Path to100%

100% Renewables Insights with Focus on Power-to-X and Flexibility

May 19th 2020

Path to100%

Global 100% RE insights with focus on Power-to-X and flexibility

Emma Tallgren
Marketing Manager
Wärtsilä Energy Business

What is Path to 100%?

Path to 100% is an objective community intended to bring together thought leaders and industry experts **to discover solutions, raise awareness, and create a dialogue** on how to achieve an operationally and financially realistic approach towards a 100% renewable energy future.

Path to 100% is made possible by **Wärtsilä**, a global leader in smart technologies and complete lifecycle solutions for energy and marine markets.

In this webinar, speakers will discuss:

- The role of Power-to-X in the transition to 100% renewable energy
- Creating synthetic fuels from renewable energy sources
- Renewable synthetic fuels and their applications
- Wärtsilä driving Power-to-X and reference case

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Global 100% RE insights with focus on Power-to-X and flexibility

Agenda

- **100% Renewables for Europe and Global**
  - Insights for 100% Renewables
    - LUT University Study
  - Power-to-X: the core of sector coupling
  - Global Results
  - Key Takeaways
- **Making Power-to-X a Reality**
- **Q&A**

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Panelists

Emma Tallgren
Marketing Manager
Wärtsilä Energy Business
Moderator

Christian Breyer
Professor for Solar Economy
LUT University, Finland

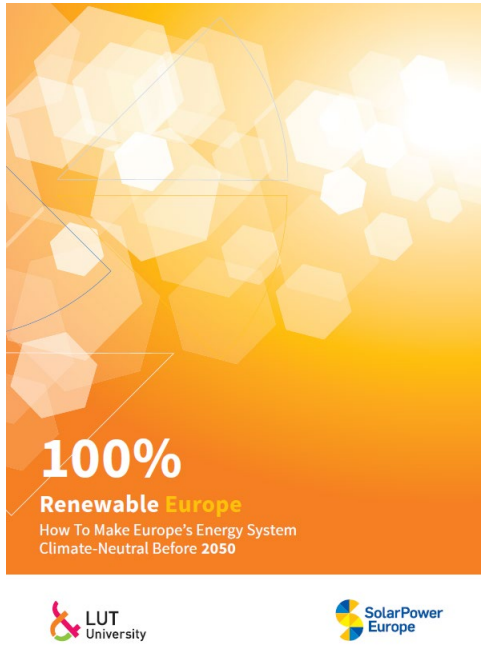
Matti Rautkivi
Director, Business Development
Wärtsilä Energy Business

100% Renewables for Europe and Global

Christian Breyer
LUT University
@ChristianOnRE

Insights for 100% Renewables

- The presented results are based on two major flagship studies carried out by the team of Prof. Christian Breyer at LUT University
- Europe results: study with SolarPower Europe, launched April 2020, featuring full sector coupling, latest cost insights, with scenarios for 100% Renewables in 2050, but also 2040
- Global results: study with Energy Watch Group, launched April 2019, featuring full power & heat sector coupling, and partly decoupled transport and desalination, with 100% Renewables in 2050



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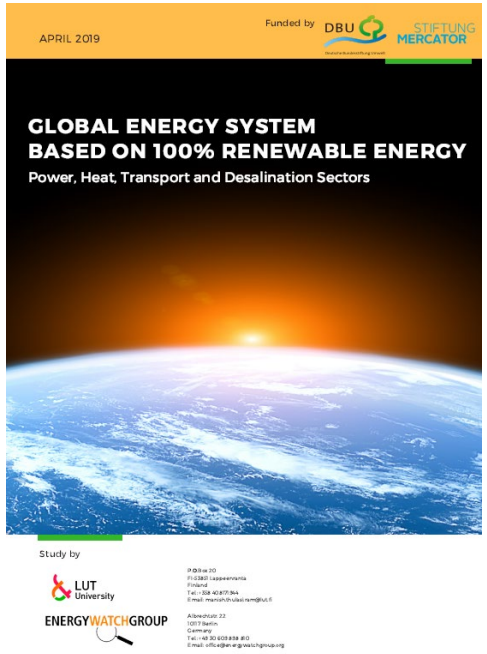

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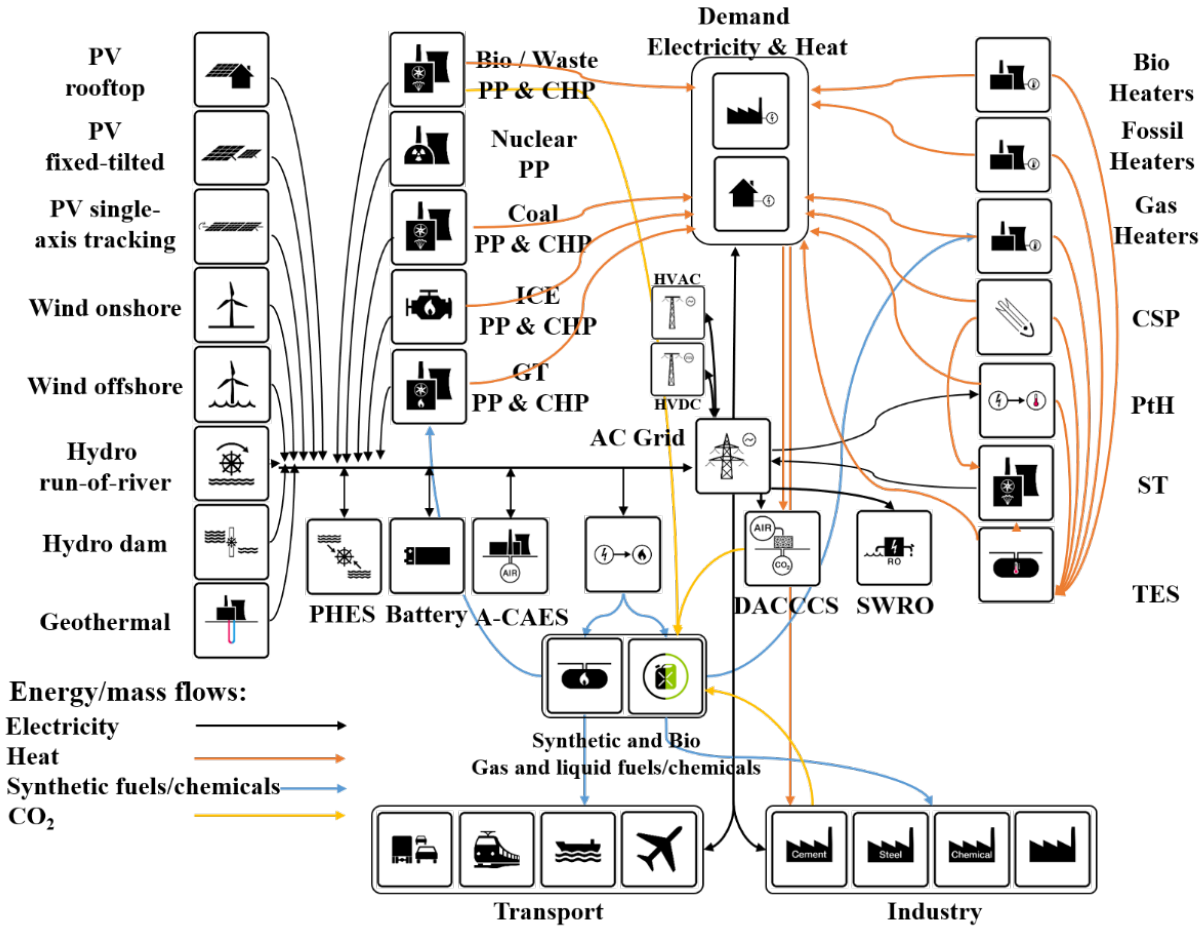
LUT Energy System Transition model

Key Features

- full hourly resolution
- applied in global-local studies
- comprising about 120 technologies
- used for several major reports, in about 50 scientific studies, published on all levels, including Nature
- strong consideration on all kinds of Power-to-X (mobility, heat, fuels, chemicals, desalinated water, CO_2)



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100% Renewables in Europe before 2050

Structure and Scenario Overview

- the following results refer to a recent study of LUT and SolarPower Europe
- Europe in this report refers to EU-27 plus Iceland, UK, Turkey, Ukraine, Switzerland, Norway, all Balkan countries
- the energy system comprises: power, heat, transport, industry; excluding non-energetic fuels demand

FIGURE 2.2 EUROPE – REGIONAL COMPOSITION

	LAGGARD	MODERATE	LEADERSHIP
RE energy share	62% by 2050	100% by 2050	100% by 2040
Paris Agreement	×	Achieved 2.0°c	Achieved 1.5°c
GHG emissions in the energy system	-90% in 2050	-100% in 2050	-100% in 2040
Fossil fuels phaseout	×	Achieved in 2050	Achieved in 2040
Nuclear phaseout	×	×	Achieved in 2040

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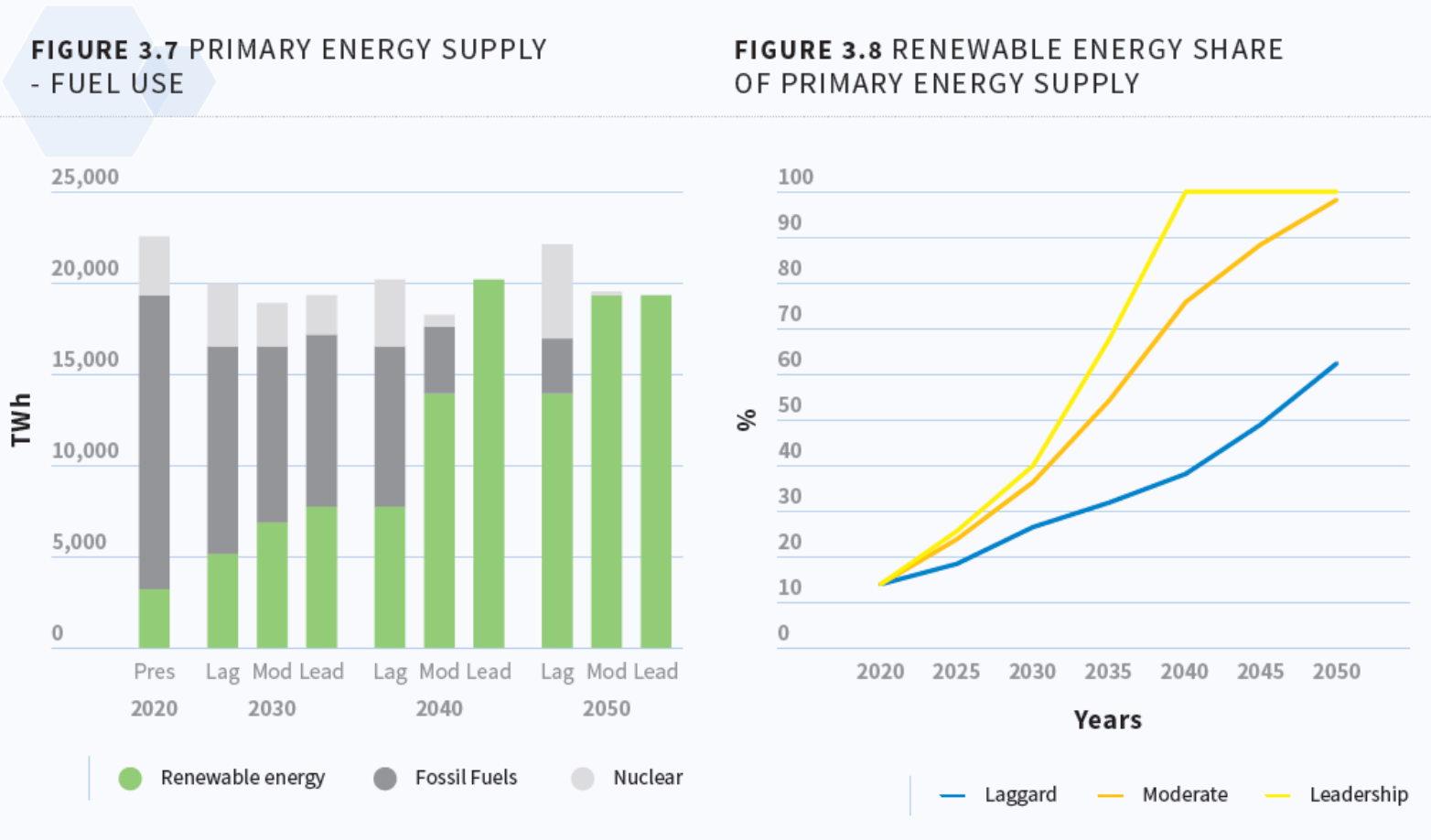
Primary energy demand

- High rate of electrification is essential to achieving a 100% renewable and integrated energy system
- Combustion processes are a burden for an efficient energy system, well documented by Laggard



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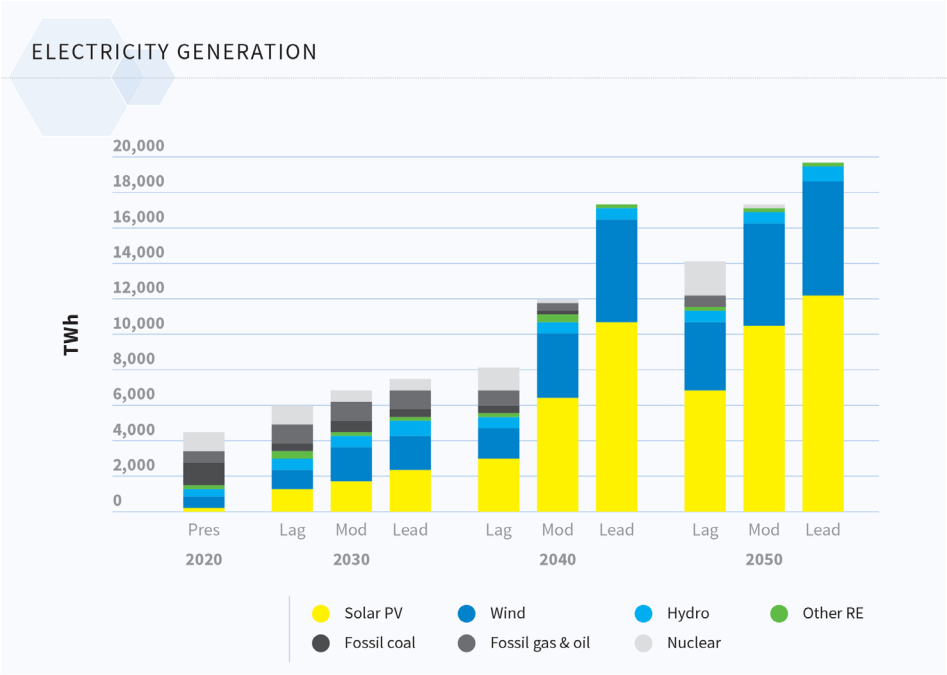
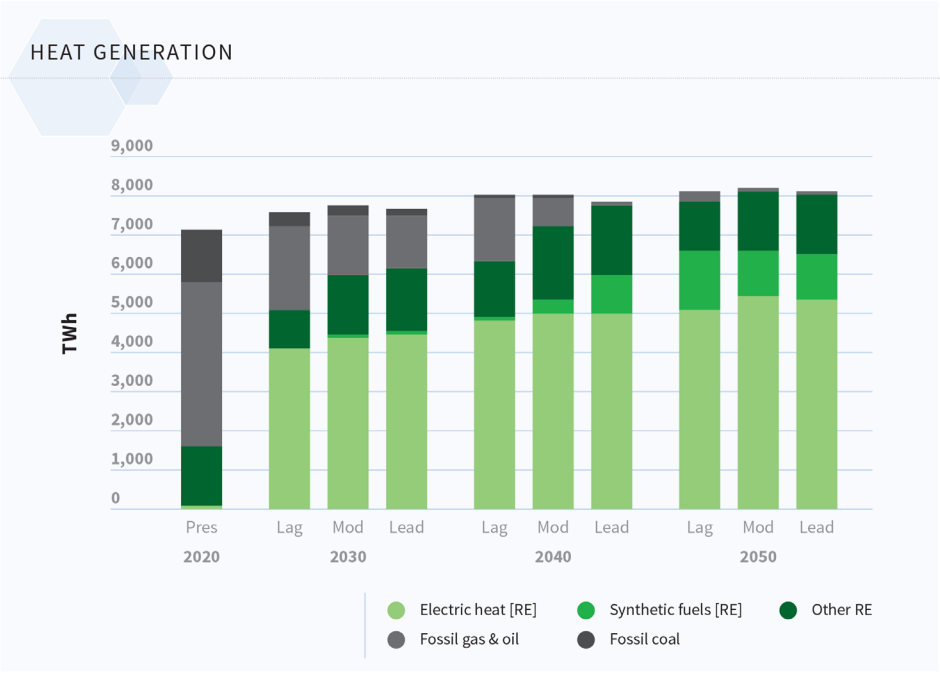
Electricity generation and heat supply



Source: SolarPower Europe. © SOLARPOWER EUROPE 2020



Source: SolarPower Europe. © SOLARPOWER EUROPE 2020

- As of 2040, solar PV will become the dominant source of electricity generation across the three scenarios, and by 2050 it will reach at least 48% in the Laggard scenario and up to 63% in the Leadership scenario
- Solar PV economics perform excellently, while benefiting from low-cost storage and Power-to-X flexibility
- Heat pumps emerge as core part of a 100% renewable system, with over 60% share of heat generation

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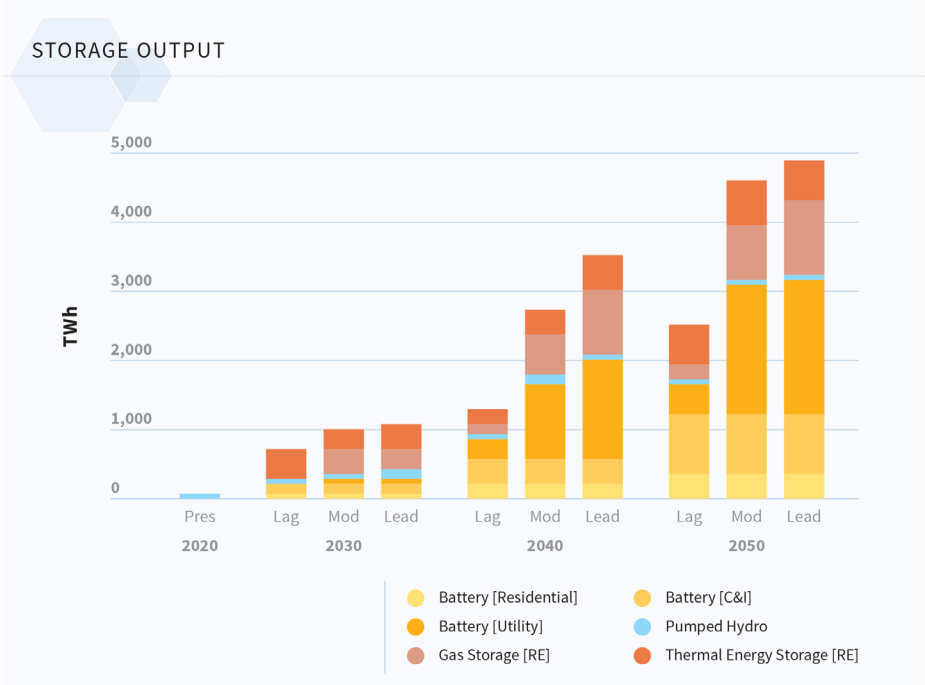
Storage output and energy demand



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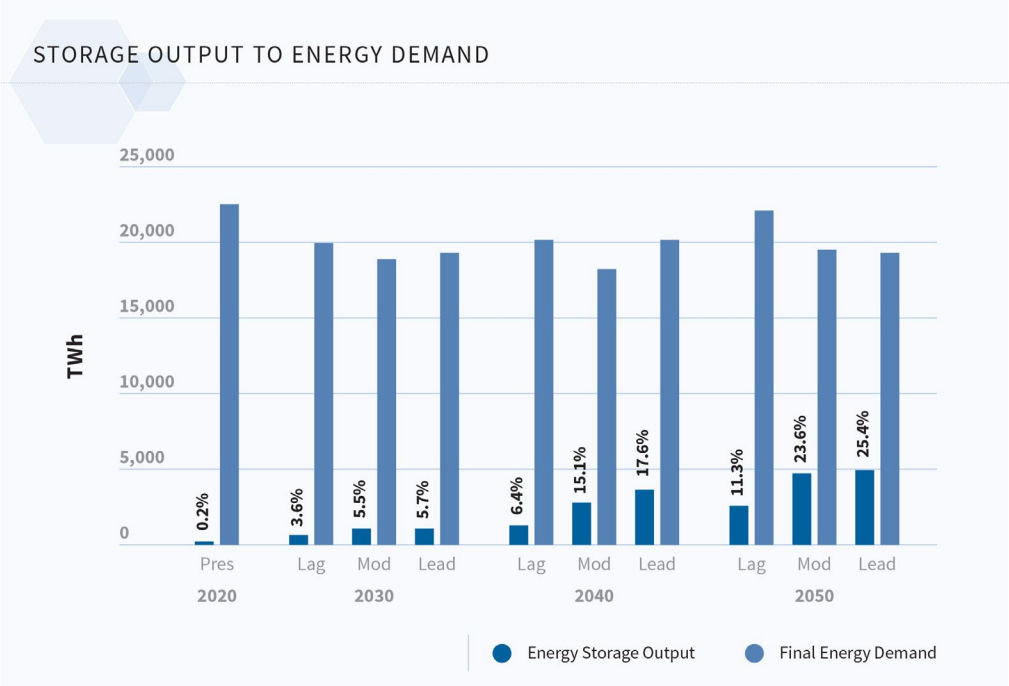

Source: SolarPower Europe. © SOLARPOWER EUROPE 2020

- Batteries provide the bulk of energy storage in a 100% renewable energy system
- Some gas-based seasonal storage is needed in a 100% renewable system, due to vast flexibility in sector coupling and broad electrification
- Full sector coupling and high electrification rates keep the growth of storage output up to 25% of final energy demand in 2050

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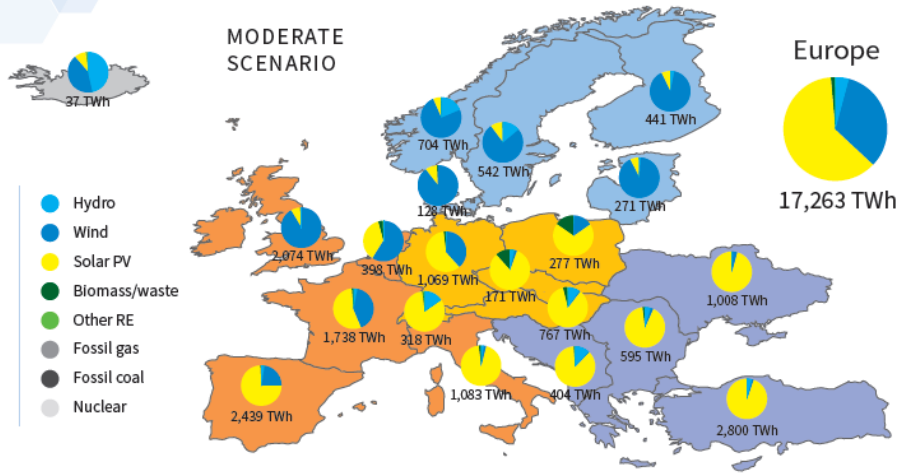
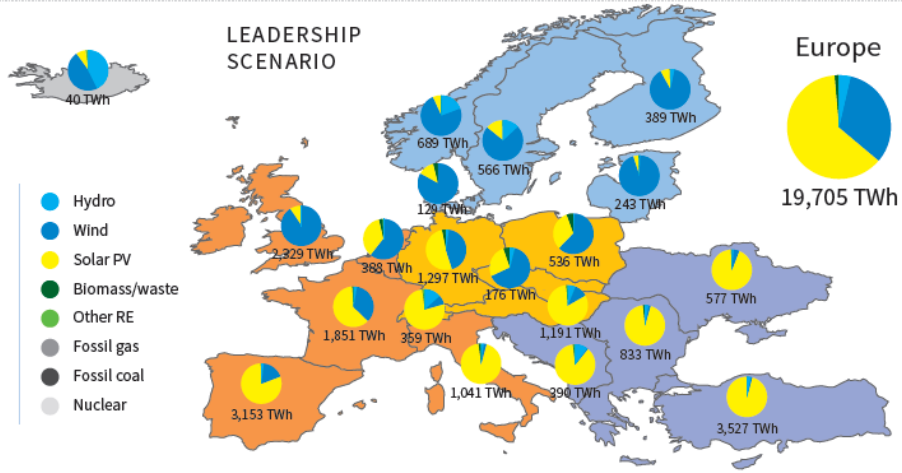
Regional electricity capacities in 2050

FIGURE 4.2 REGIONAL ELECTRICITY GENERATION IN 2050 ACROSS EUROPE





Key insights

- Full sector coupling provides energy security for Europe, with PV capacities predominantly located in the southern regions, while wind energy systems are mainly installed in the northern and western regions of Europe
- Leadership requires more electricity than Moderate, since more combustion processes have to be covered by 2040 due to failed investments in 2010s and 2020s
- Export of synthetic fuels in 2040s may lead to net-negative GHG emissions in Europe
- Faster transition requires more wind, slightly delayed transition leads to more solar PV, see for instance Germany
- Curtailment is 4-5%, while 15% cross-border trade

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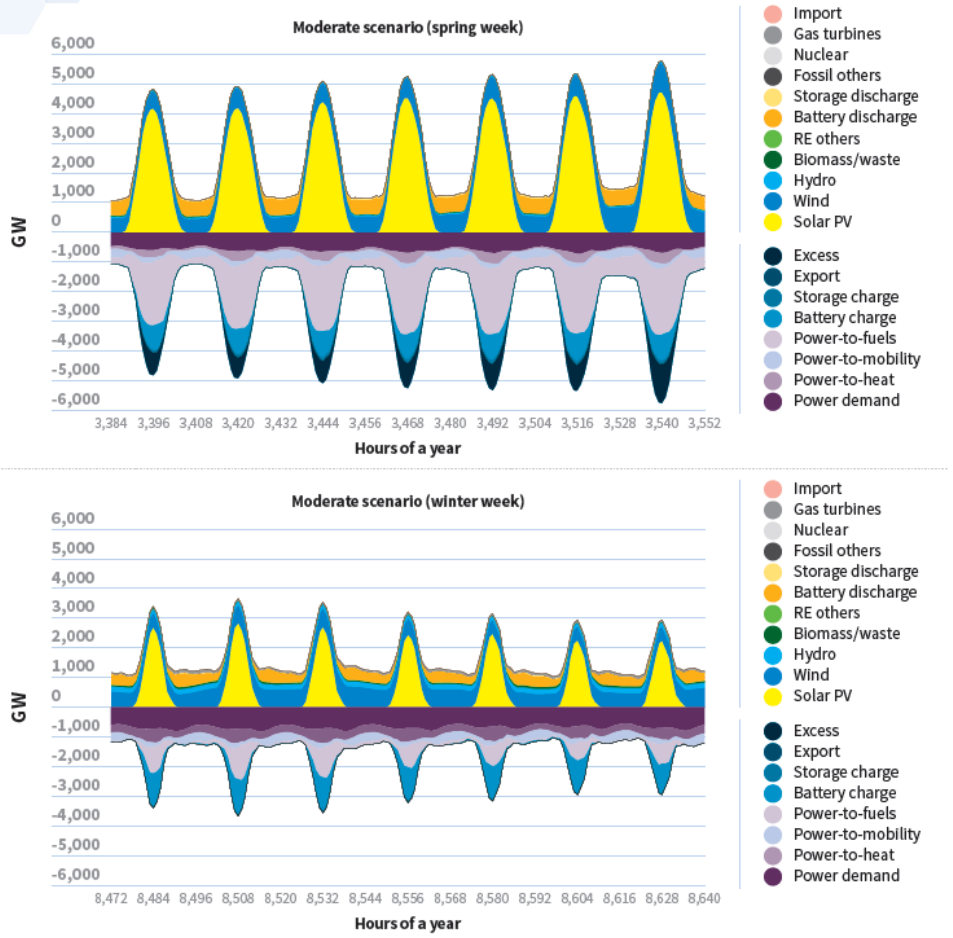
Hourly operation of the energy system

FIGURE 4.8 HOURLY OPERATION OF THE EUROPEAN ENERGY SYSTEM



Key insights:

- Week of least renewables supply (winter) and most renewables supply (spring) is visualized
- A 100% renewables-based and fully integrated energy system in 2050 will function without fail every day of the year: Even in the dark winter days the country easily copes with energy demand
- Key balancing component are electrolysers (Power-to-fuels) which convert electricity to hydrogen, when electricity is available, but drastically reduce their utilisation in times of low electricity availability
- Massive ramp rates in the energy system have to be managed, as well as forecasting errors require balancing

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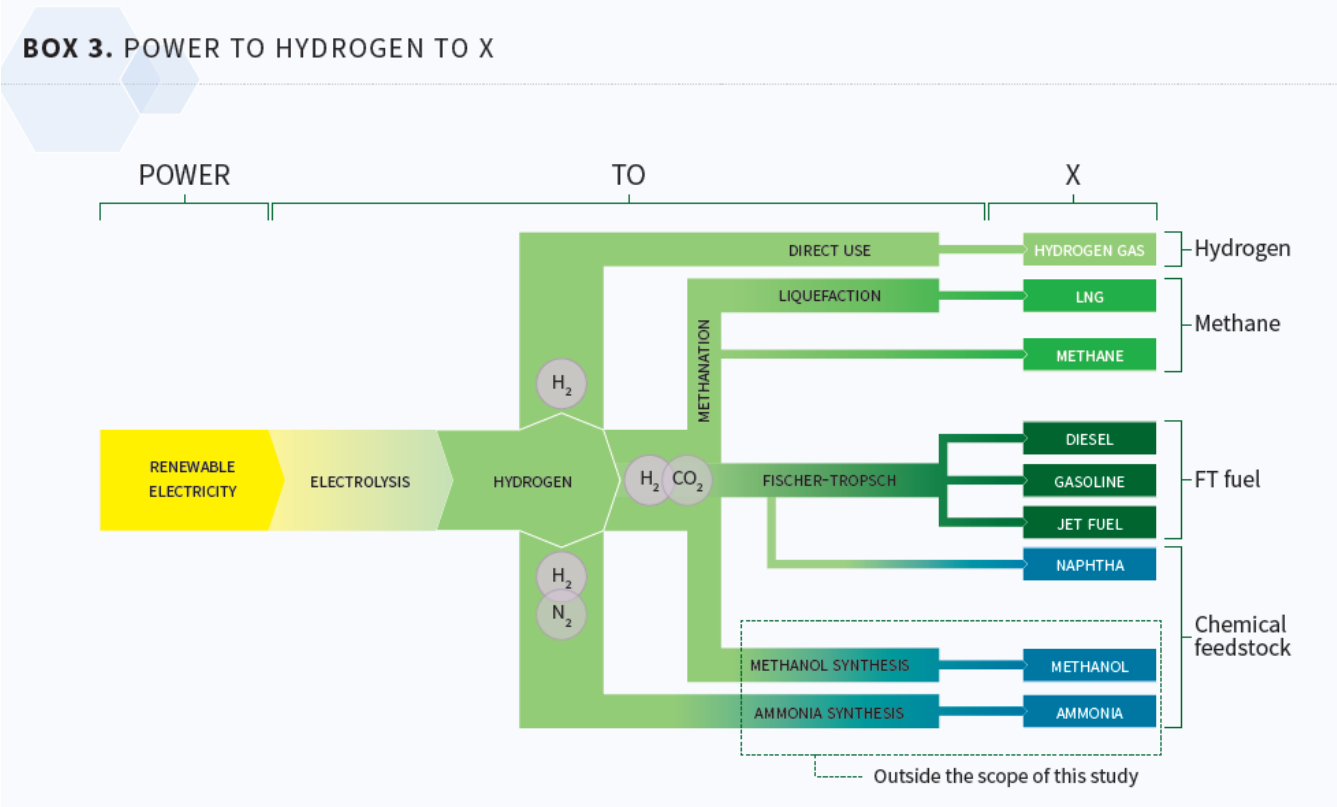
Power-to-X: the core of sector coupling



Key insights:

- Power-to-X comprises: Mobility, Fuels, Chemicals, Heat, Steel, Desalinated Water, CO_2
- Hydrogen is ONLY required, where direct electrification fails, e.g. chemicals, fuels for aviation/ marine

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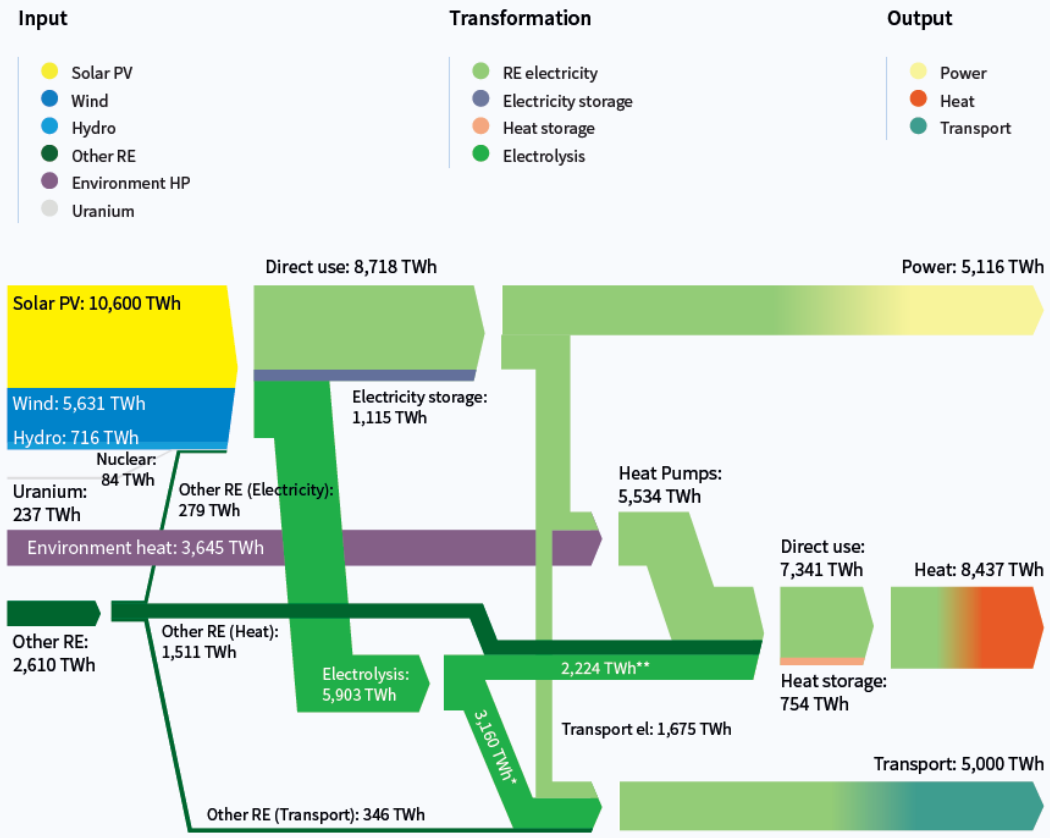
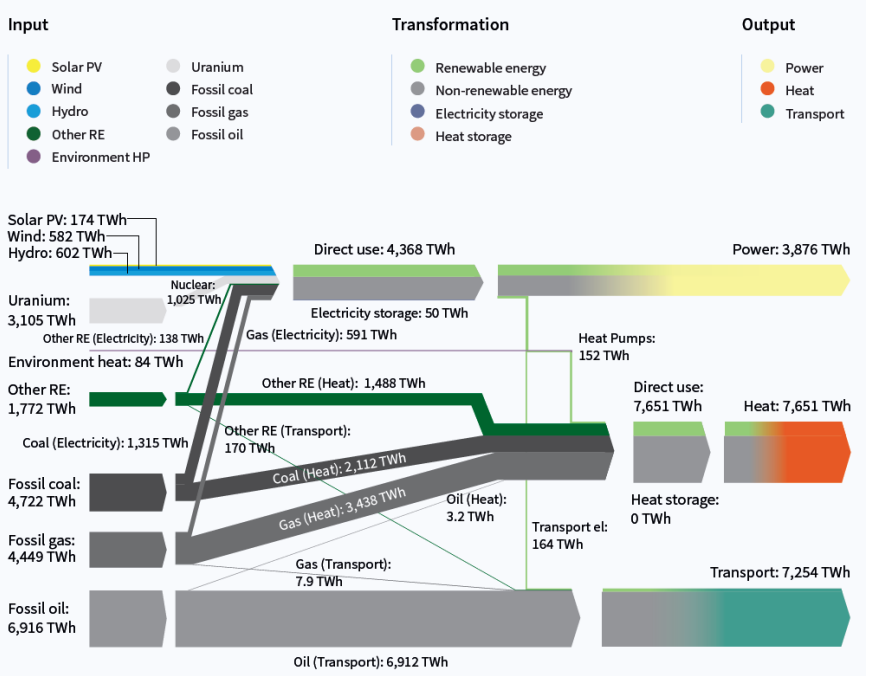
Energy system dynamics: Silos to integration

FIGURE 3.25 ENERGY FLOWS FOR THE EUROPEAN ENERGY SYSTEM IN THE MODERATE SCENARIO IN 2050



*RE synthetic fuels for transport.
**RE synthetic fuels for heat, recovered heat.

FIGURE 3.24 ENERGY FLOWS FOR THE EUROPEAN ENERGY SYSTEM IN 2020



Past/ Present

- Energy sectors (power, heat, transport) practically separated
- Dominating role of fossil fuels
- Transport sector has practically not yet started the transition

Future

- 100% renewables will lead to a strongly coupled energy system
- Most important energy carrier is electricity, while second most important is green hydrogen
- Fossil and nuclear fuels are not part of a sustainable and least cost energy system

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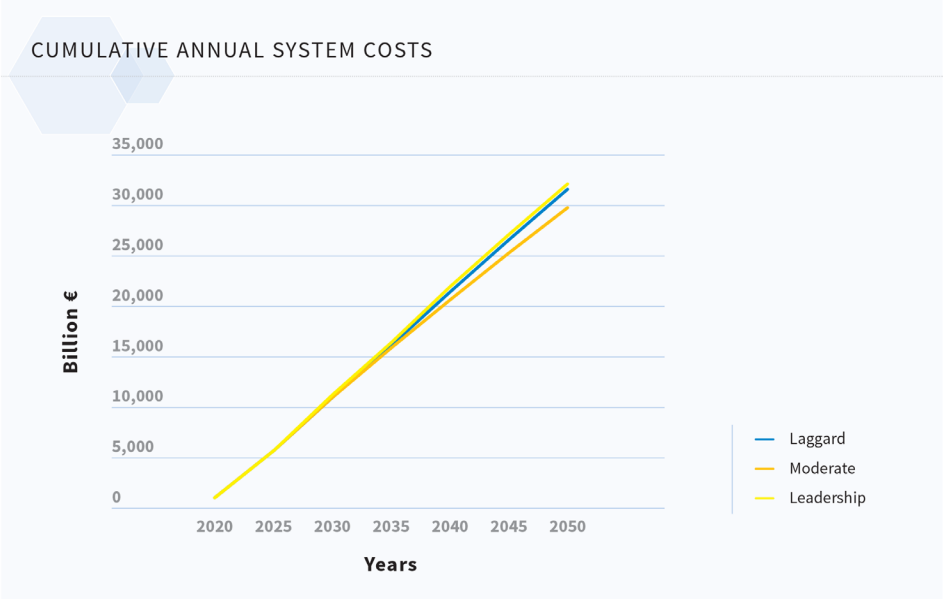
Energy System Cost: Cumulative and Specific



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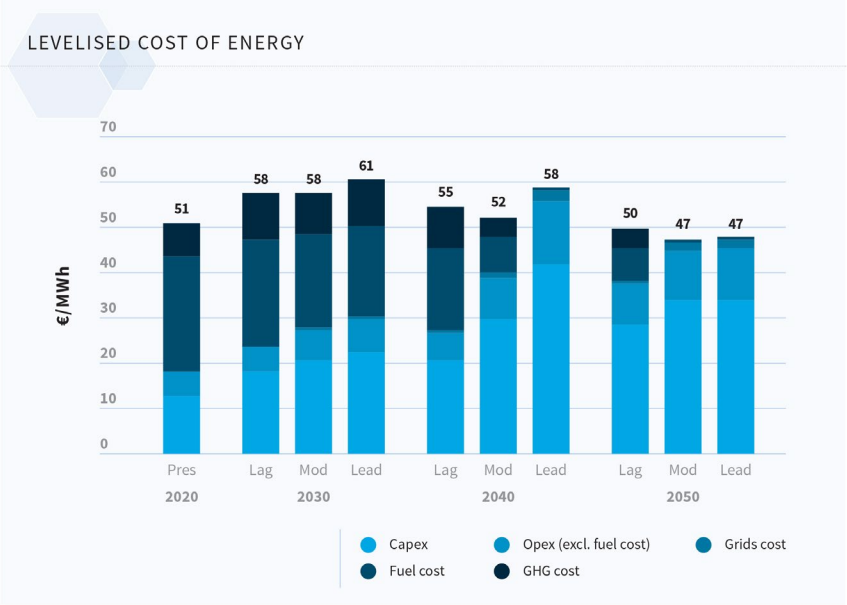

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- A 100% renewable energy system is the most cost-efficient way to become climate neutral by 2050: cumulative costs of achieving 100% renewable energy by 2050 in the Moderate scenario are 6% lower than the cost of the less ambitious Laggard scenario
- The Leadership scenario achieves zero GHG emissions by 2040, for slightly higher cost than for a zero GHG emission system by 2050, while it costs practically the same as a delayed transition
- In 2050, the levelised costs of energy in the 100% renewable scenarios are 5–6% lower than costs in a less ambitious scenario, and at the same time 7% more competitive than today's costs

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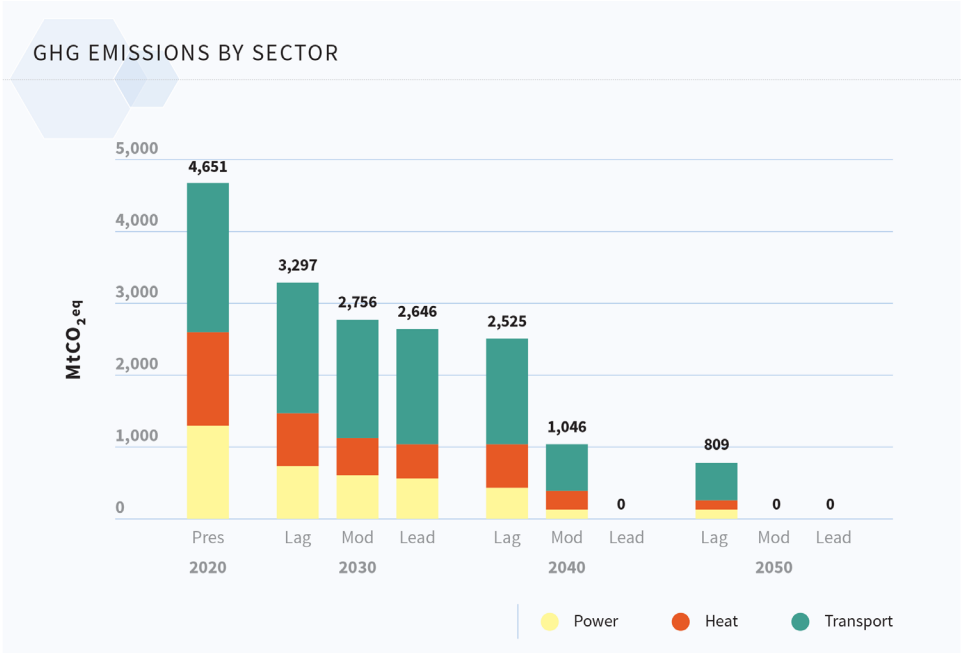
GHG Emissions: per Sector, cumulative



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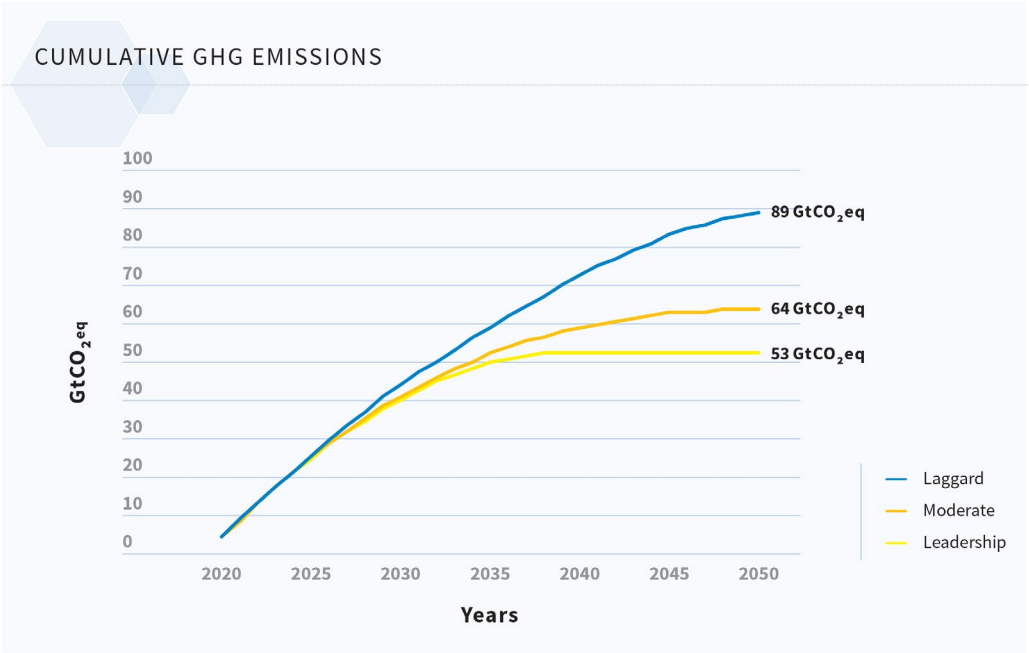

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- A 100% renewable transition triggers the sharpest decline in GHG emissions, decline by over 60% by 2030, and will be down to zero in 2050, or even 2040 in the Leadership scenario. By contrast, Laggard scenario still emits around 800 million tonnes of CO_{2eq} per year by 2050
- The Leadership Scenario has the most positive impact on the climate, resulting in remaining cumulative GHG emissions of only 53 $GtCO_{2eq}$ and down to zero over the next 20 years. Leadership scenario emits 41% and 28% less GHG emissions compared to Laggard and Moderate, respectively

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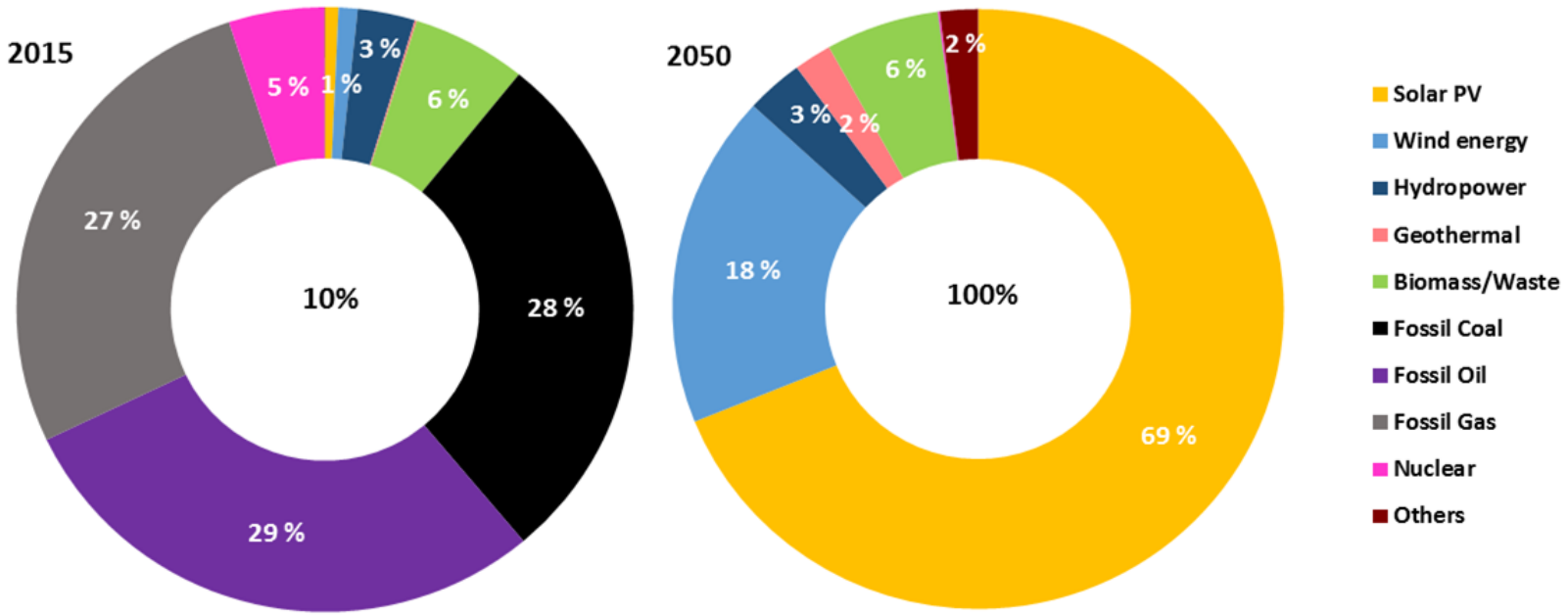
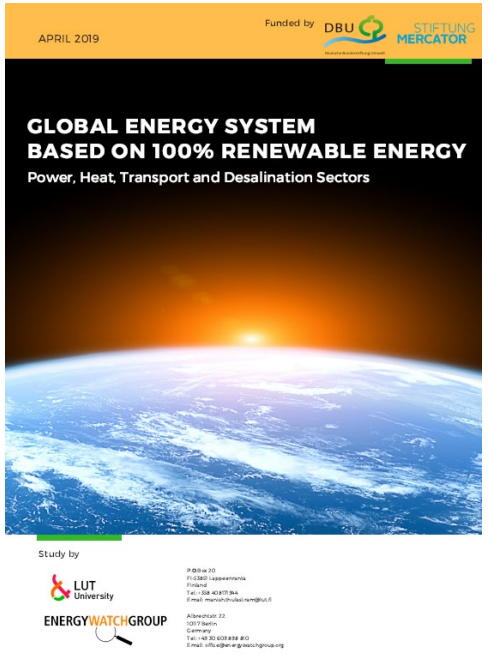
Global Results





link to report

- Primary energy shifts from being dominated by fossil fuels in 2015 towards solar PV and wind energy by 2050
- Renewable sources of energy contribute just 22% of TPED in 2015, while in 2050 they supply 100% of TPED
- Solar PV drastically shifts from less than 1% in 2015 to around 69% of primary energy supply by 2050, as it becomes the least cost energy supply source

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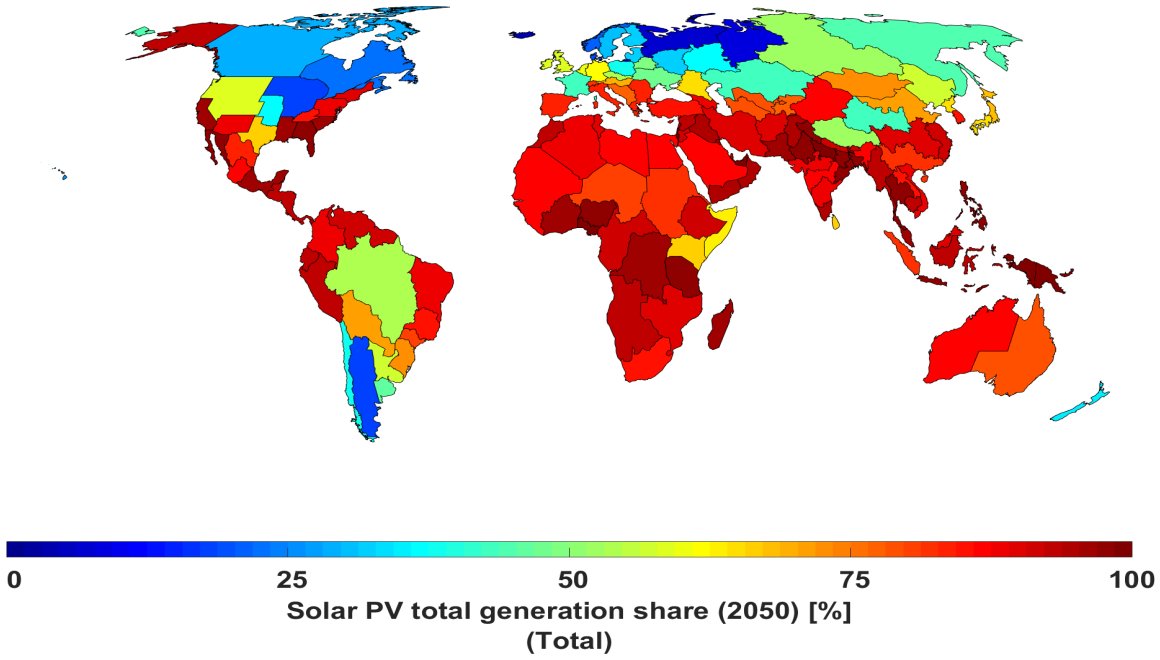
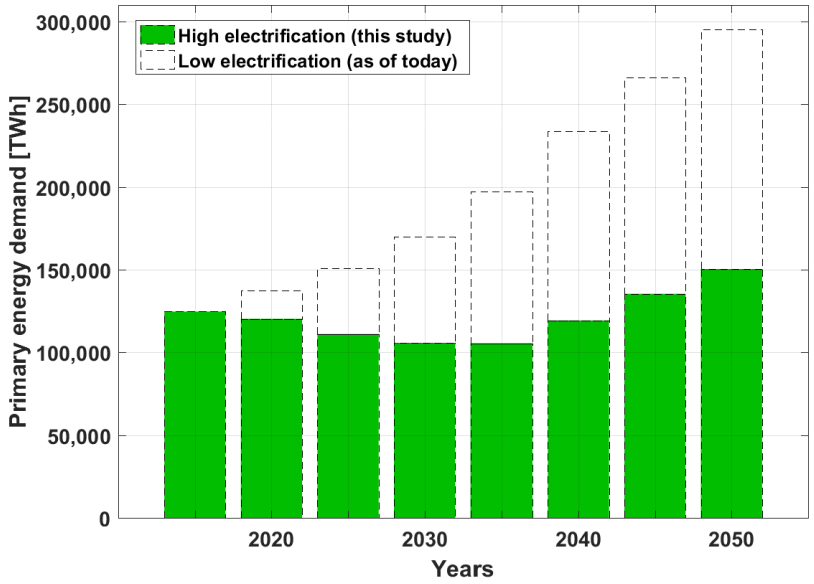
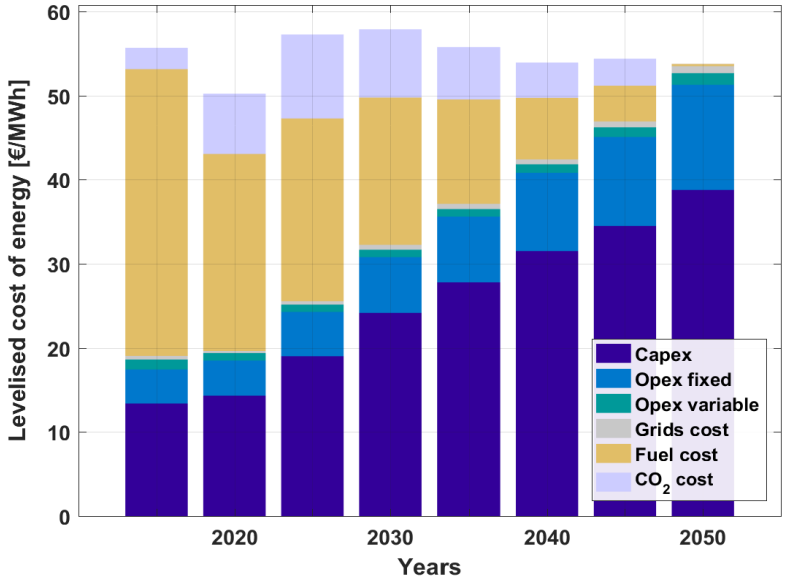
Global Results







- Solar PV dominance, due to low-cost PV, batteries, and Power-to-X
- Broad electrification enables a massive efficiency gain
- Total system cost remain stable, while overall sustainability is achieved
- This is the only known cost-neutral 1.5°C energy transition scenario

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Key takeaways

1. **100% Renewables is the new normal**
   - Drivers are very low-cost variable renewables: solar PV and wind energy
   - Variable renewables are ONLY system compatible with low-cost batteries and massive system flexibility
   - Power sector provides only little flexibility, thus dispatchable renewables (hydro dams, bioenergy) are very valuable
   - Power sector requires some flexible and fast ramping thermal capacities, based on sustainable fuels
2. **Value of Power-to-X**
   - Flexibility is the new king: fast ramping (thermal, storage, electrolysers, etc.)
   - X means: heat, fuels, chemicals, mobility, steel, desalinated water, CO_2
   - physically ALL energy demand can be based on electricity, water and air
   - Renewable electricity is the central and dominating energy carrier, while green hydrogen is the second fundamental carrier
3. **What's not part of a long-term solution**
   - Fossil CCS (Carbon Capture and Storage): it's high-cost, inflexible, 80-90% capture efficiency, PM2.5/PM10 emissions remain
   - Nuclear energy: it's high-cost, inflexible, no relevant liability insurance, risk of melt-downs remain (natural disasters, terrorism, etc.)
   - No action: the youth forces action of the present decision making generation, and no actions lead to substitution of unwilling staff

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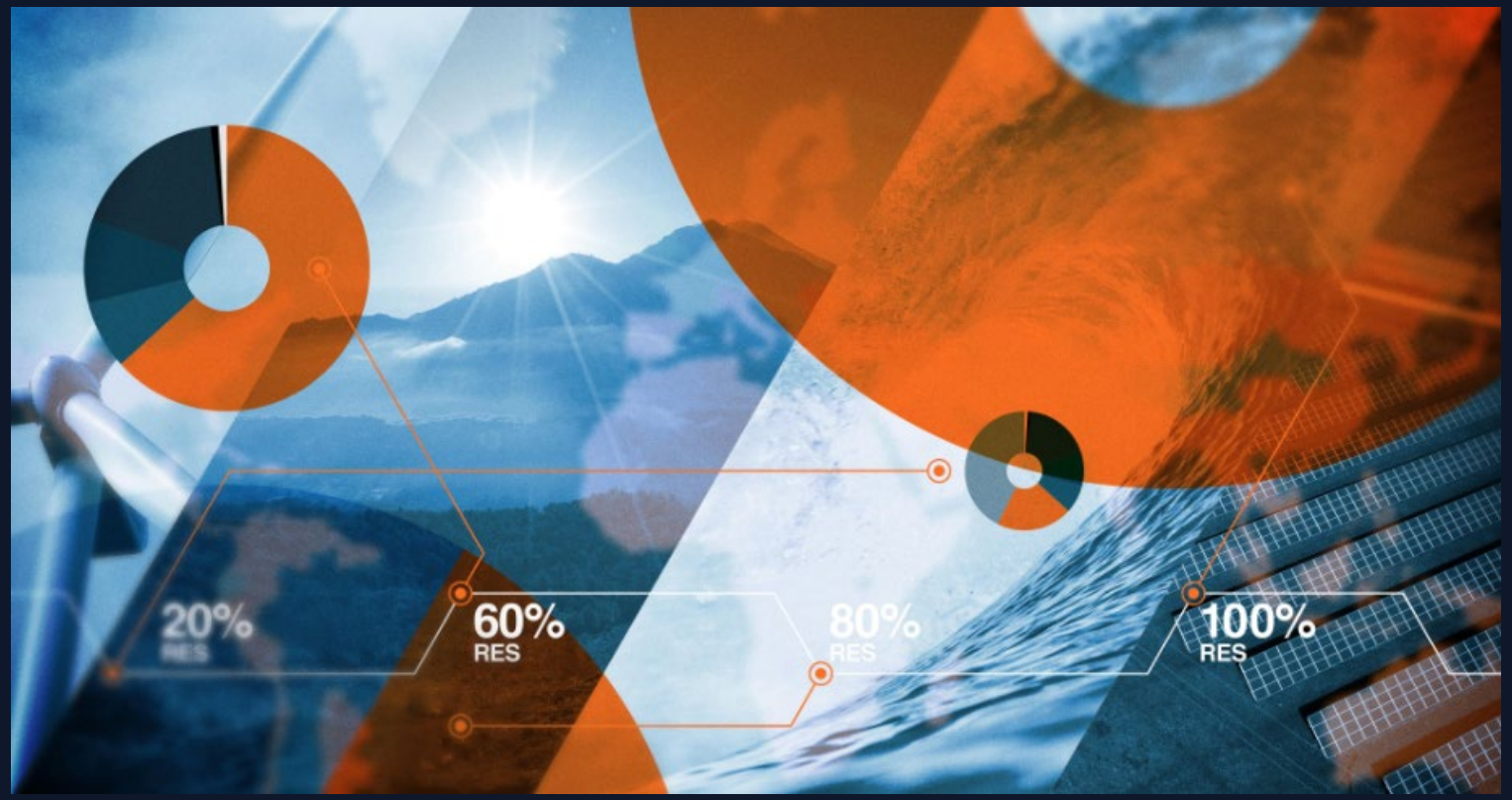
MAKING POWER-TO-X REALITY

Matti Rautkivi
Director, Business Development
Wärtsilä



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OUR VISION

100% RENEWABLE ENERGY

Wärtsilä has modelled 145 countries and regions to find the optimal way to produce electricity from 100% renewable energy sources. The map illustrates how the power system of each of these regions would look like if they were to be optimally built from scratch, not considering the burden of existing power plants. Each region has unique solar and wind conditions which makes the optimal energy mix for each region unique.

SELECT YOUR LOCATION BELOW

VISIT THE ATLAS OF 100% RENEWABLE ENERGY »

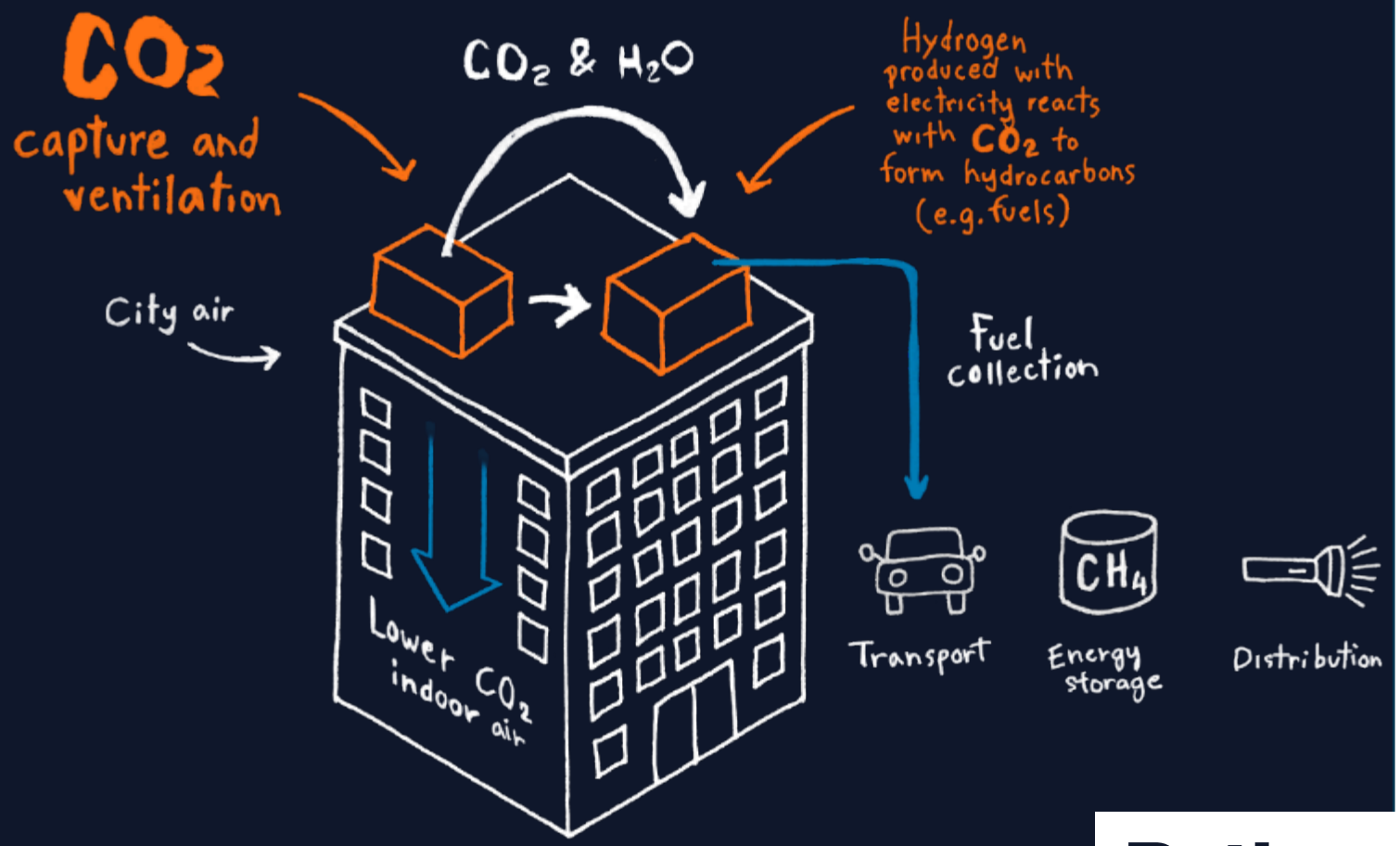
NEBRASKA PUBLIC POWER DISTRICT & LAPPEENRANTA UNIVERSITY OF TECHNOLOGY

Wärtsilä, Lappeenranta University of Technology (LUT) and Nebraska Public Power District (NPPD), signed a Memorandum of Understanding for the study of the development of a business case for the use of alternative fuels with Wärtsilä generating sets.

The aim is to achieve a technically and commercially viable solution that will allow NPPD to proceed with an industrial scale pilot project. This initiative will help accelerate the move towards a future based on 100% renewable carbon free sources. The specified alternative fuels include methanol, dimethyl ether (DME) and ammonia, synthesised from hydrogen, CO_2 and nitrogen.

WÄRTSILÄ X SOLETAIR POWER

- Wärtsilä is seed funding Soletair Power Oy
- Soletair Power's solution represents an important step towards carbon neutral societies and supports Wärtsilä's strategy in leading the energy sector's transformation towards a 100% renewable energy future
- Improved efficiency in people because of the improved air quality



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WÄRTSILÄ X Q POWER

Wärtsilä and Q Power, a Finnish pioneer in biomethanisation, will cooperate to accelerate the development and commercialisation of renewable synthetic fuels.

Both companies will work closely together to further develop the market and to find business opportunities for biomethanisation and synthetic fuels globally. The first target of the cooperation is to showcase a mobile demonstration plant at the Finnish pavilion at Expo 2020 Dubai between October 2020 and April 2021.

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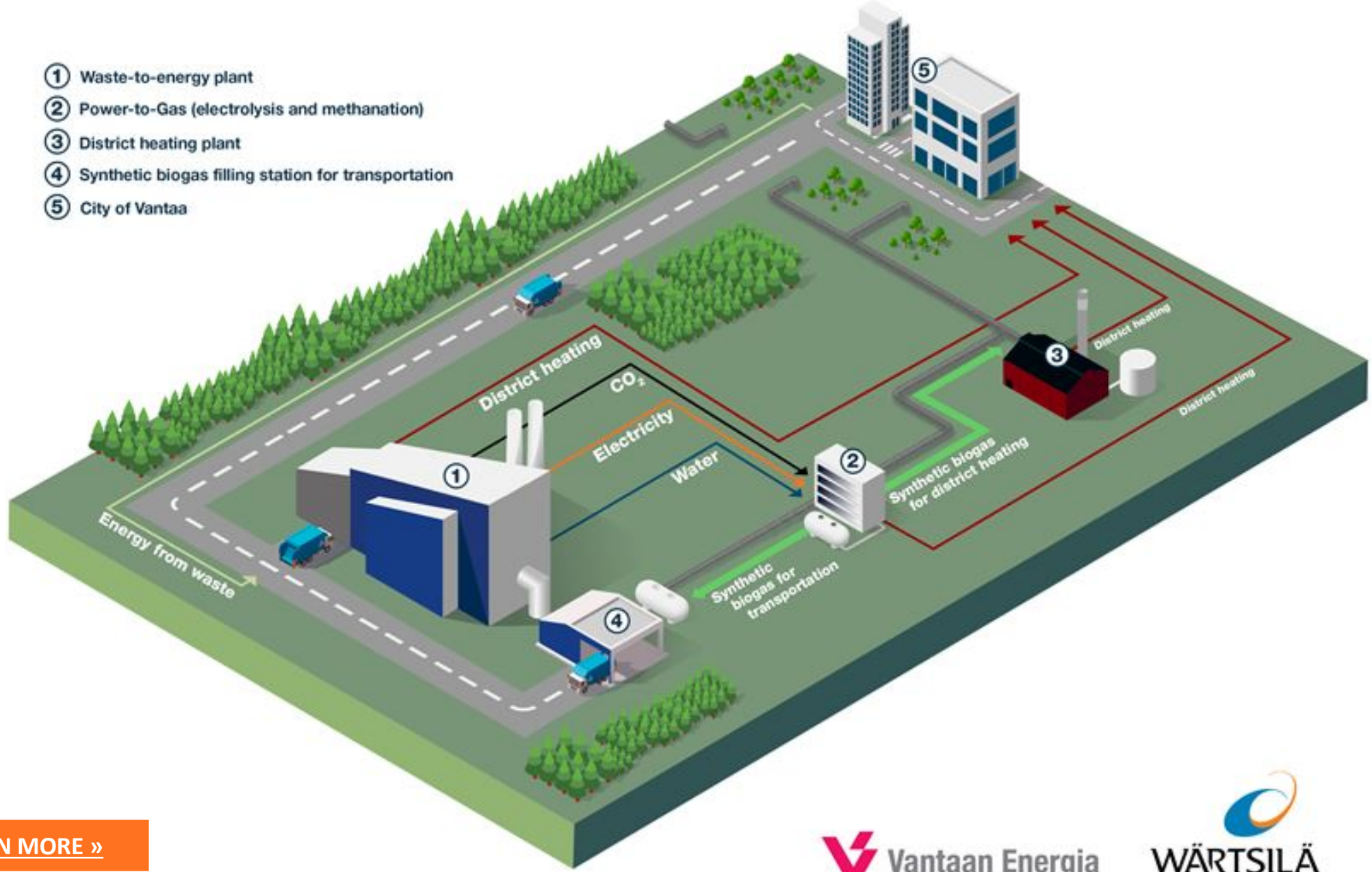

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