Energy transition and decarbonization!

From only environmental focus to become a question of global competitiveness

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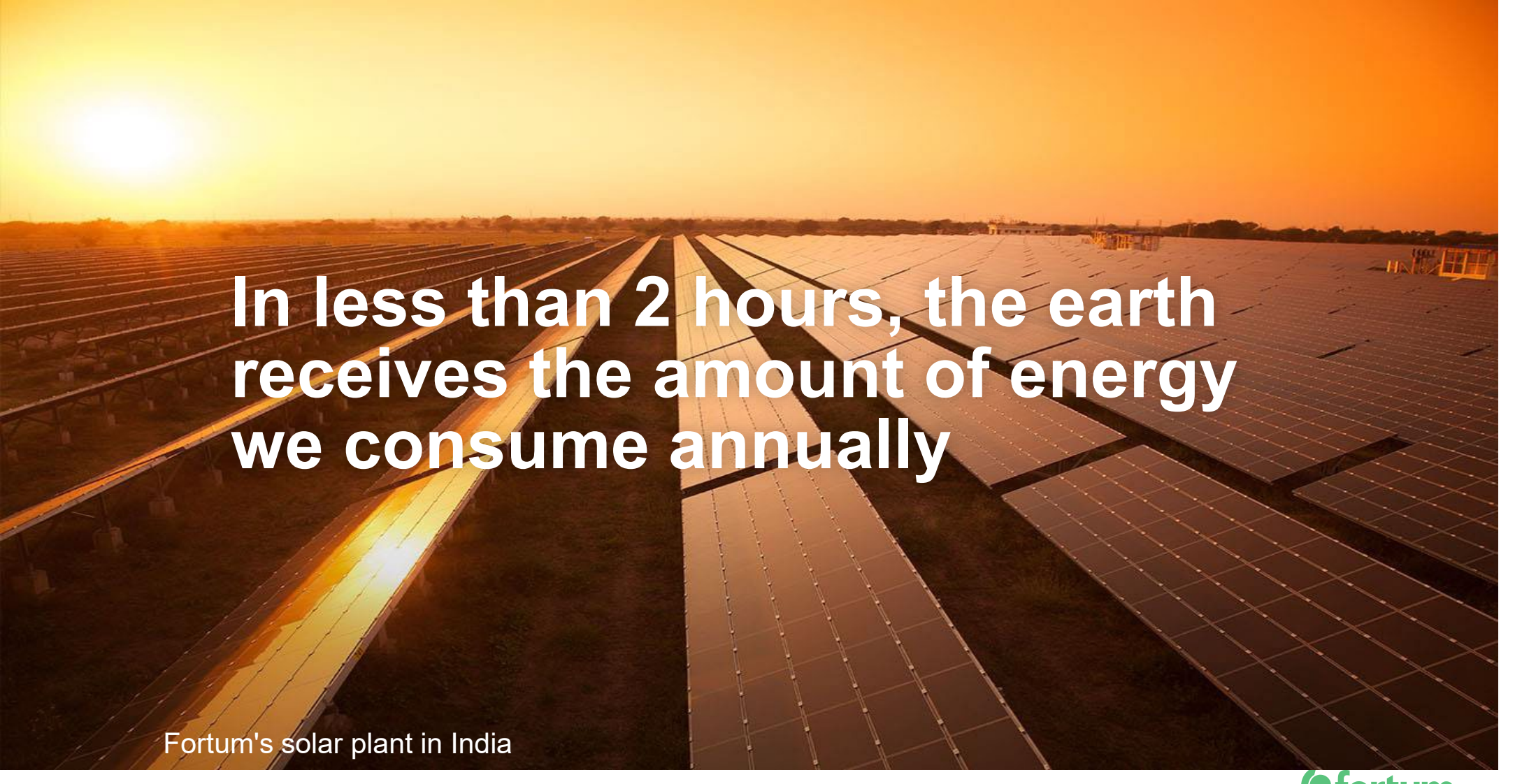

Fortum's solar plant in India

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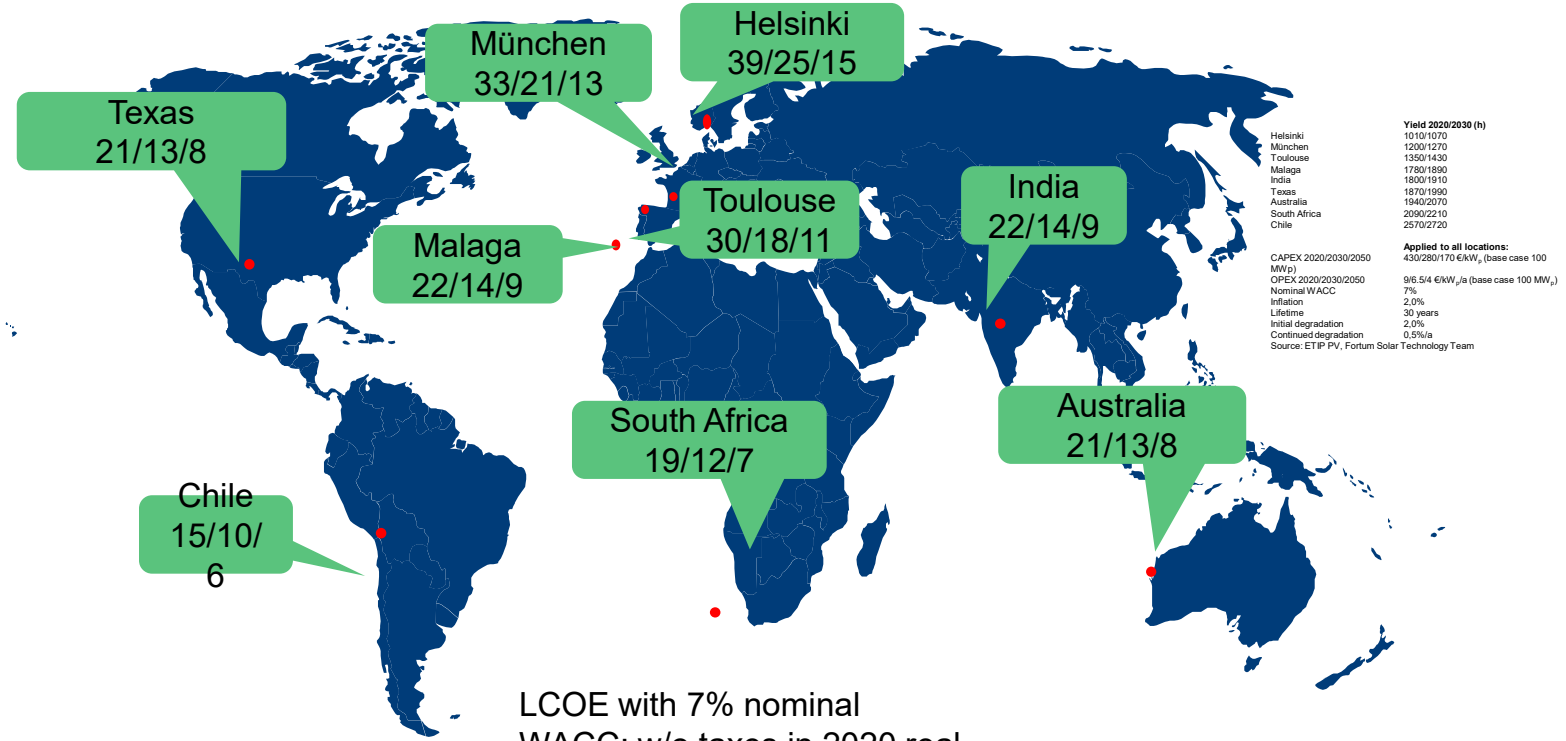
PV is already the cheapest electricity form almost everywhere

The trend with decreased prices is expected to continue

Utility-scale PV LCOE (€/MWh) based on average 2020/2030/2050 CAPEX



	Yield 2020/2030 (h)
Helsinki	1010/1070
München	1200/1270
Toulouse	1350/1430
Malaga	1780/1890
India	1800/1910
Texas	1870/1990
Australia	1940/2070
South Africa	2090/2210
Chile	2570/2720

Applied to all locations:	
CAPEX 2020/2030/2050	430/280/170 €/kW$_p$ (base case 100 MWp)
OPEX 2020/2030/2050	9/6.5/4 €/kW$_p$/a (base case 100 MW$_p$)
Nominal WACC	7%
Inflation	2.0%
Lifetime	30 years
Initial degradation	2.0%
Continued degradation	0.5%/a

Source: ETIP PV, Fortum Solar Technology Team

LCOE with 7% nominal WACC; w/o taxes in 2020 real €/MWh

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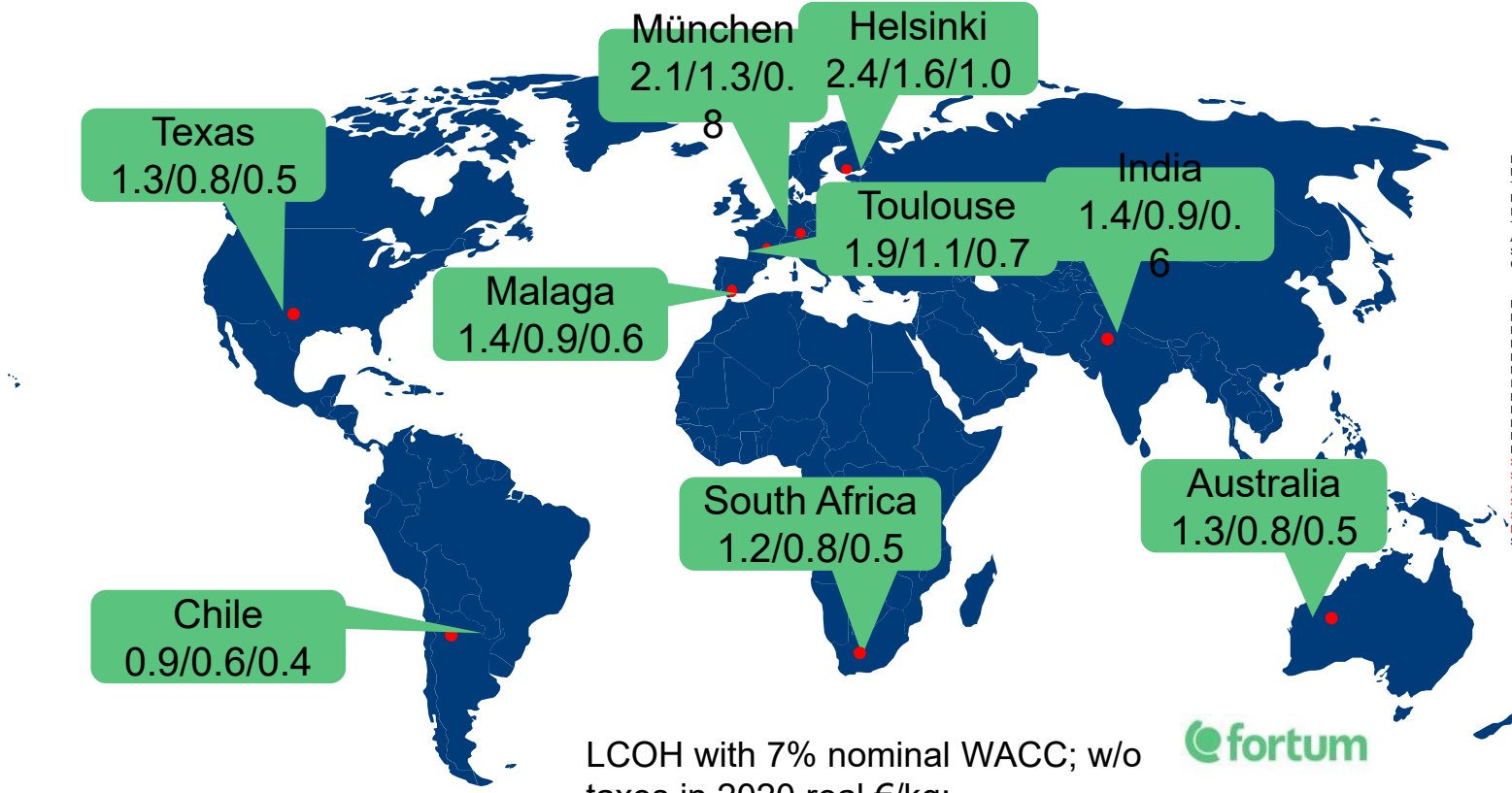
Solar hydrogen starts to be a competitive fuel around 2030

Utility-scale solar hydrogen LCOH (€/kg) based on PV LCOE and electrolyser CAPEX 2020/2030/2050; as a reference, LCOH is **1.1 €/kg** for hydrogen produced from natural gas (15 €/MWh) with steam reformer and without CCS; CCS would add ~50% to LCOH



	PV Yield 2020/2030 (h)
Helsinki	1010/1070
München	1200/1270
Toulouse	1350/1430
Malaga	1780/1890
India	1800/1910
Texas	1870/1990
Australia	1940/2070
South Africa	2090/2210
Chile	2570/2720

	Applied to all locations:
PV CAPEX 2020/2030/2050	440/280/170 €/kW$_p$ (base case 100 MWp)
PV OPEX 2020/2030/2050	9/6.5/4 €/kW$_p$/a (base case 100 MW$_p$)
PV Initial degradation	2,0%
PV Continued degradation	0,5%/a
Nominal WACC	7%
Inflation	2,0%
Lifetime	30 years
Electrolyser CAPEX '20/'30/'50	170/115/80 €/kW (unit size 3/10/100 MW)
Electrolyser OPEX '20/'30/'50	4/3/2 €/kW/a
Electrolyser efficiency	67%
Electrolyser utilisation and lifetime	as with PV
Steam reformer CAPEX	870 €/kW
Steam reformer OPEX	32 €/kW/a
Steam reformer utilisation	8000 h/a
Steam reformer lifetime	30 years
Steam reformer efficiency	70%
Natural gas price	15 €/MWh

Source: ETIP PV, BNEF, Fortum Solar Technology Team

LCOH with 7% nominal WACC; w/o taxes in 2020 real €/kg;
lower heating value 33.3 kWh/kg

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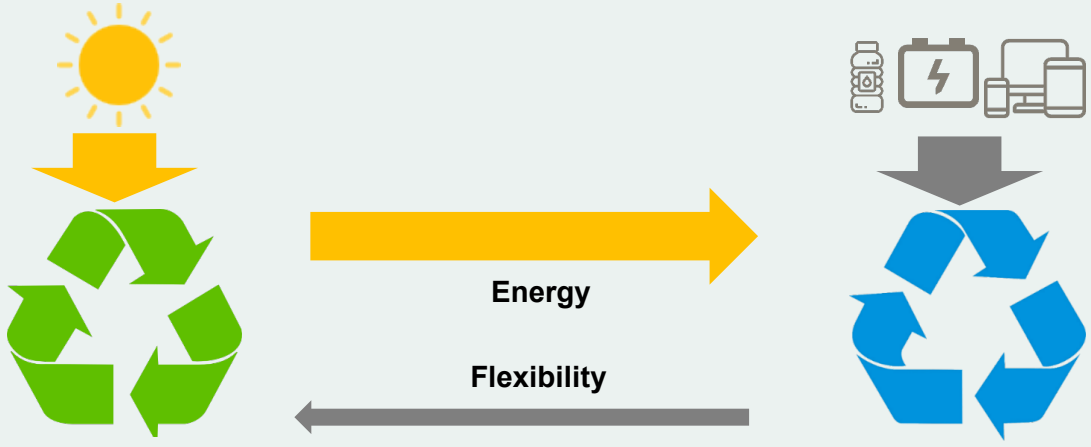
Renewable Energy is the key enabler for circular solution

A massive amount of energy is needed to maximize ”man made” circular system



Natural circular system
- Solar, PV
- Wind
- Hydro
- Fresh water
- Bio

Man made circular system
- Metals, minerals
- Synthetic hydro-carbon
- Bio-based hydro-carbon
- H2, Fresh water

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Four advices and activities

How to decarbonize without losing your competitiveness if you live far from the solar belt

1&4	Is a long-term challenge, and will define how well we will be able to decarbonize our society
2&3	Is short-term question, that needs to be solved today, and will define how competitive we will become in the Nordics

1.

Stop focus on energy efficiency

Start focus on material efficiency and capacity optimization

Steer the societies investments, subsidies and tax systems from energy efficiency to capacity optimization and material efficiency.

2.

Improved utilization of infrastructure

Secure effective sector coupling

- Electricity,
- Natural gas, Hydrogen (H2)
- Electricity, networks (TSO and DSO), Gas Networks, Natural gas and
- District heating
- Traffic

Create a holistic framework to steer all sectors in the same direction

- How to minimize Security of Supply cost and grid cost?
- How to transport energy over long-distances (1000 to 3000 km), electricity or H2?
- Finnish, Nordic or European perspective?

Build new infrastructure, Electricity and Hydrogen

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3.

Improve markets drivers

Secure and maintain effectiveness and competitiveness of current system:

- Fossil free electricity production
- Value flexibility and Security of Supply
- District heating

Secure a system or market that enable large investment into:

- Wind
- H2, production and pipe

Set target for CO2 reduction in end products

- Steel, Cement, Fertilizer, Liquid fuels

Create a market to enhance the value of flexibility

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4.

Re-define the meaning of ”sustainability” so it allows a green industrialization

- Sustainability needs to be defined, so human activities can be something positive, and more human activities the make the world even better.
- Today, the definition of sustainability makes human activities bad or problematic
- Sustainability definition needs to be able to handle the global impact in relation to local impact, at the same time allowing society to develop
- We use the precautionary principle to broad in conjunction with environmental law, it has become a tool to stop the development, instead of improving the environment.

Legal framework needs to be adopted and changed

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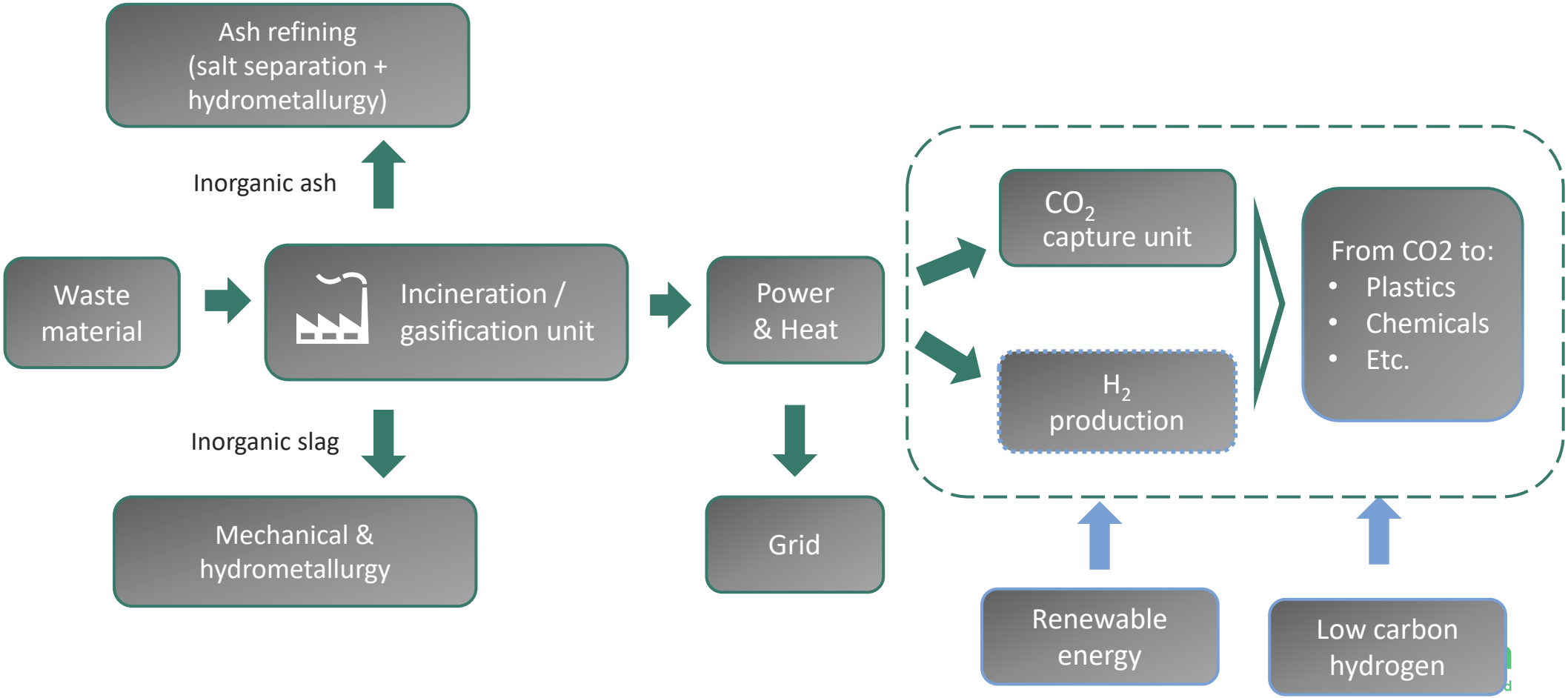
From Waste-to-Energy towards Waste-to-Materials

Vision: From 98% energy efficiency to 98% material efficiency



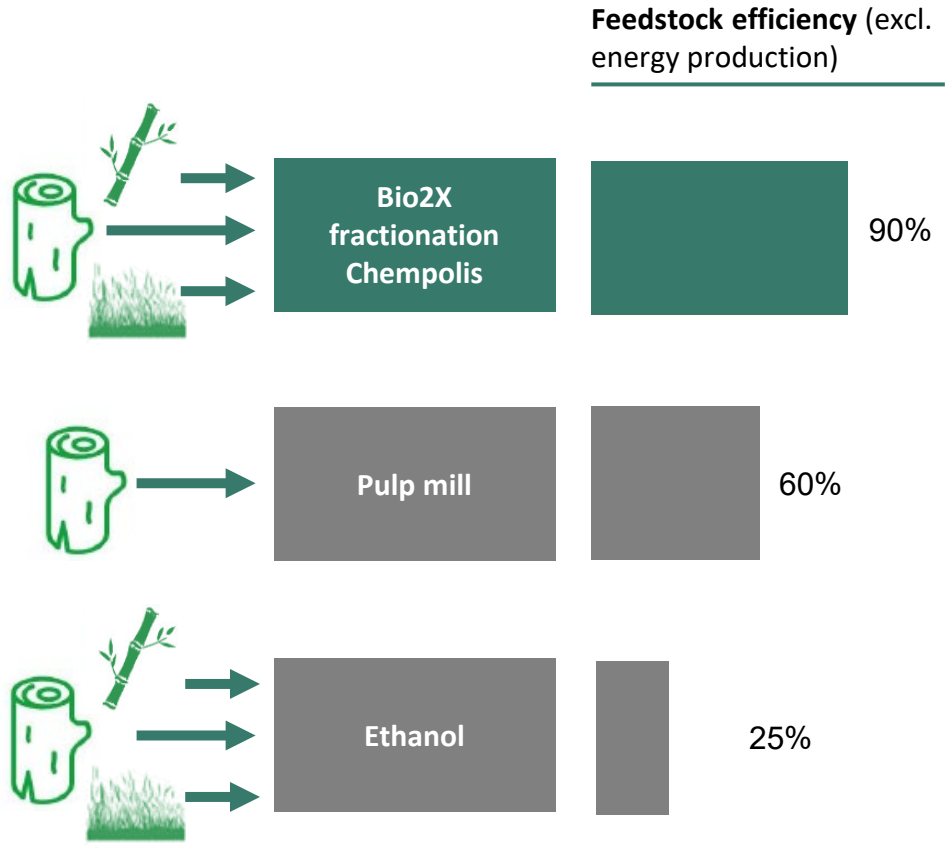
Renewable energy will be endless resource – scarcity of materials will set limits for economy

Technical benefits:

- **Purity of all fractions**, enabling cost-effective production of end-products
- **Optimized properties of all fractions** (vs. conventional pulp mills: only pulp is optimized)
- **Smaller unit size** (e.g. 1/5) with at least the same feasibility as large pulp mills
- **Flexibility in feedstock,** e.g., possibility to use **waste** (e.g., straw)
- Ability to **combine best parts of different technologies**

Environmental benefits:

- Possibility to **replace fossil raw materials**
- **Lower pollution** (e.g. CO_2) **& reduced water consumption**
- **Reduced land degradation & deforestation**



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Man-made circular system, two major global areas

Focus on molecules, not products

Metals and Minerals

Hydrocarbon

Man-made circular system needs focus on

- Upgrading of material
- Material efficiency

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