“Solar as a feedstock?”

Large Scale Solar EU

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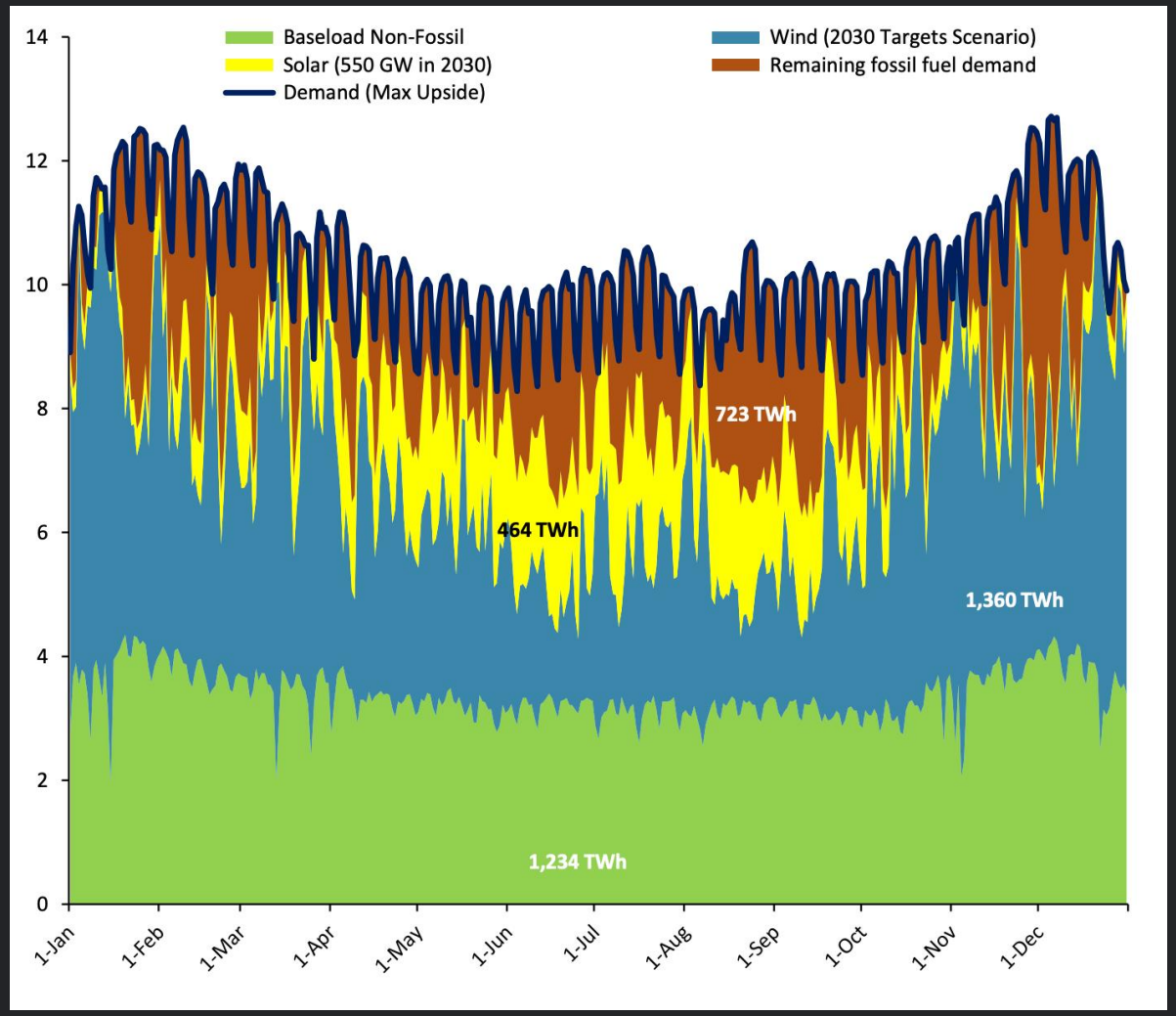
Lisbon, 26. March 2024

The Integration Challenge Beyond a Critical RES Share



Source: WindEurope

Source: GE Vernova

Beyond Electricity: Solar as Feedstock

Electrical Energy

New Solar photovoltaic plant, Benban Complex, Southeast Egypt

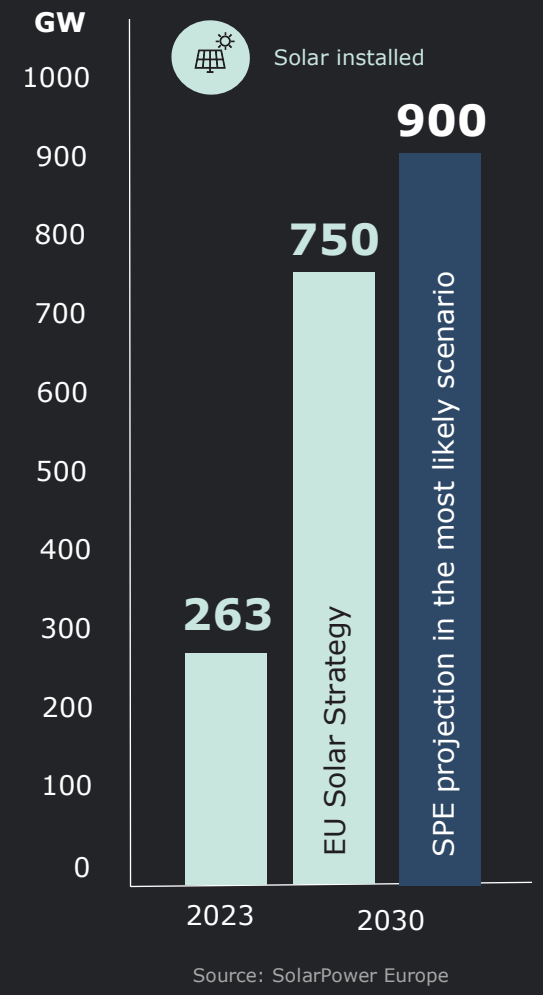
Renewable H2 and RFNBOs

Combined 304MW solar plant, green hydrogen production facility and e-methanol facility in Kassø, Aabenraa, Denmark

Feedstock

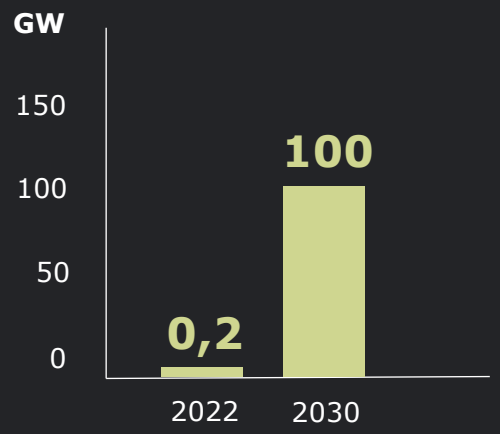
EU RES targets

EU PV target
by 2030

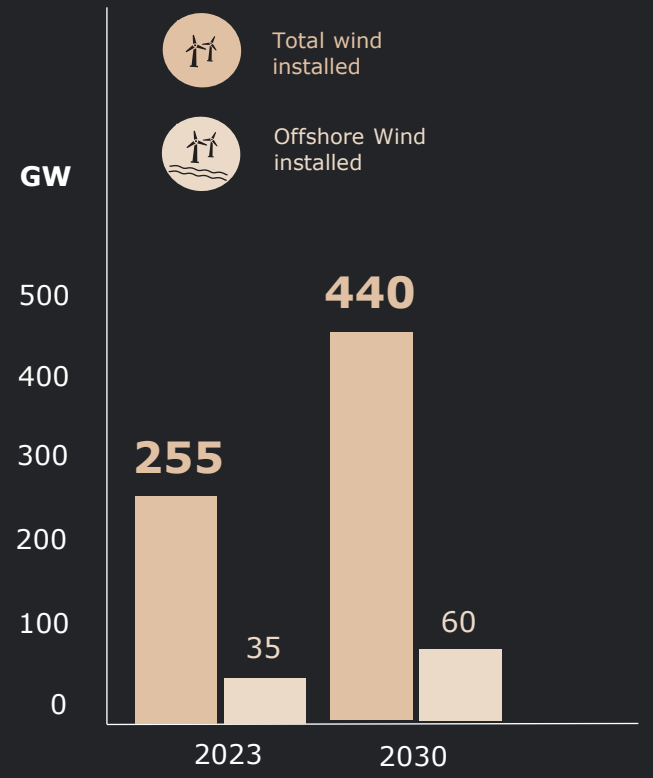


Source: SolarPower Europe

EU Electrolyser target
by 2030



EU wind target
by 2030

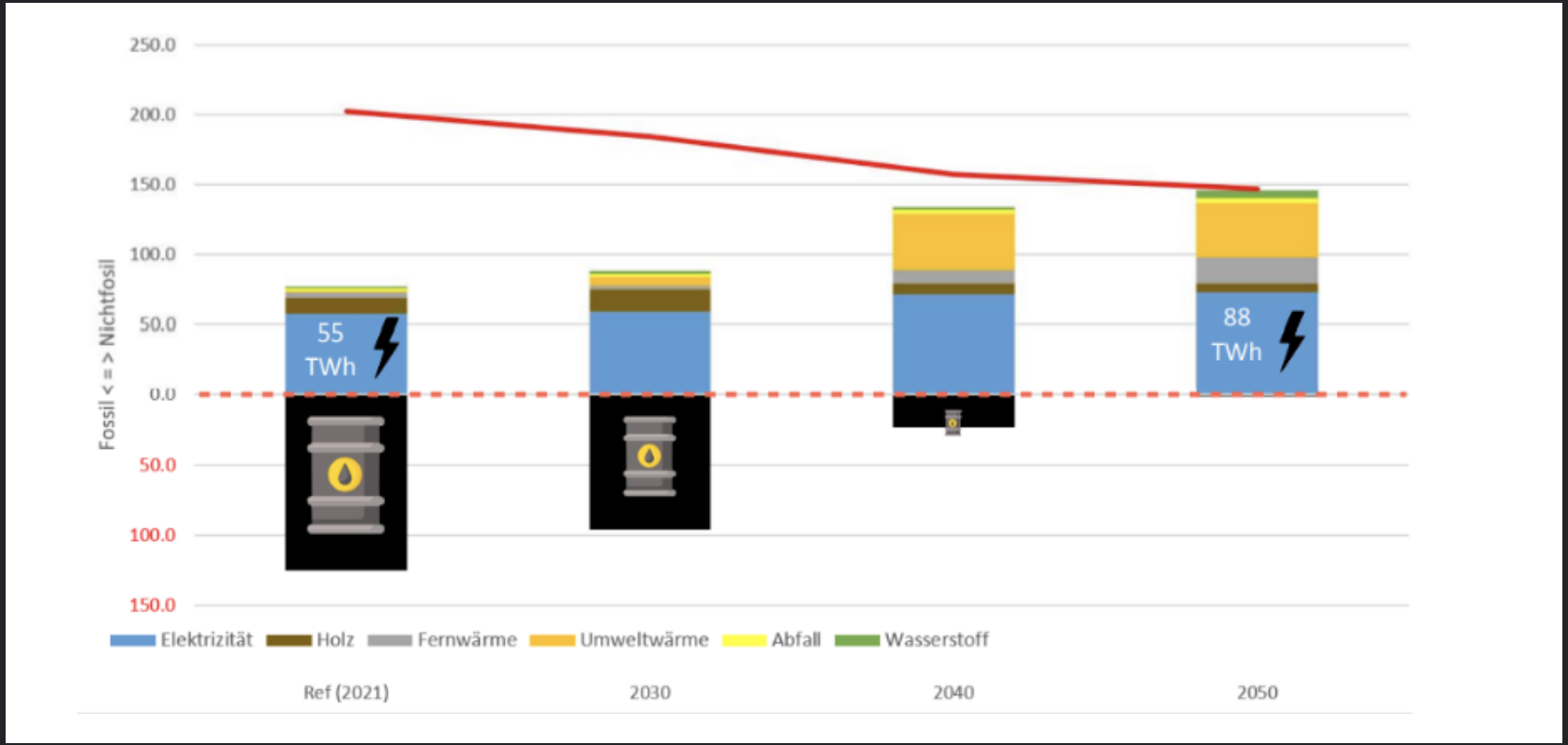


Off-shore wind targets, to be revised following increased targets of RePower EU

Source: Wind Europe, European Commission

Replacing fossil in the energy supply is a mix of measures including sector coupling – example Swiss Energy Roadmap Scenario

Energy savings, electrification, new RES including H2 projected for CH

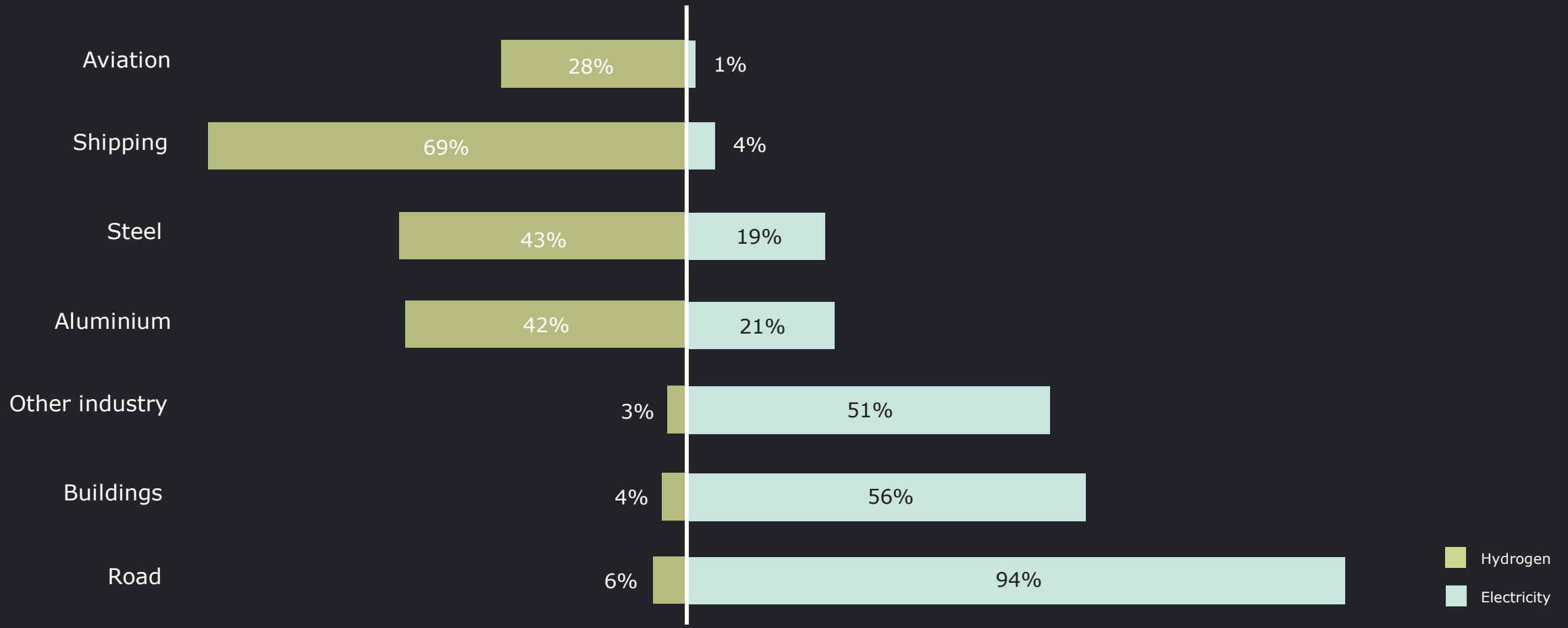


- Increasing demand of electricity means growing RES in Switzerland beyond hydro.
- Solar ambitions strongly increased. Role of hydrogen still under development with awaited Swiss H2 strategy.

Source: TNC, Innovations Forum Mobilitat 2023

Hydrogen plays an important role in hard to electrify sectors

Share of hydrogen vs electrification in 2050 final energy demand in Europe in a Net Zero Scenario

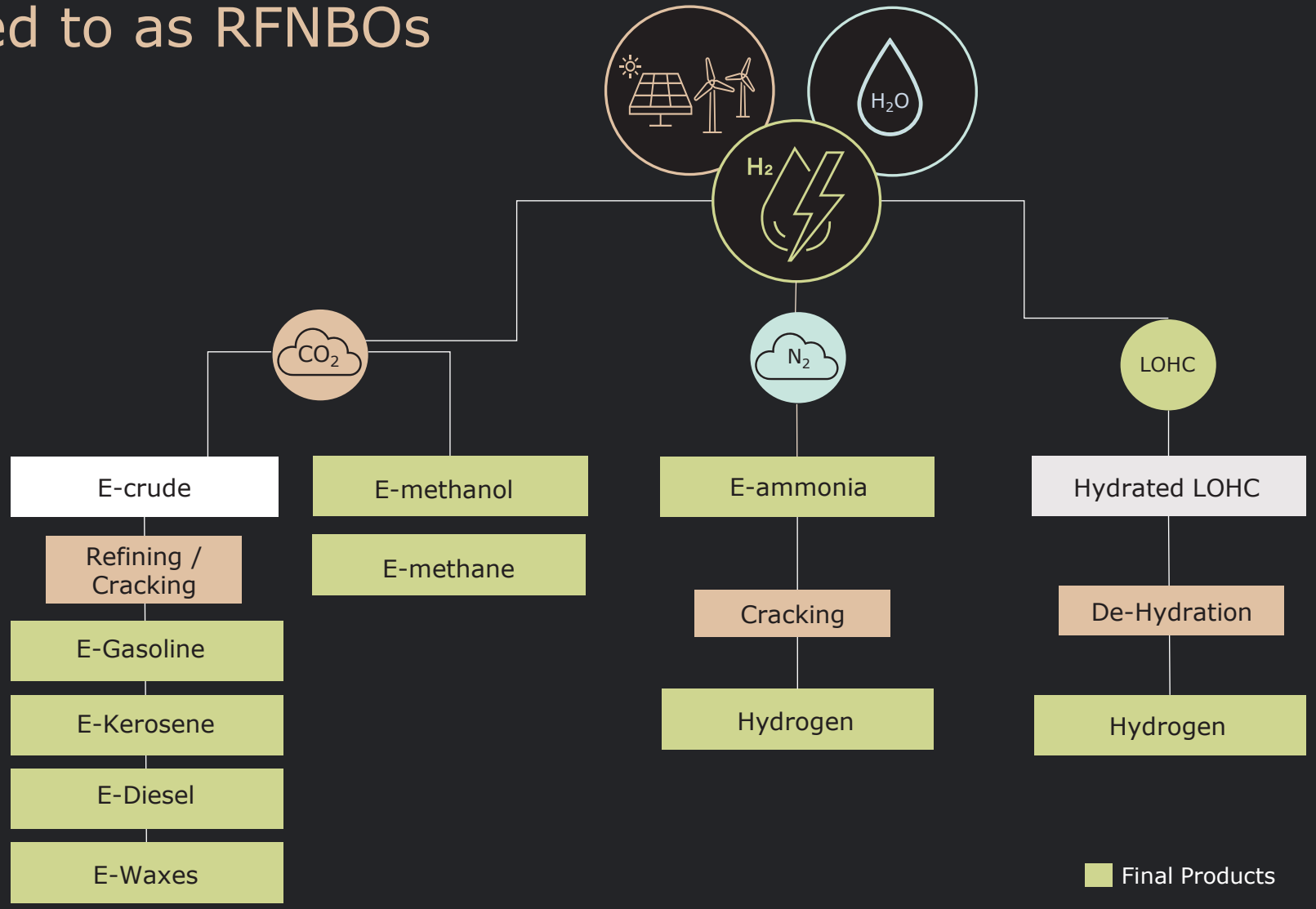


Source: BloombergNEF. Note: »Other Industry» includes low and medium temperature industrial processes. When hydrogen and electricity do not add up to 100%, the remaining share has been provided by other sources of primary energy such as bioenergy,, heat or fossil fuels

EU Regulations apply to hydrogen and its derivatives, also referred to as RFNBOs

Main Hydrogen based products

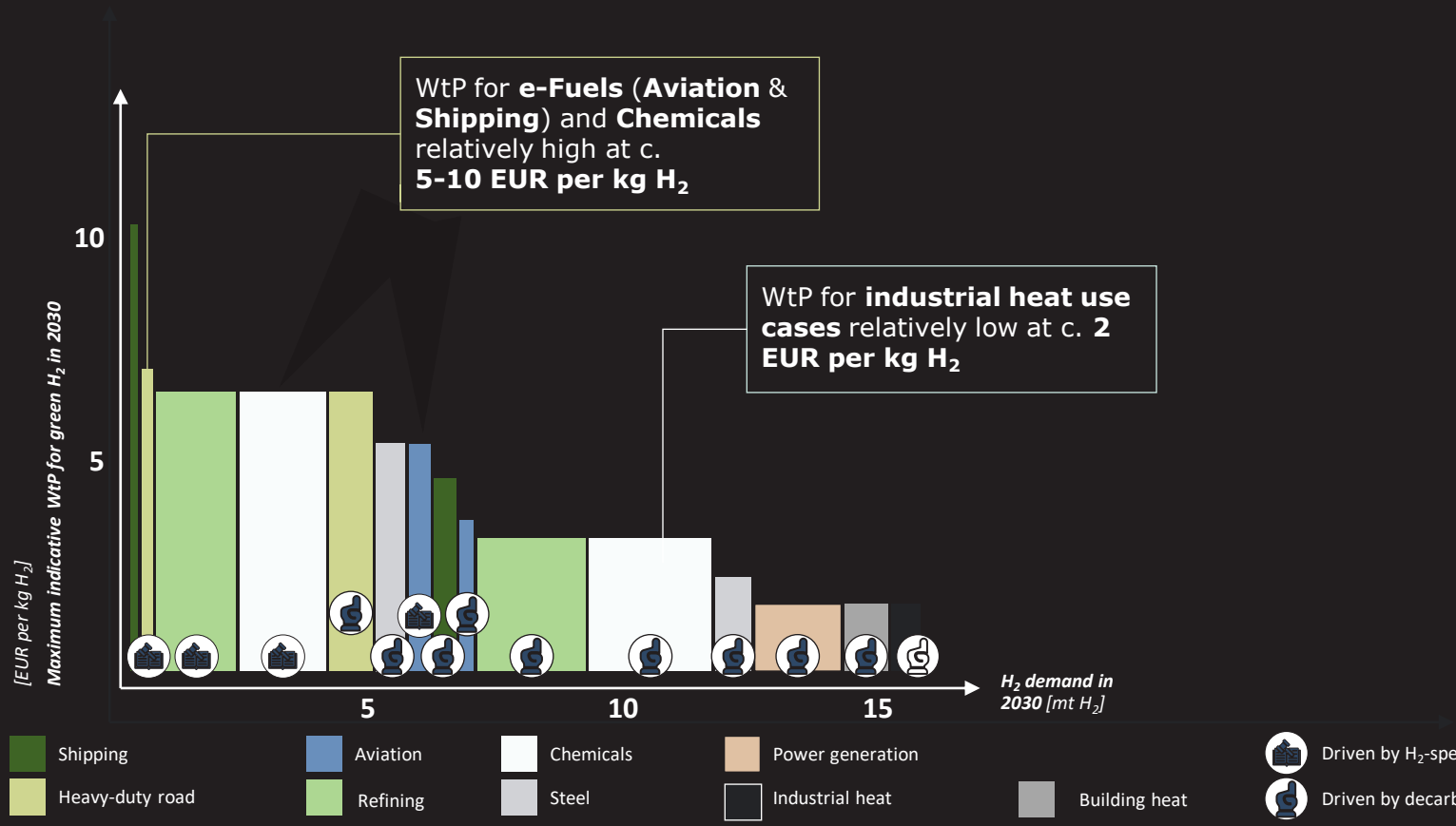
- H2 as feedstock for industry (chemical, petrochemical, fertilizer, …)
- Resulting derivatives
- New chemical processes (e.g. reductor in steel)
- High temperature processes
- Energy carrier
- Storage (short to long-term)
- Electricity through Fuel Cell



Willingness-to-Pay (WtP)

Industry and transport sector are expected to have substantial WtP for green H_2, driven by H_2 regulation and CO_2 prices/Voluntary demand; in Europe, policy is already taking shape

Maximum indicative WtP for green H_2 in Europe[1] in 2030, regulatorily & voluntarily driven



Key WtP drivers

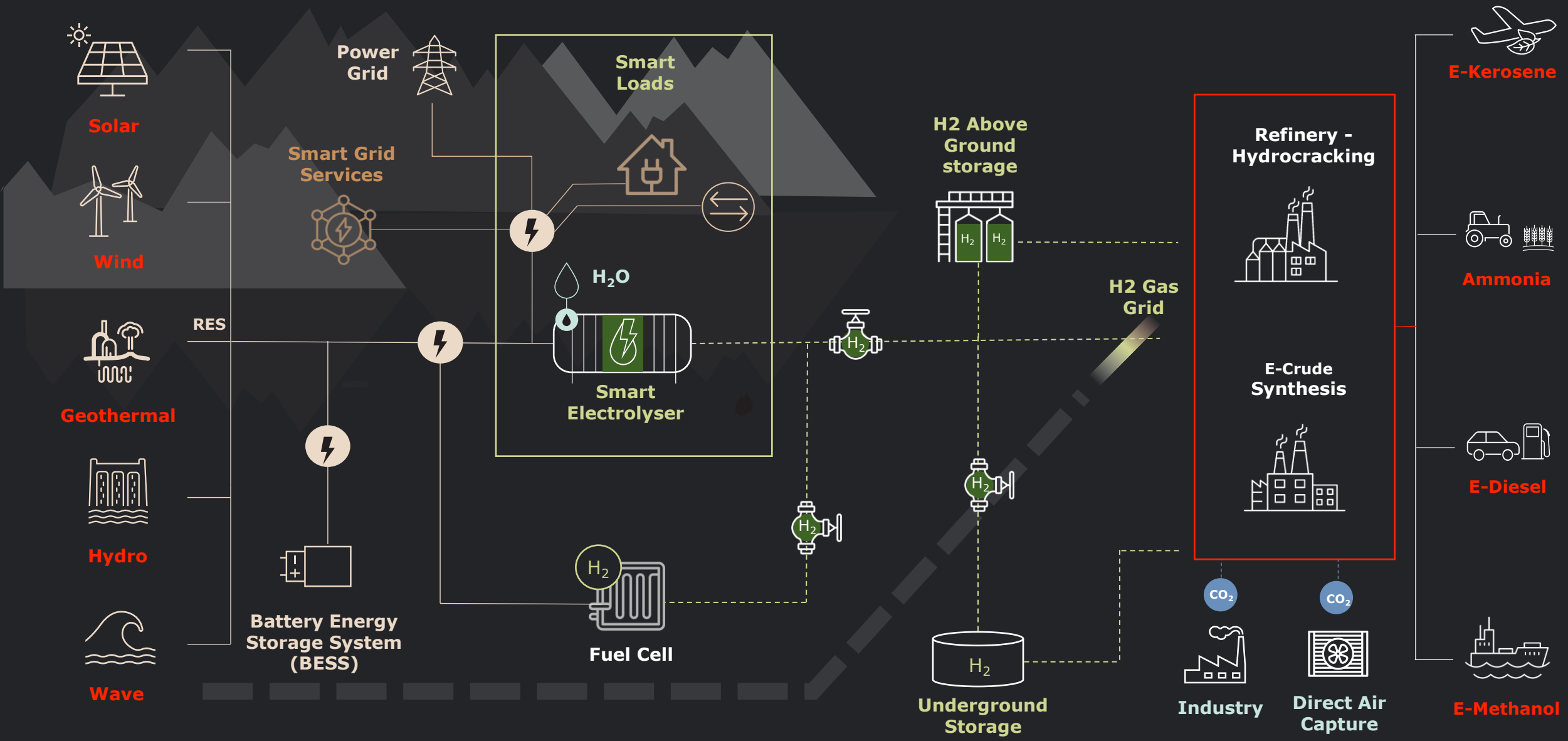
1. **H_2-specific regulatory demand:** H_2 regulations (e.g., RED II/III, ReFuel Aviation, FuelEU Maritime), incl. quotas and penalty payments, increase WtP
2. **Decarbonization demand** Non-H_2 specific regulations (e.g., EU ETS) might cause use of green H_2 to avoid payments for CO_2 emissions
3. **Voluntary demand** companies might be willing to pay premium for green H_2 due to strategic reasons (e.g., marketing)

Key assumptions

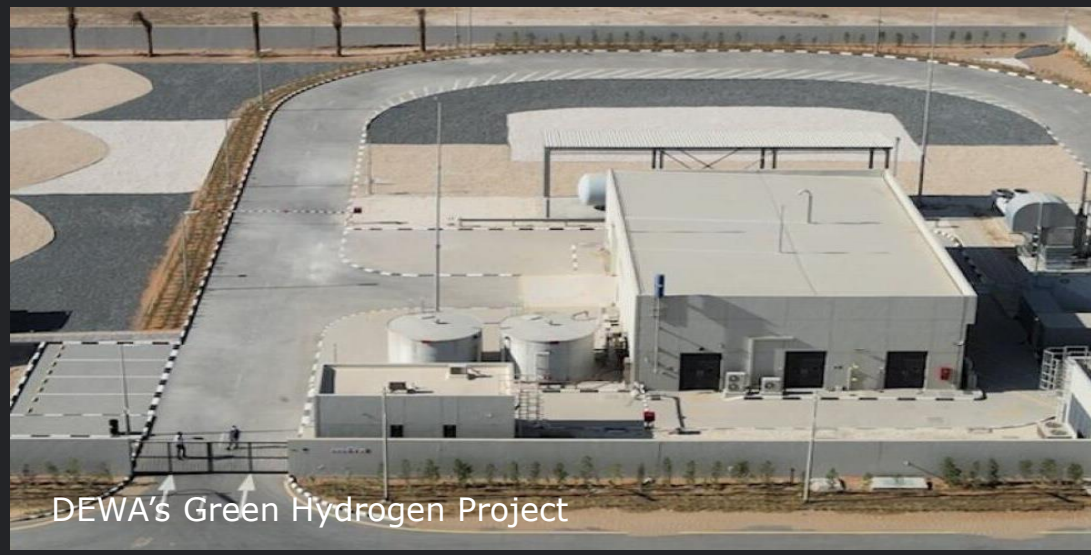
1. **CO_2 price** c. EUR 175 / ton CO_2 in 2030, EUR 210 / ton CO_2 in 2035
2. **Natural gas price** c. EUR 40 / MWh in 2030, EUR 38 / MWh in 2035
3. **Emergence of voluntary demand** driven by ESG motivations (e.g., in aviation via SAF commitments)

1) Analysis includes key expected H2 demand segments; several sectors not shown due to expected low H2 demand potential (e.g, rail or passenger cars); regulations on European level considered, might vary per country due to country-specific regulation
Source: Roland Berger

Towards a high-solar future: Symbiosis is Key



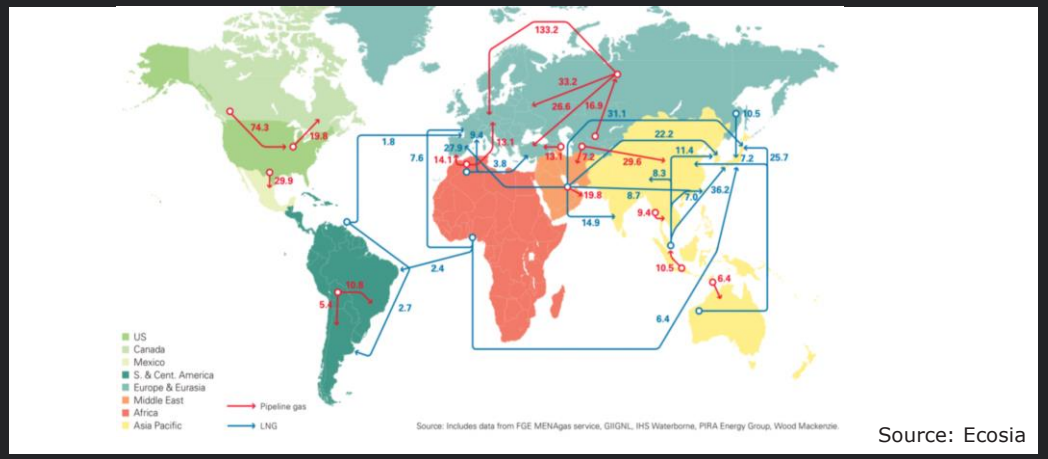
Electrolysers: A Perfect Match for Large Scale Solar!



Main global gas and oil flows

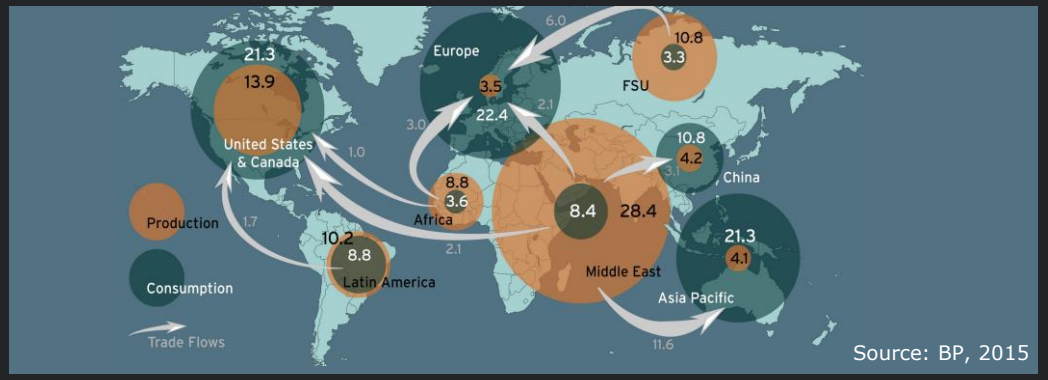
Reshaped and gradually substituted by hydrogen and derivatives flows based on cheap electricity resources

LNG & Pipeline in 2015 (bcm)



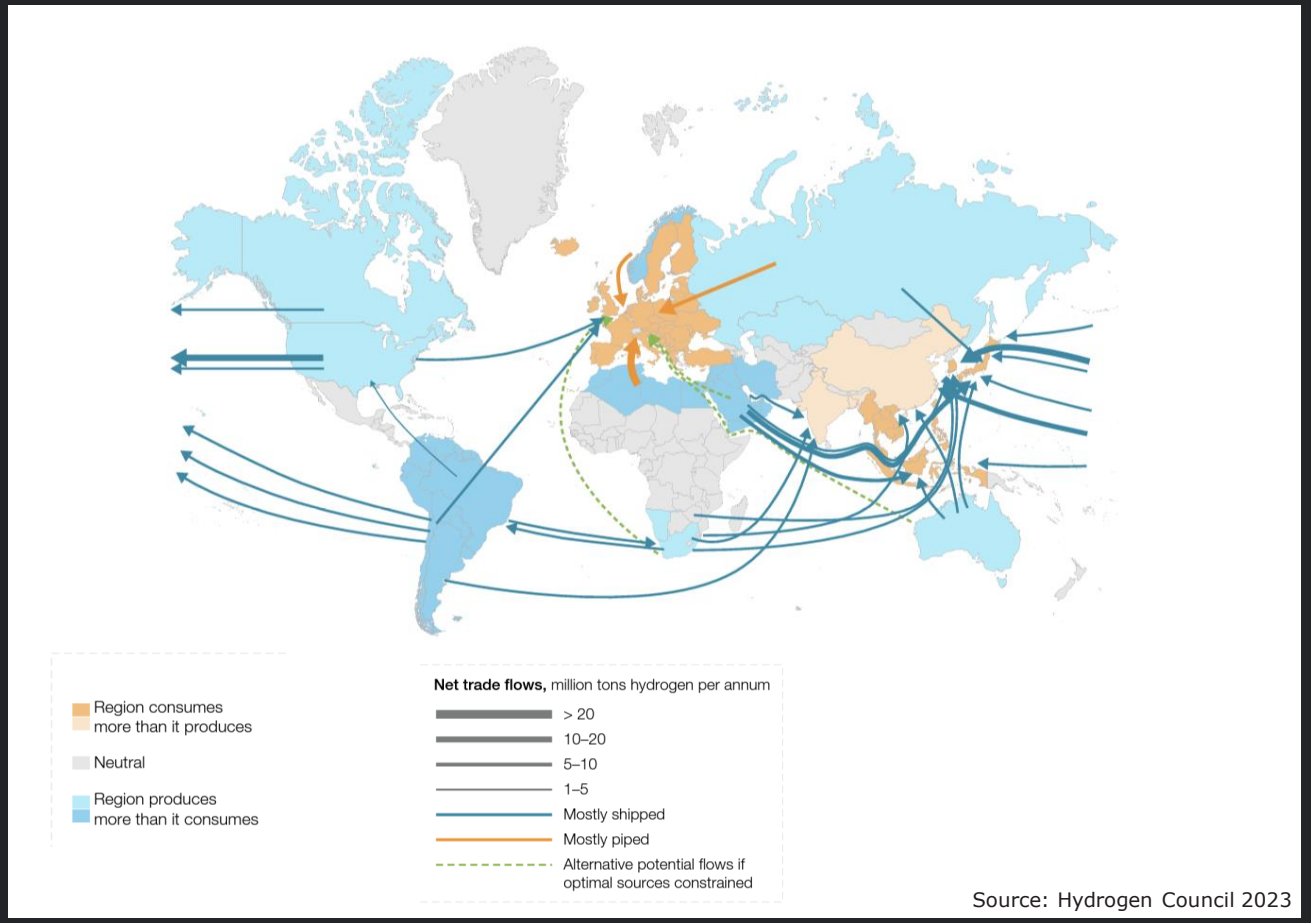
Source: Ecosia

Oil in 2015 (mbpd)



Source: BP, 2015

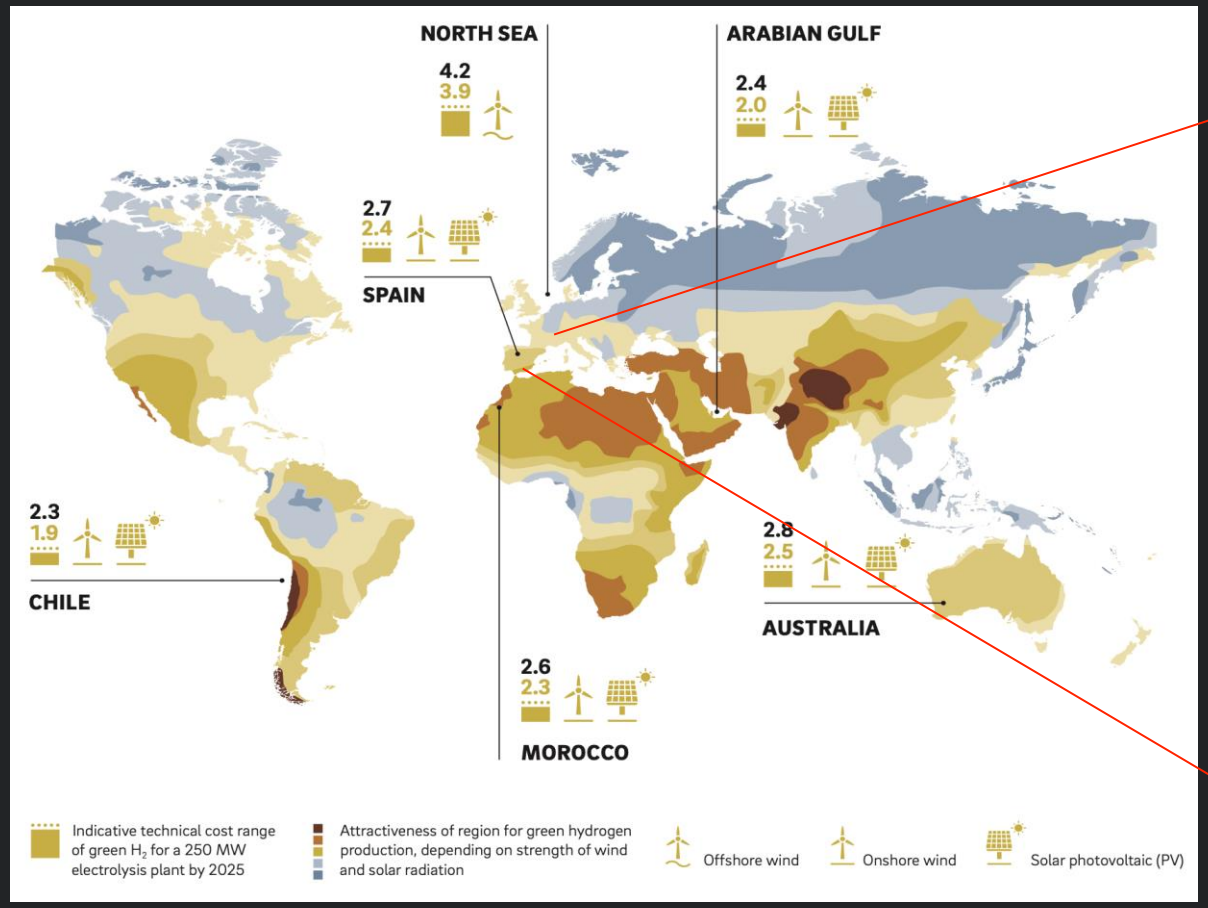
Major flows of hydrogen and derivatives in 2050 (million tons H2 eq.)



Source: Hydrogen Council 2023

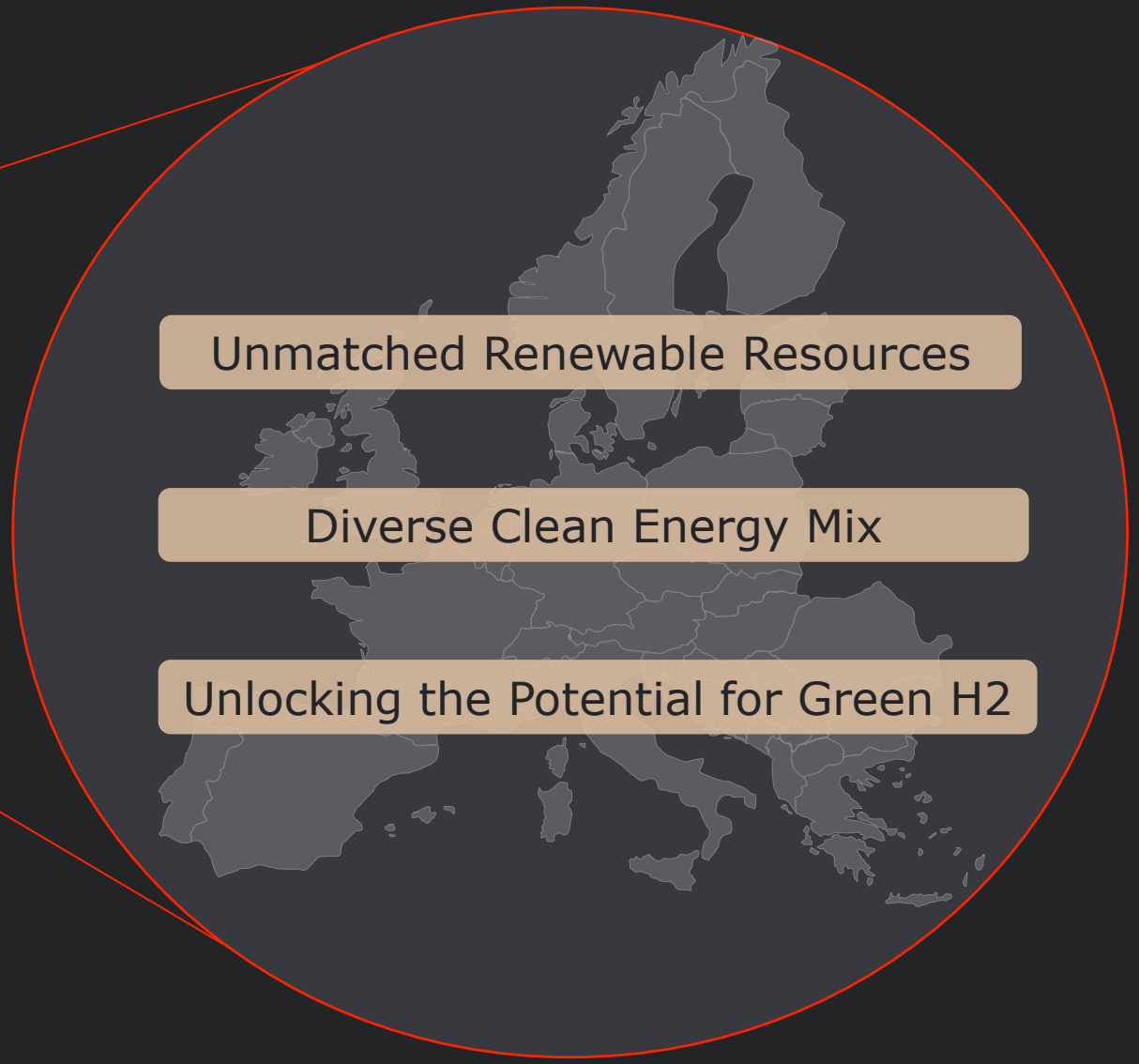
IBERIA – Abundant Solar and On-shore

Wind translate into competitive Green Hydrogen



Cost-competitive renewable electricity and green hydrogen production in Iberia [EUR/kg]

Source: Roland Berger



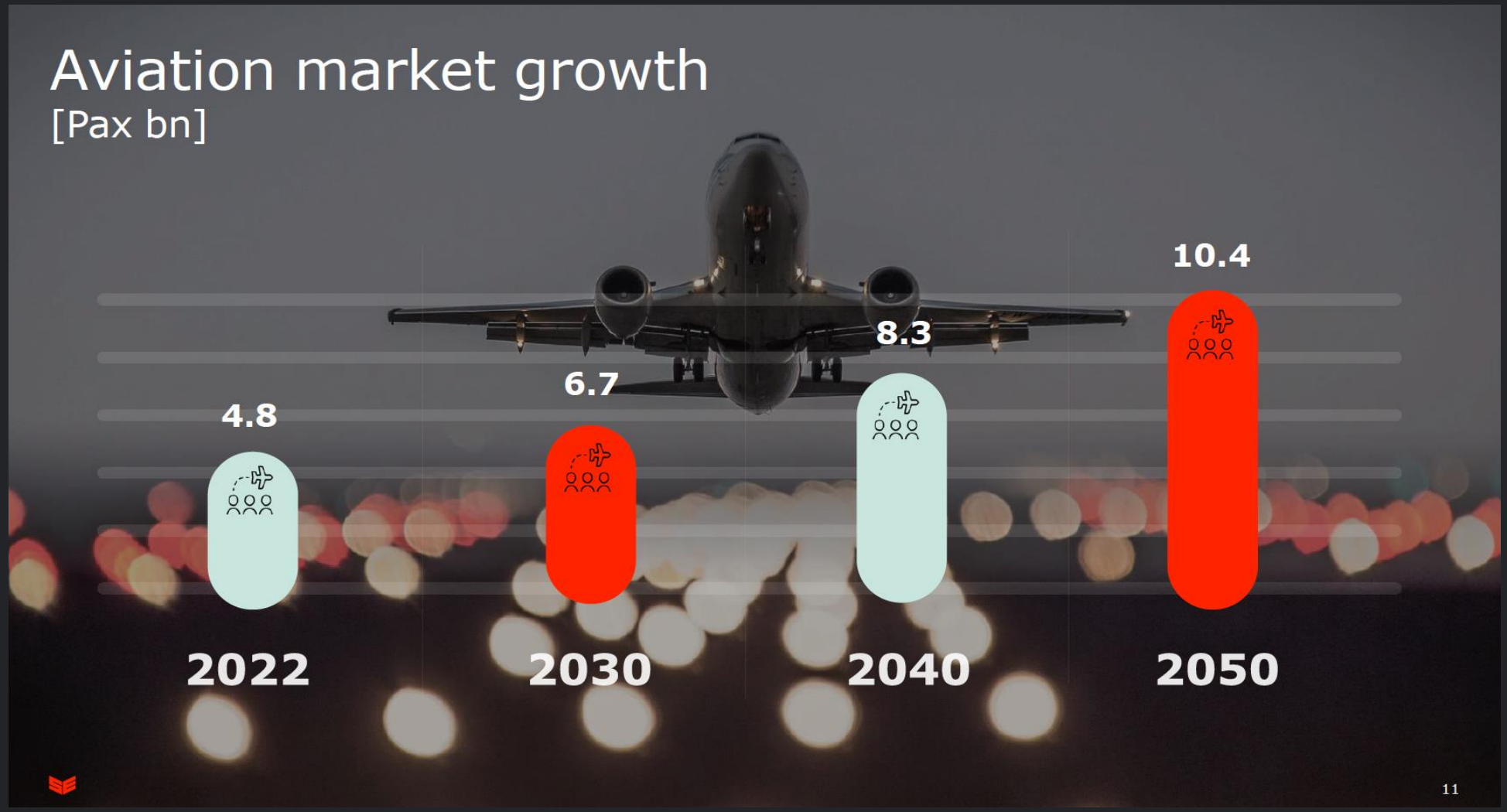
How much progress has been made depends on the perspective taken

Airbus path towards zero emissions

Source: Airbus at H2 Forum Berlin, Jun 2023

How much progress has been made depends on the perspective taken

Aviation is a growing industry!



SAF is the future of clean aviation

Direct CO2 emission savings while using existing infrastructure

Sustainable Aviation Fuel (SAF)

Jet fuel produced from bio feedstock or renewable energy

CO_2 emission savings

Direct CO_2 emission reductions of c. 80%

Proven technology

Globally approved by IATA[1)], SAF can be blended up to 50%, 100% coming

Ready to use

Can be used in existing aircrafts without any engine adjustments and with existing fuel handling infrastructure

1) International Air Transport Association: Guidance Material for Sustainable Aviation Fuel Management, 2nd Edition, 2015

Dedicated H_2-projects for sustainable aviation fuels

1 Project "Galileu"

760 MW

c. 31 k t
SAF p.a. (2028-2029)

c. 49-80 k t
SAF p.a. (2030+)

2 Project "Leça"

465 MW

c. 20 k t
SAF p.a. (2028-2029)

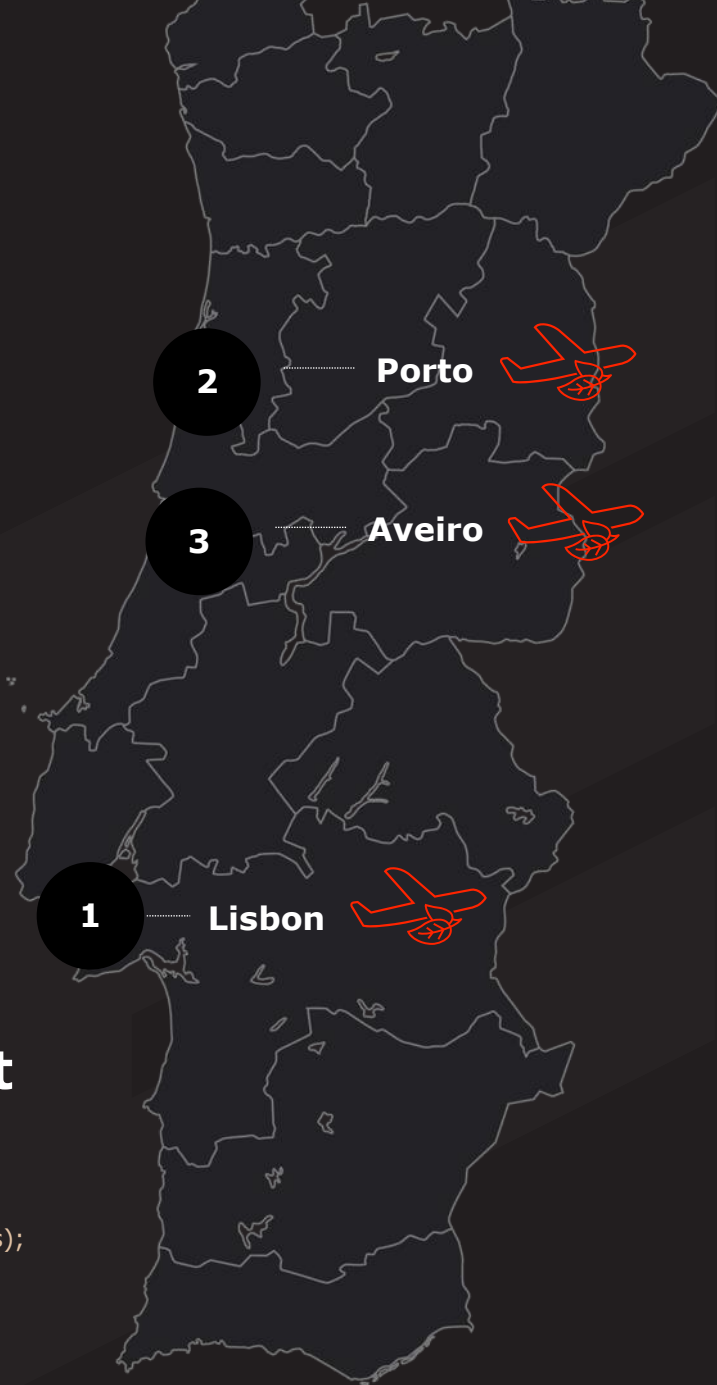
c. 31-49 k t
SAF p.a. (2030+)

3 Project "Mondego"

1.6 GW

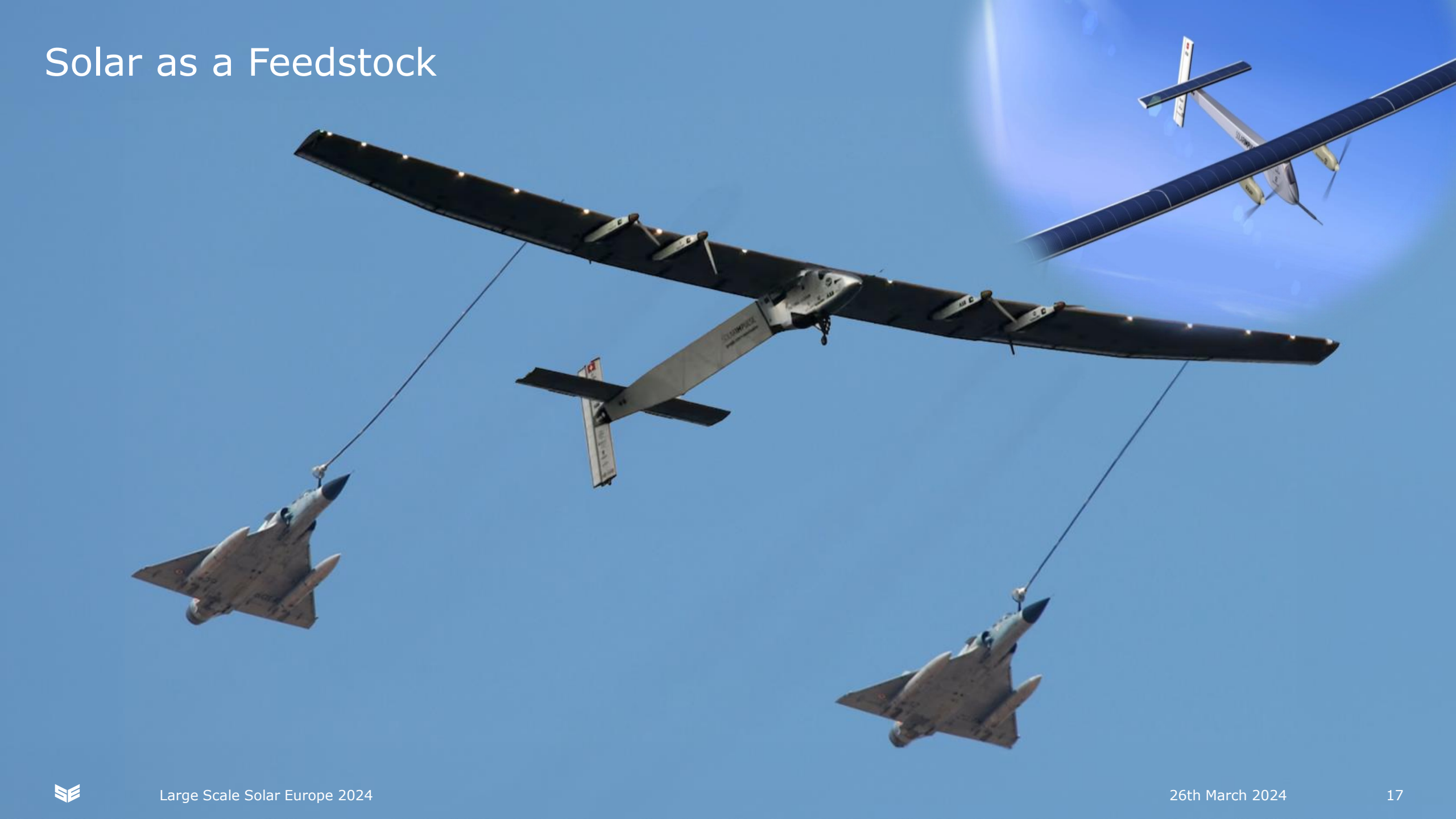
c. 69 k t
SAF p.a. (2028-2029)

c. 108-177 k t
SAF p.a. (2030+)



Notes:
1. Projects' COD planned before end-2027 to ensure exemption from the Delegated Act's "additionality" principle until end-2037;
2. Calculation assumes increasing load factor of electrolyzer production from 35% ('27-'29) to 55% with own renewables (from 2030 onwards);
3. Load factor of electrolysis can be further increased to c. 90% either through PPAs (ensuring hourly correlation, which are exempt from the additionality principle (see 1.), or once the Portuguese electricity mix reaches a 90% share of renewables

Solar as a Feedstock



Thank you!

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