased energy)
- **1 : 4** Energy from electricity : fuels
- **3,500 GWh** Total energy consumption
- **> 1 Mt** Total production volume
- **2,400,000 m^3** Total water consumption
- **< 10%** Share of renewable and recycled feedstock

- Large chemical facilities comprise the backbone of the chemical industry. Facilities are capital-intensive and operational for long periods of time. Major investments and retrofits to reduce emissions are only possible during a turnaround (typically every 4 – 6 years).
- Typical energy-intensive unit processes include distillation, reforming, polymerization. Products include transport fuels, petrochemicals, plastics, large volume specialty chemicals.
- Operating largest plants in the industry, and most of energy is obtained from fossil fuel combustion. Own emissions (Scope 1) are very large.
- The share of recycled and renewable raw materials of all feedstock remains very low. Changing sources for feedstock in this category is very challenging, but results in massive GHG reduction throughout the value chain.
- Companies are large multinationals, and include Neste, Kemira, Borealis, etc.

Main solutions

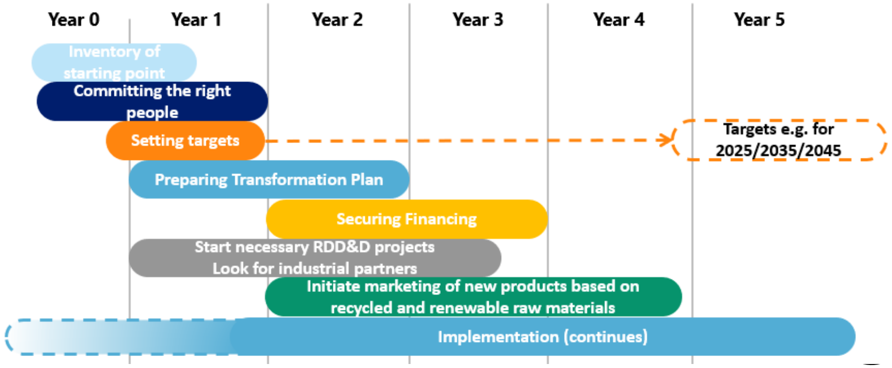
In the short term
- Fuel switches to low-carbon fuels; gain supply agreements for low-carbon electricity; invest in heat pumps, enhance efficiency

In the long term
- New process technology, e.g. through synthetic biology, catalysts, reaction engineering and low-temperature processes (e.g. crackers)
- Substitute fossil-origin feedstock with low-carbon alternatives: synthetic chemicals, biomass and recycled materials. Capture and utilisation of CO_2 as feedstock.

Specific drivers and challenges

Drivers
- Shifts and pressure from transportation sector affect product portfolio

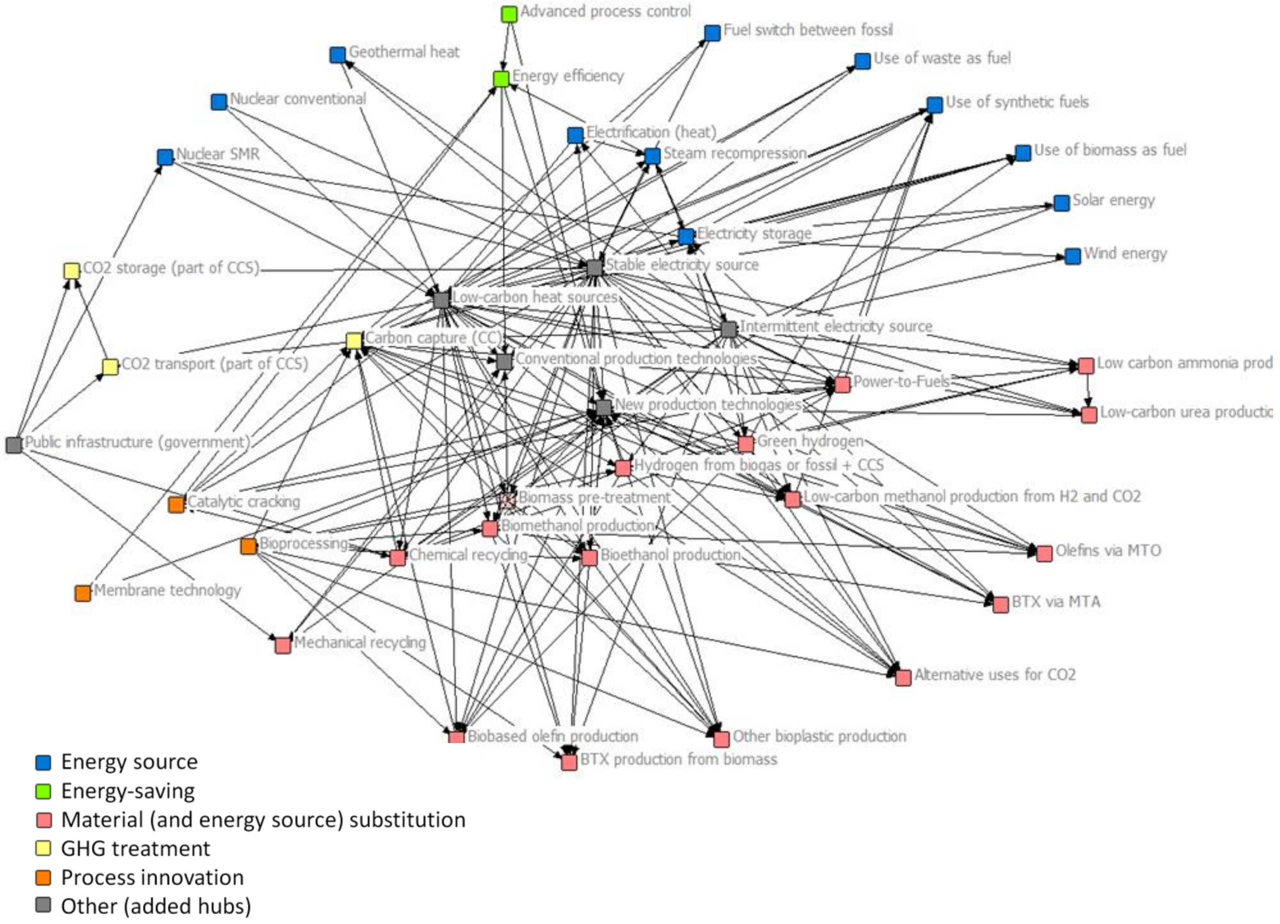
Challenges
- Complex facilities are old and require heavy investment, if process is significantly altered.
- Feedstock volumes are large (e.g. 15 Mt of crude oil); alternative feedstock is not as abundantly available.
- Further focus required on recycling and material efficiency



5. Technology networks – how to get the biggest impact

Considering also water efficiency and other relevant aspects

WHERE TO INVEST: Technologies form a network – in which some are more crucial than others with varying estimates of handprint impact globally



Role of tech	Technologies	Foot-print, MtCO2/a	Handprint, MtCO2/a
Central enabler	-Prosessiteknologiat -Laitos- ja prosessisuunnittelu -IoT valmistavassa teollisuudessa -Erikoisrobotiikka	5	13
Mediator tech	-Satamatoimintojen optimointi -Bioenergiateknologia -Valaistus -Hissit ja liukuportaat -Nosto- ja siirtolaitteet	5	3
Reaping the benefit-tech	-Laivojen energiatehokkuusratkaisut -Hiilineutraaleja energianlähteitä käyttävät moottorit meriliikenteessä -Ruostumaton teräs -CO2 neutraali teräs -Taajuusmuuttajat -Synteettisten polttoaineiden valmistusteknologia -Älykäs sähköautojen latausinfra	10	39

Takeaways

Five rules of thumb for climate roadmaps and implementation

1. Start early enough

Stepwise investments with a clear plan will be most cost-efficient

2. Technologies are not equal

Some technologies are the basis for others, who reap the greater gains – pick the right combination

3. Splitting the industry into clusters helps

It is hard and also (legally) complex to go to company level – but dividing an industry into sectors enables specific technology viewpoints

4. A train is moving…

Especially with the US entering the Paris agreement, China promising carbon-neutral by 2060 and EU driving a complex web of regulation…

5. … but tickets are still available

For a country such as Israel and e.g. chemicals/biotech, e.g. collaborating with Finland, the possibilities on the EU/US market are open

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Thank you!

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Diving deep and looking high

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