

TOWARDS A **100% RENEWABLE** ENERGY FUTURE

20%
RES

60%
RES

80%
RES

100%
RES

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2. Renewable energy is changing the market
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20%
RES

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Towards a 100% renewable energy future

The energy landscape is in transition towards more flexible and sustainable energy systems.

We envision a 100% renewable energy future.

Wärtsilä is leading the transition as the **Energy System Integrator** – we understand, design, build and serve optimal power systems for future generations.

Engines and storage will provide the needed **flexibility** to integrate renewables and secure **reliability**.



REALITY

Renewables are getting cheap

TIPPING POINT

Existing thermal capacity replaced with flexible generation

RENEWABLE BASELOAD

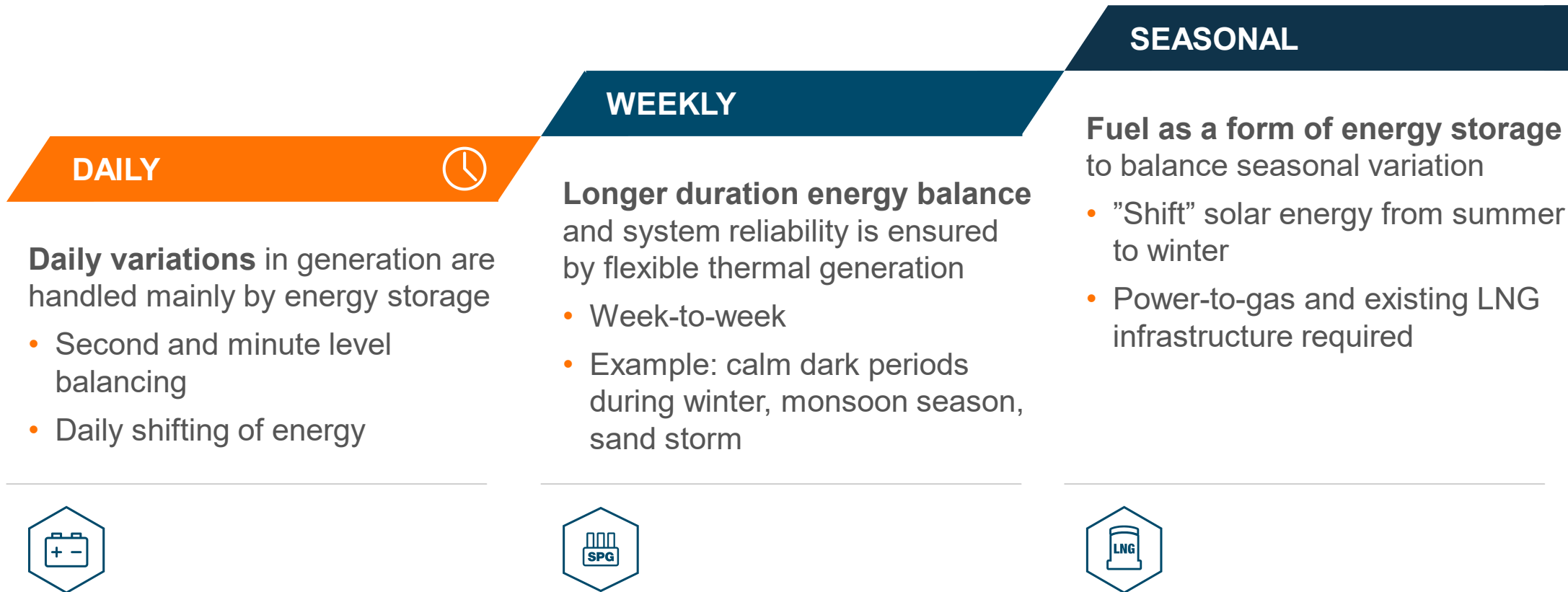
Energy storage becomes affordable, enabling increase in renewable energy

100% RENEWABLE ENERGY

Flexible thermal capacity provides seasonal back-up, daily energy variations managed with storage



The 100% renewable energy system requires multiple forms of flexibility



RENEWABLE ENERGY IS CHANGING THE MARKET



80%
RES

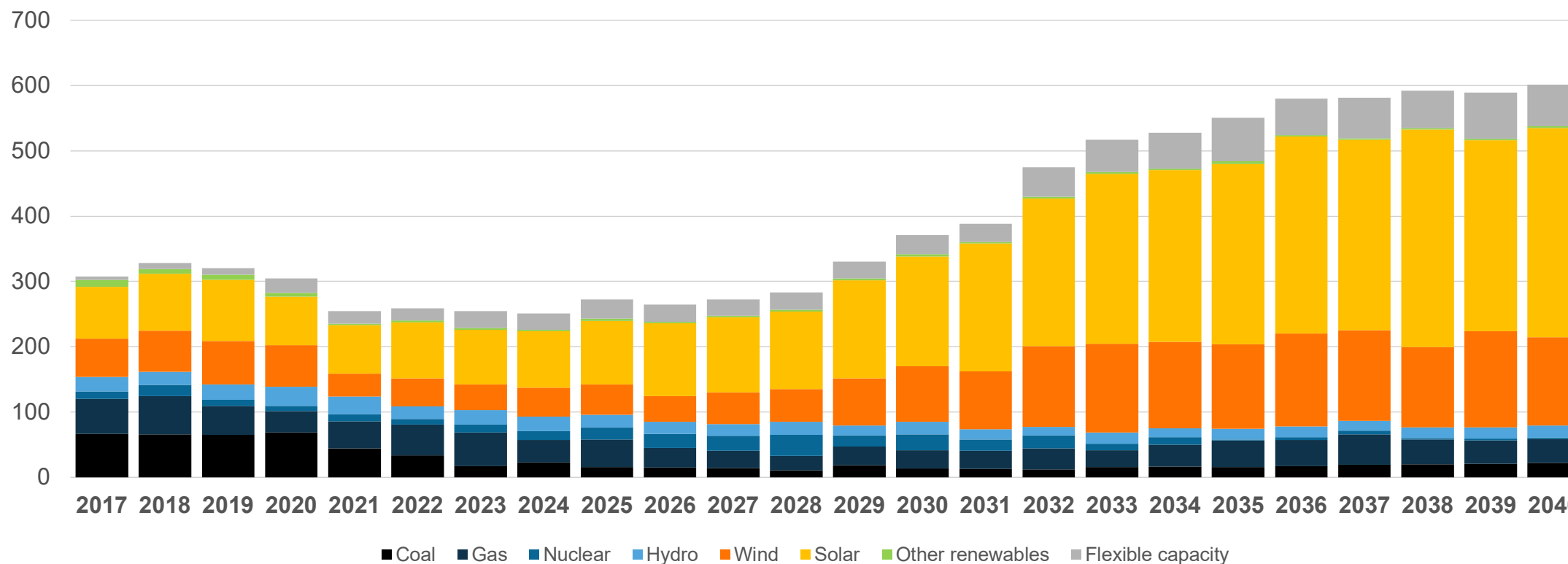
100%
RES

Wind and solar cumulative installed capacity will increase from 14% in 2017 to 48% in 2040

Engines and storage will enable the transition

Annual gross capacity additions (GW) 2017-2040

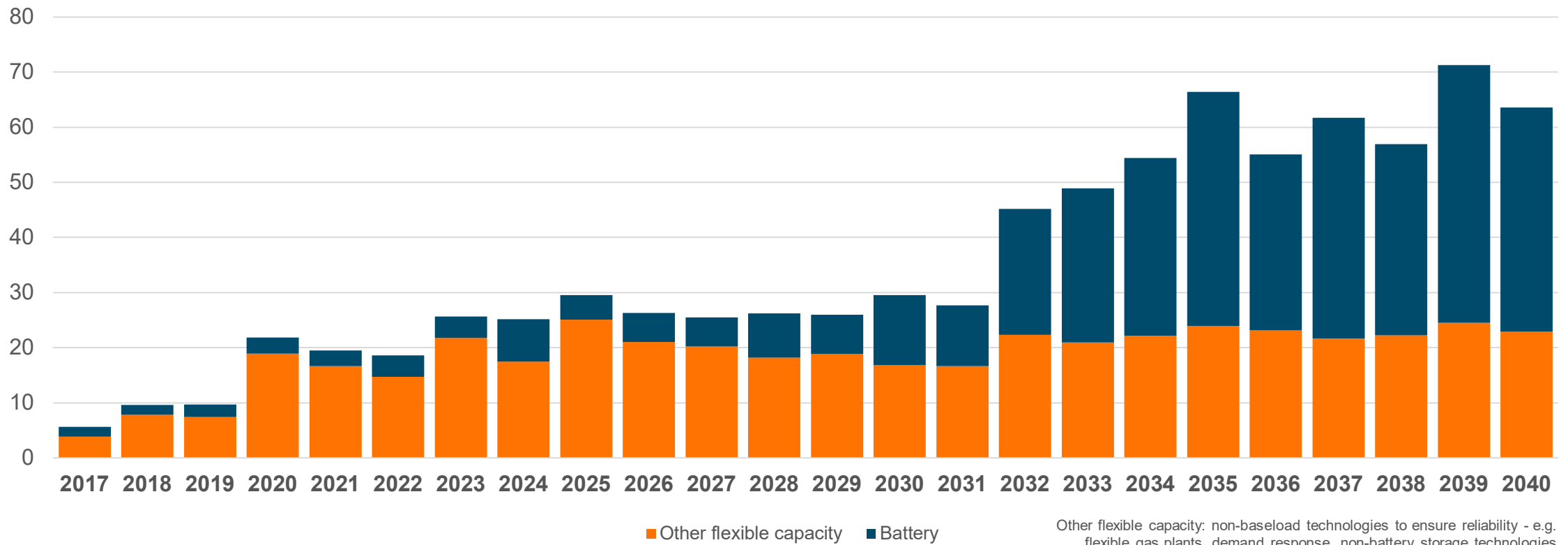
Source: Bloomberg New Energy Outlook 2017



Flexible capacity by application type

Annual gross capacity additions (GW) 2017-2040

Source: Bloomberg New Energy Outlook 2017



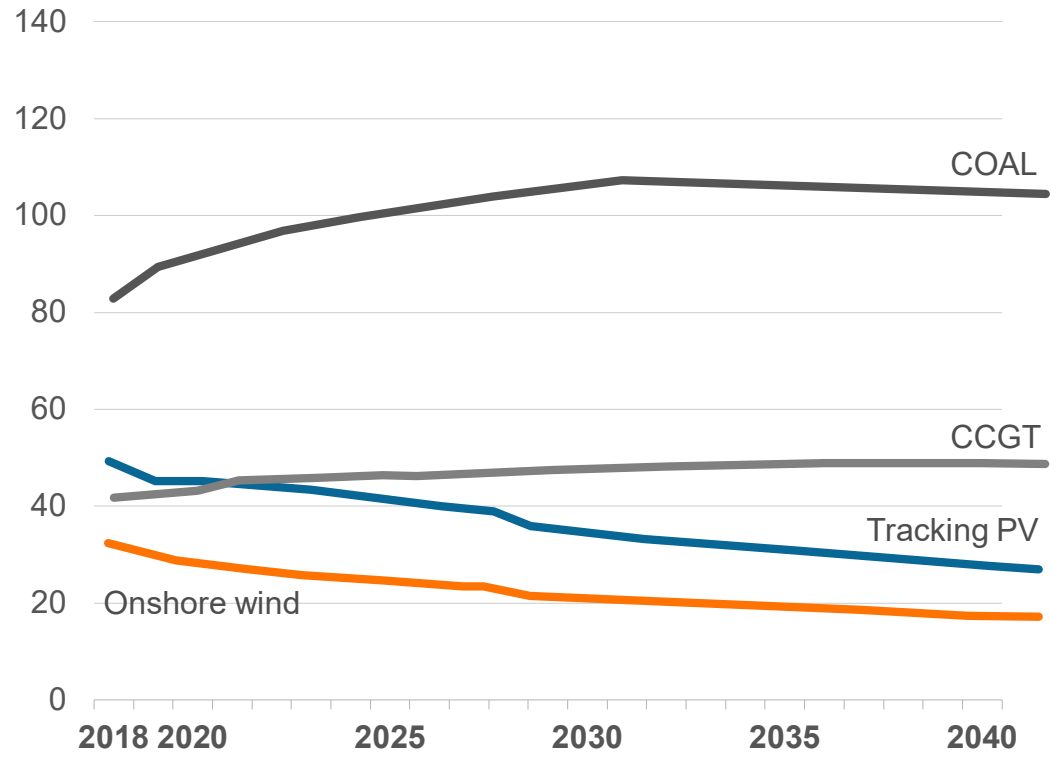


Price for renewable energy has reached a tipping point – all across the world

Prices of renewables continue to drop

UNITED STATES

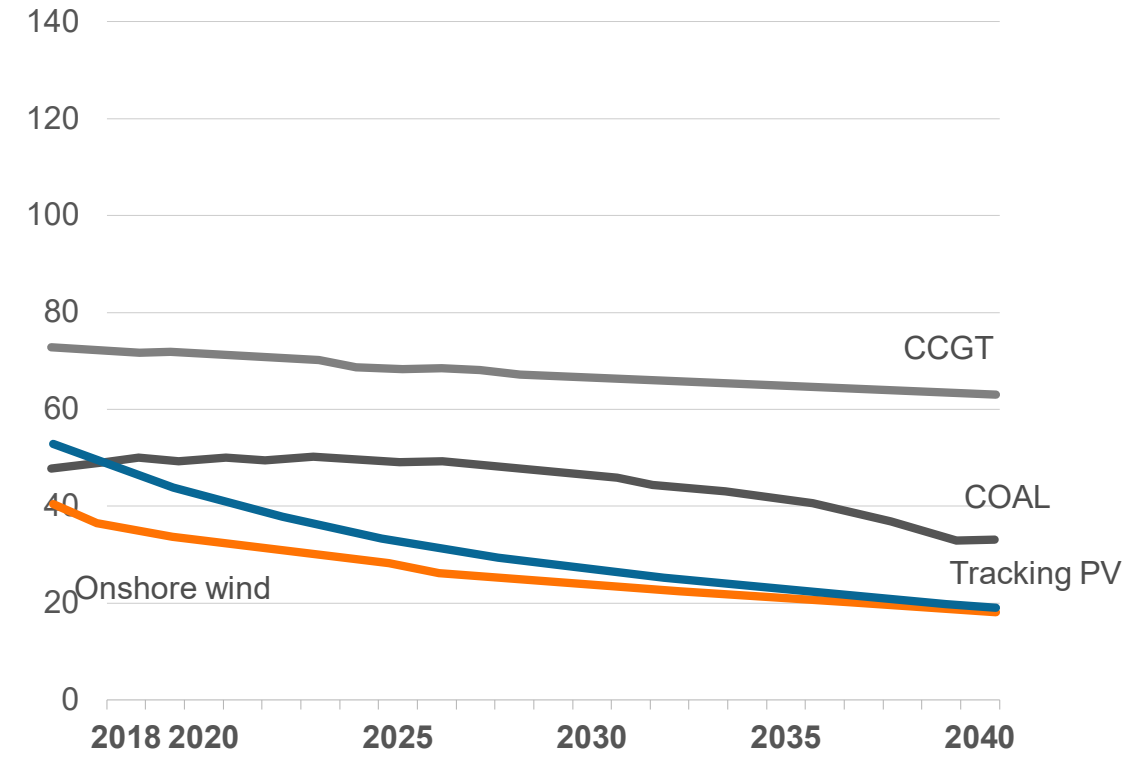
LCOE (\$/MWh, 2017 real)



Source: Bloomberg New Energy Finance Note: capacity factors: Tracking PV: 14%-30%, onshore wind: 29%-49%. Coal and gas plants capacity factors are a result of our NEO 2017 dispatch analysis. LCOEs are calculated on an unsubsidized basis. The offshore wind LCOE is a global forecast.

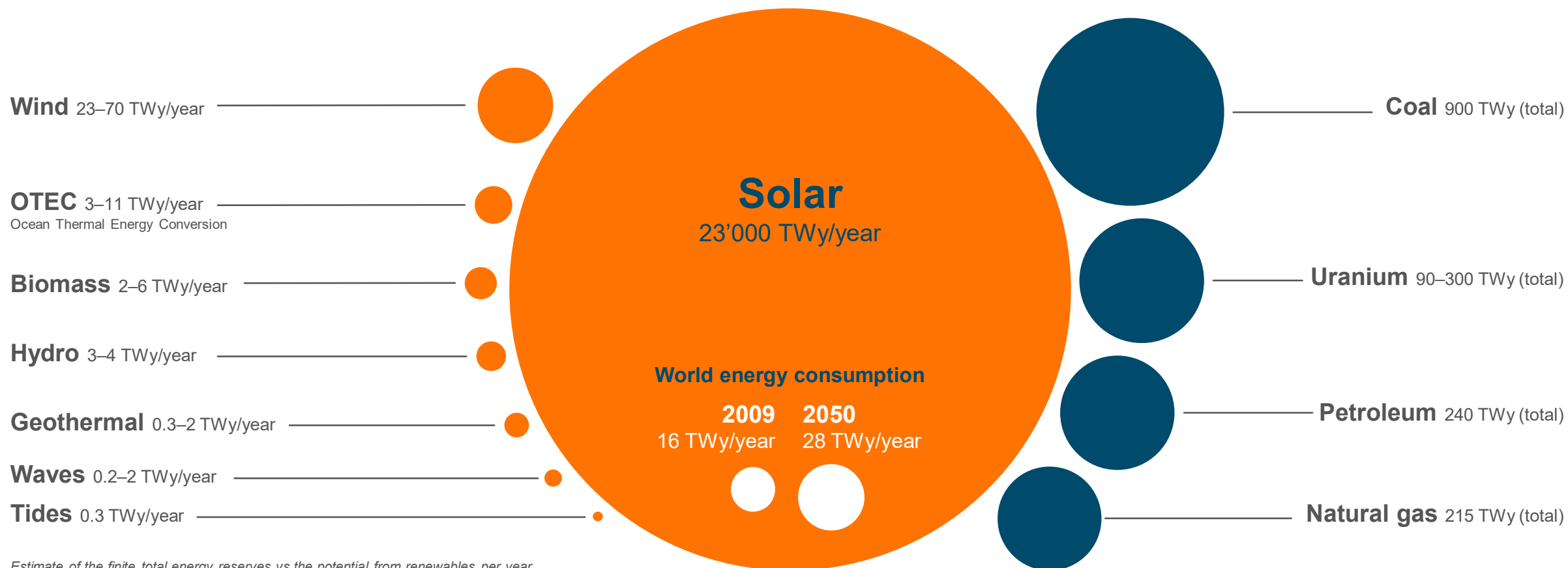
CHINA

LCOE (\$/MWh, 2017 real)



Source: Bloomberg New Energy Finance Note: capacity factors: PV: 12%-18%, onshore wind: 23%-32%. Coal and gas plants capacity factors are a result of our NEO 2017 dispatch analysis. LCOEs are unsubsidized. The LCOE for thermal plants in China includes the carbon pricing. The offshore wind LCOE is a global forecast.

Engines and storage will provide the needed reliability and ensure affordable cost of power systems

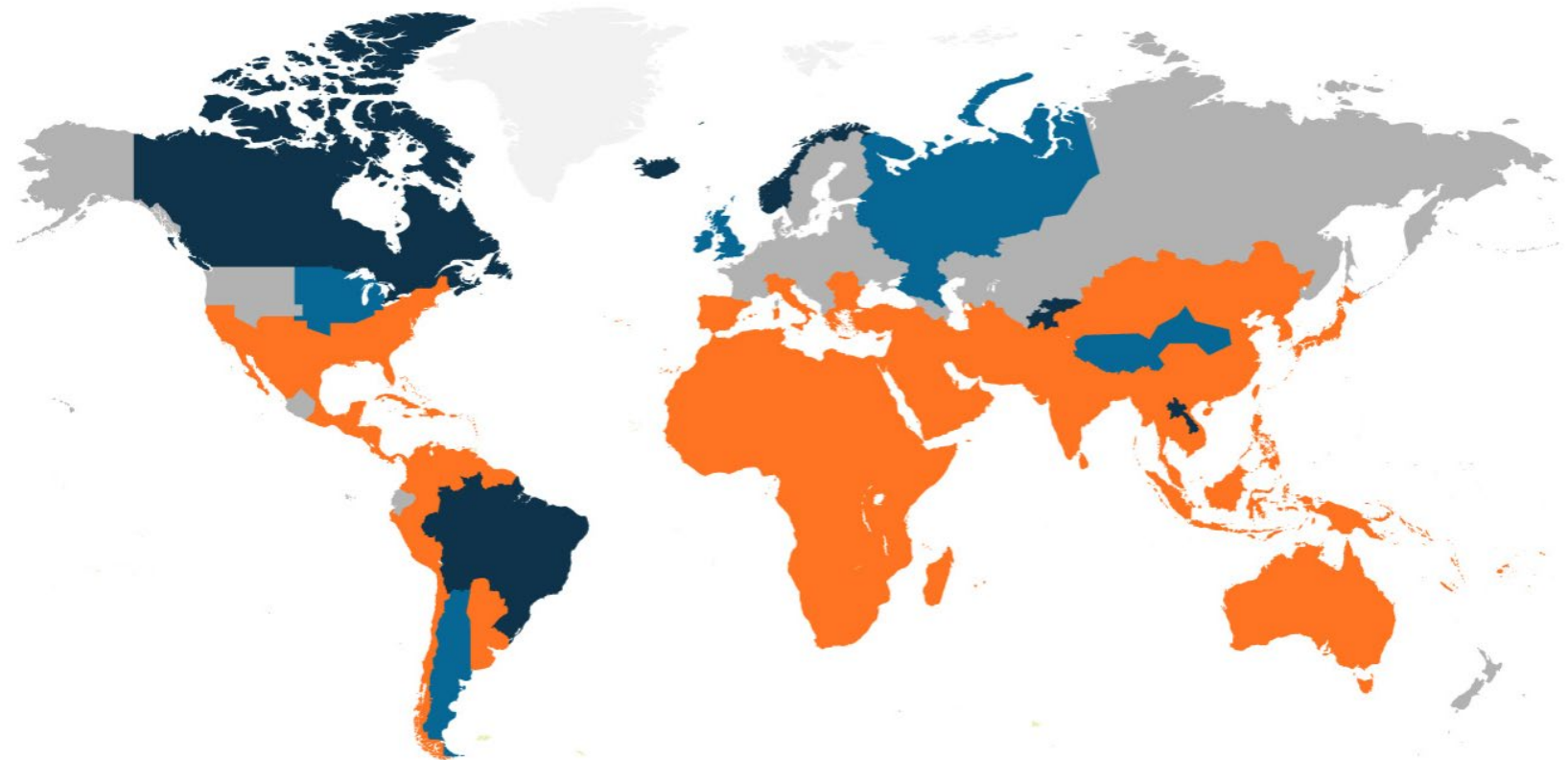


Estimate of the finite total energy reserves vs the potential from renewables per year.
Source: Atmospheric Sciences Research Center, at the State University of New York at Albany, 2018

A high renewable world will require massive amounts of solar and energy storage

PV will become the main energy source in the Sun Belt with **22 TWp global capacity** for the power sector

- Solar PV based system
- Wind turbines based system
- Hydro power based system
- Technologies mix based system



Source: Lappeenranta University of Technology

BUILDING THE PATH TOWARDS 100% RENEWABLE ENERGY



80%
RES

100%
RES

Renewables are eroding the existing business model where centralized large units made the money and it was all about economics of scale
 Investments define and lock in the company strategy for many years

WE'RE HERE

PSEG shuts down its last coal plants: 'It's just economics'

Updated: MAY 30, 2017 — 3:01 AM EDT

ACTION

Building the optimal path to a renewable world

SELF-CONFIDENCE

I need to change – I know the path...

ACCEPTANCE

Our old business model doesn't work and we need to renew ourselves → old capacity leaving the market

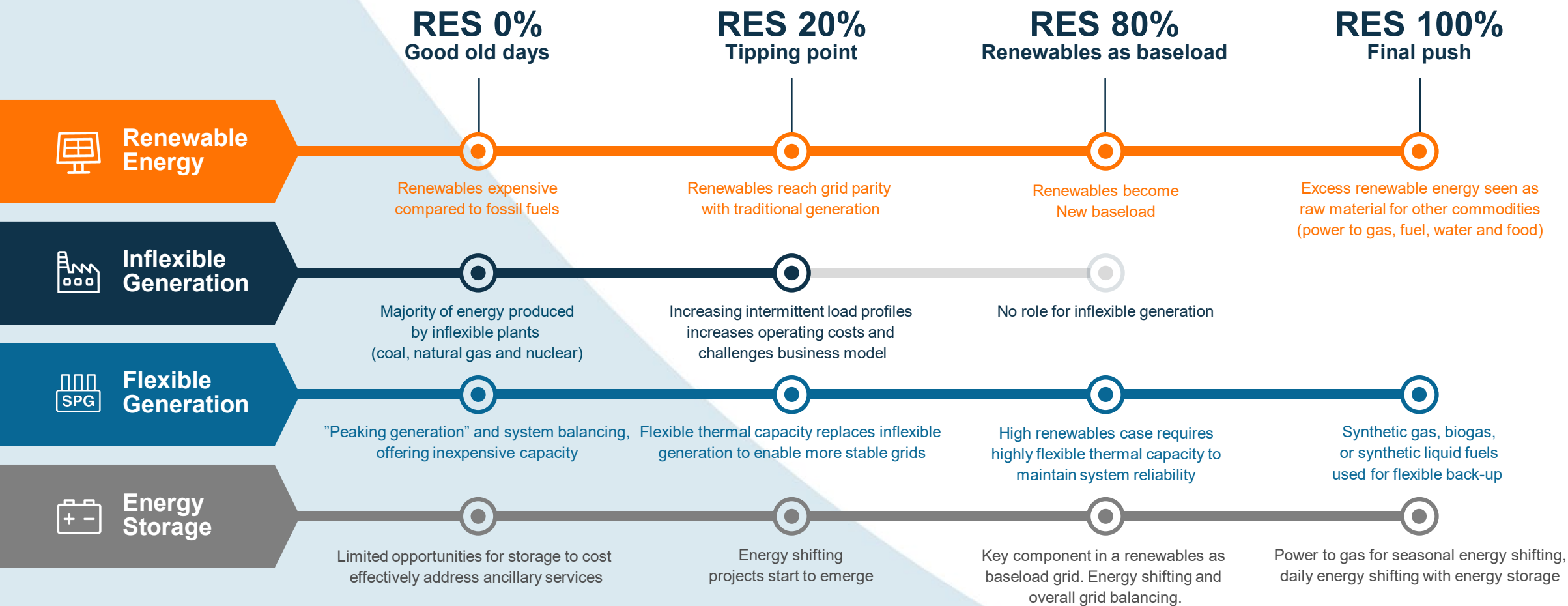
UNDERSTANDING

Renewables are changing the power system and utility business model

DENIAL

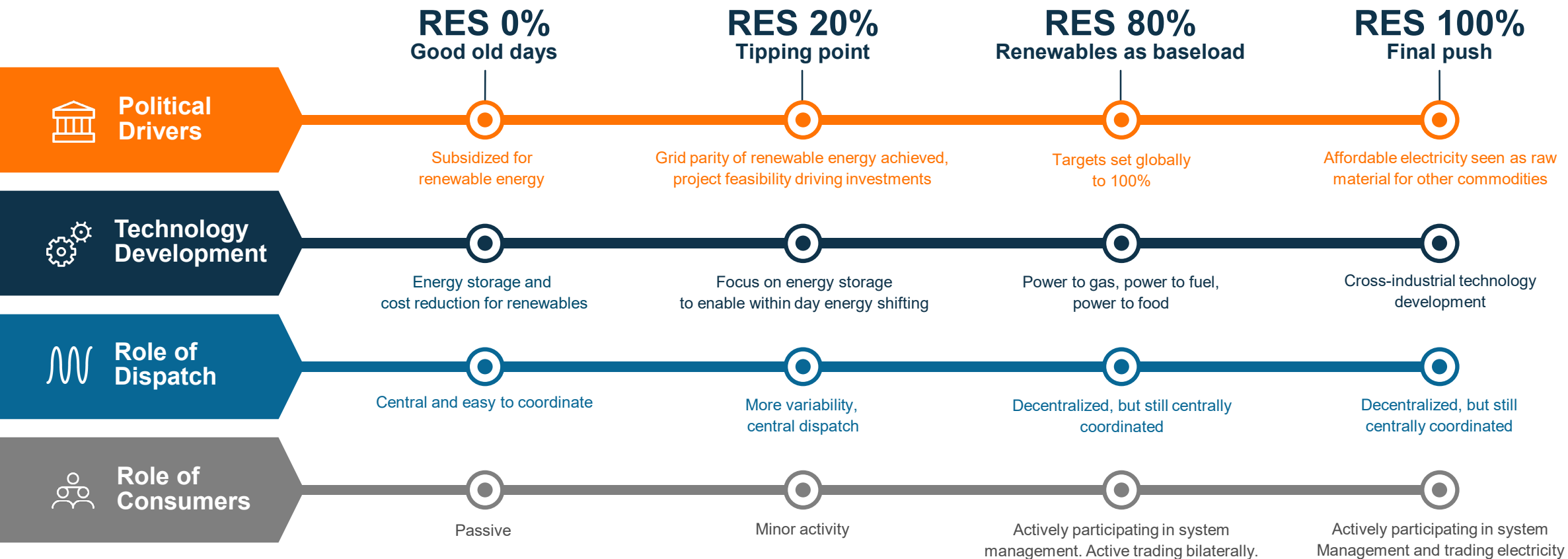
Renewables are not coming and they are always too expensive





\$ Cost of Renewable Energy

HOW ENERGY SYSTEMS CHANGE WITH HIGHER SHARE OF RENEWABLES





ENGINE POWER PLANTS

Ultra-flexible internal combustion engine based power plants



ENERGY STORAGE AND INTEGRATION

Utility-scale energy storage solutions and advanced software



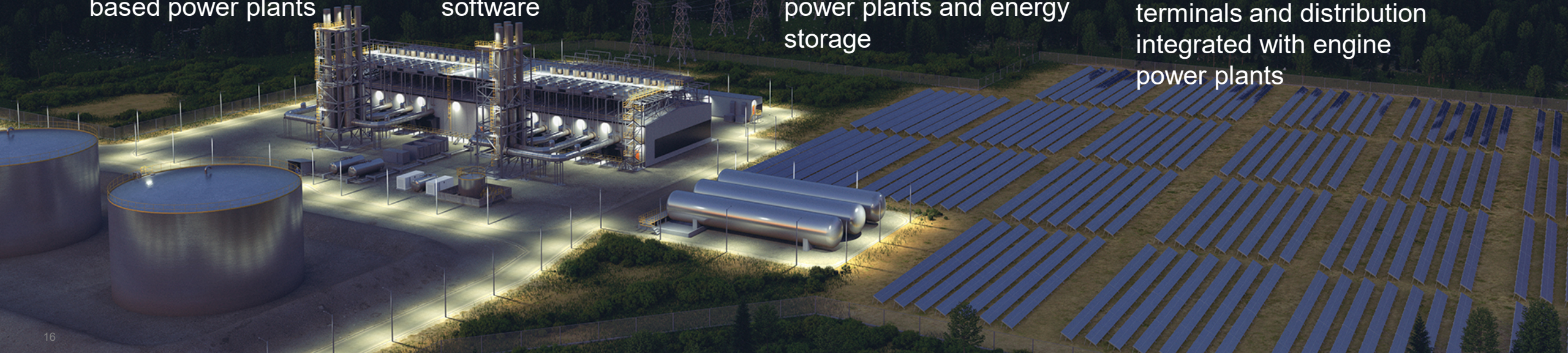
RENEWABLES

Utility-scale solar power plants integrated with engine power plants and energy storage



GAS-TO-POWER

Small and medium scale liquefaction plants, terminals and distribution integrated with engine power plants

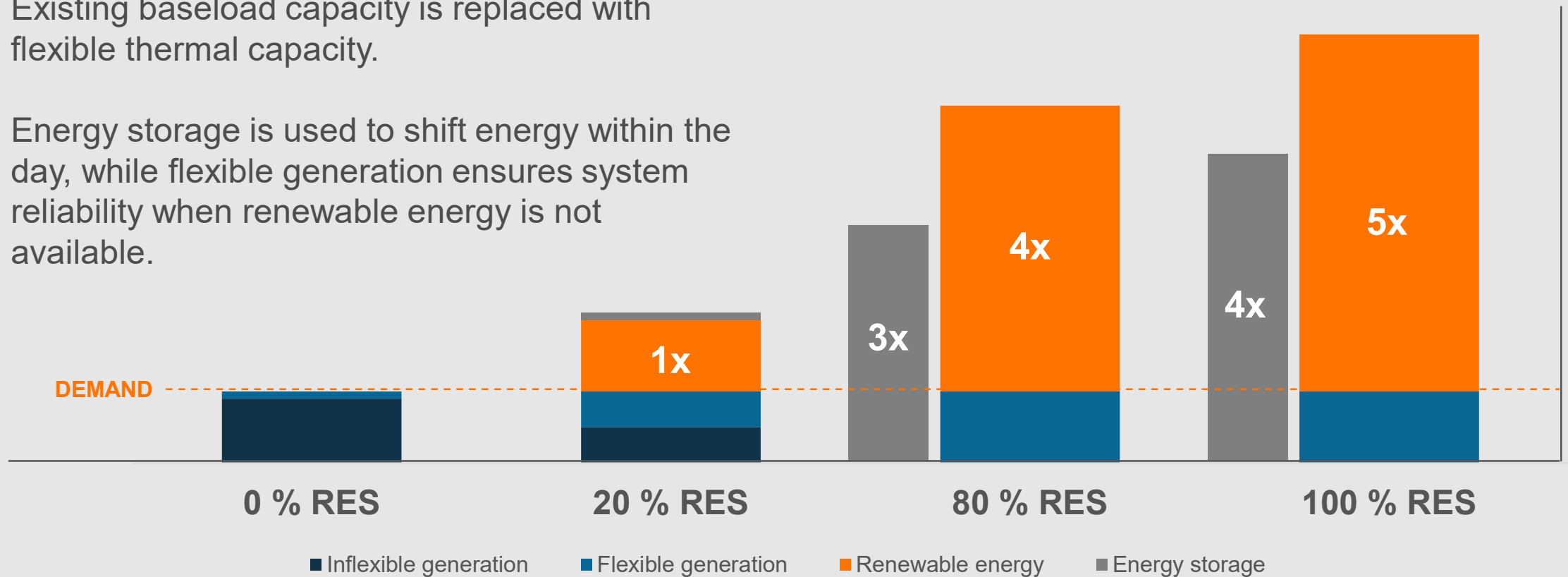


Capacity vs peak demand

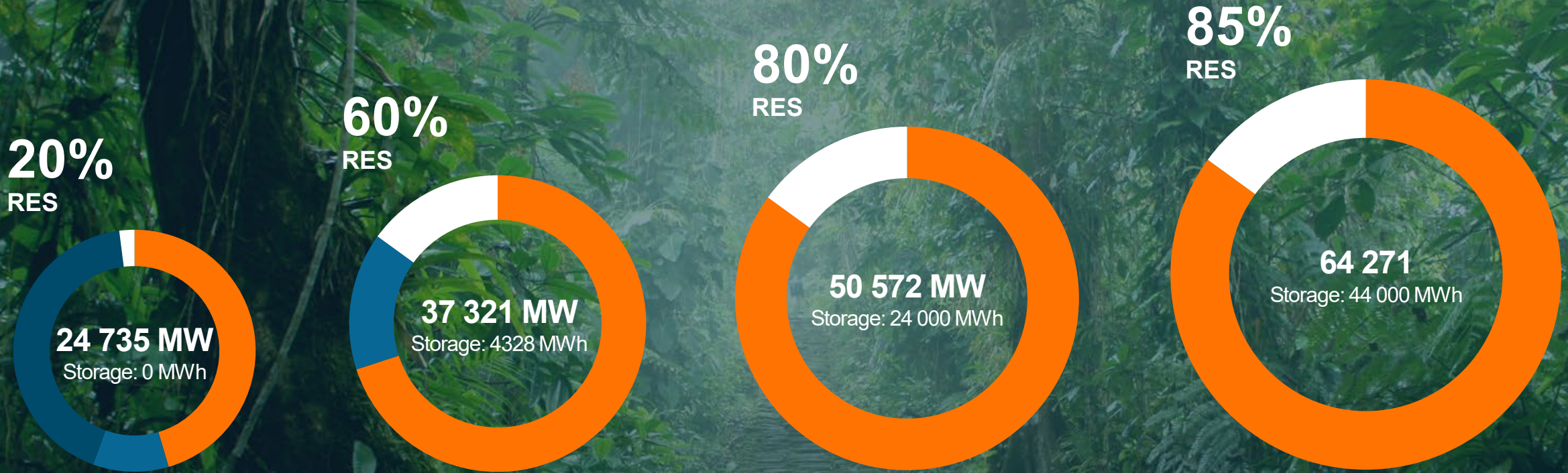
The transition to a 100% renewable system requires massive investment in new capacity.

Existing baseload capacity is replaced with flexible thermal capacity.

Energy storage is used to shift energy within the day, while flexible generation ensures system reliability when renewable energy is not available.



Optimal path towards 100% renewable energy system

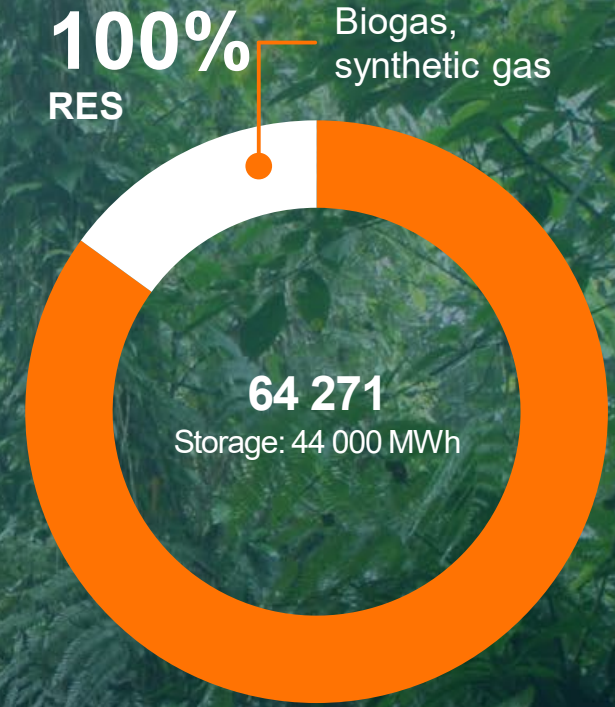
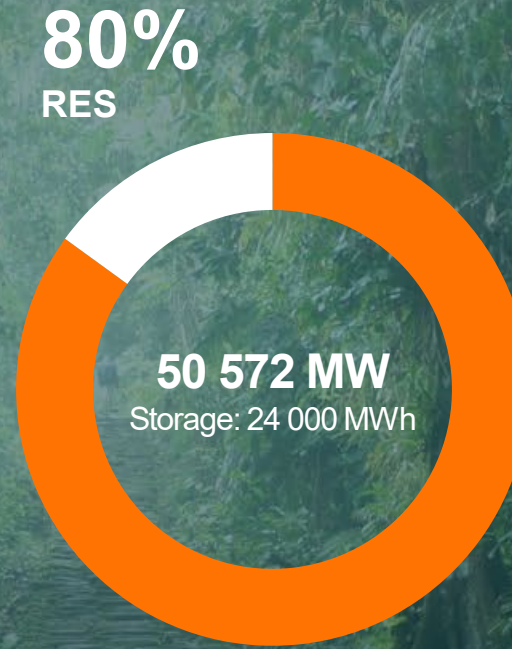
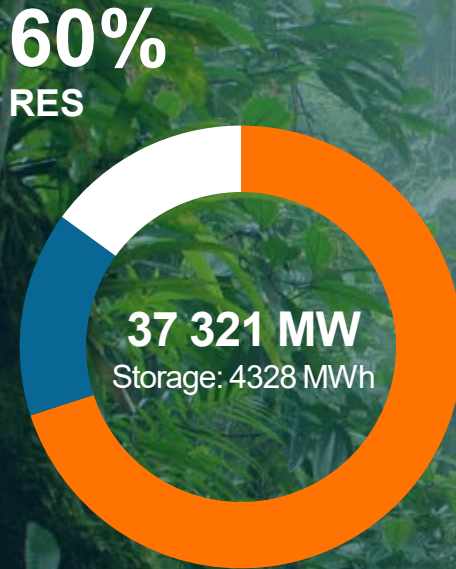
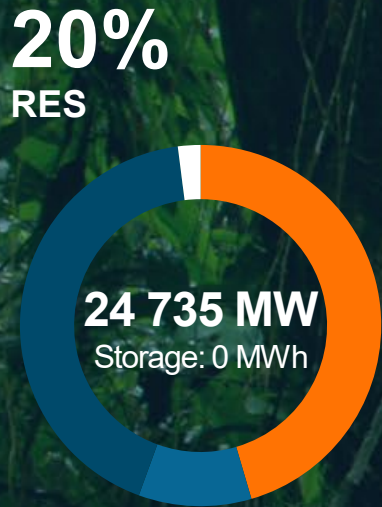


Installed capacity

- Renewables
- Coal
- Baseload gas
- Flexible gas

Source: Wärtsilä Energy Solutions, 2018

Optimal path towards 100% renewable energy system



Installed capacity

- Renewables
- Coal
- Baseload gas
- Flexible gas

Source: Wärtsilä Energy Solutions, 2018

WÄRTSILÄ'S ROLE AS THE ENERGY SYSTEM INTEGRATOR



80%
RES

100%
RES

Wärtsilä creates optimal paths towards **100% RENEWABLE ENERGY SYSTEMS**

As an energy system integrator Wärtsilä understands the role of different technologies as part of our customer's power systems, and puts the assets of the customer together through software, full EPC offerings and global services capabilities.



Understand

We understand the evolving energy market and recognise **value-based opportunities** for our customers in the utility and industrial market



Design & Build

As a leading **EPC** and lifecycle support provider, we also support our customers with **engine power plants, gas infrastructure solutions, hybridised solar PV, energy storage and integration.**



Serve

We provide a comprehensive understanding of energy systems, including **fully integrated assets** and advanced software complete with value adding **lifecycle services** for our customers.

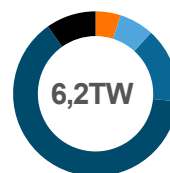
Comparing generation capacity today and in a 100% renewable energy world

The transition towards a sustainable electricity system will demand a **radical transition** of the power system.

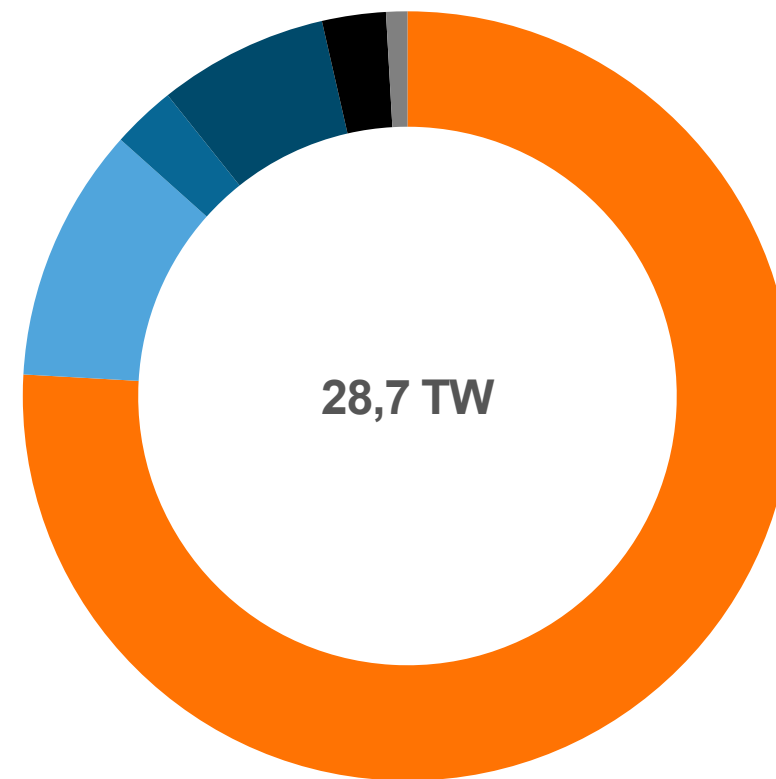
This is a fantastic opportunity for Wärtsilä since the new world requires a massive amount of new **flexible capacity**.

Wind and solar PV generation will become the **backbone** of the power system, covering 87 % of electricity demand.

GENERATION CAPACITY



TODAY



100% RES

Comparing storage energy capacity today and in a 100% renewable energy world

Energy storage technologies will become an **inevitable part** of the power system, both capacities and throughout of storage will increase hundredfold.

More than a **quarter of all electricity** in the system will go through storage.

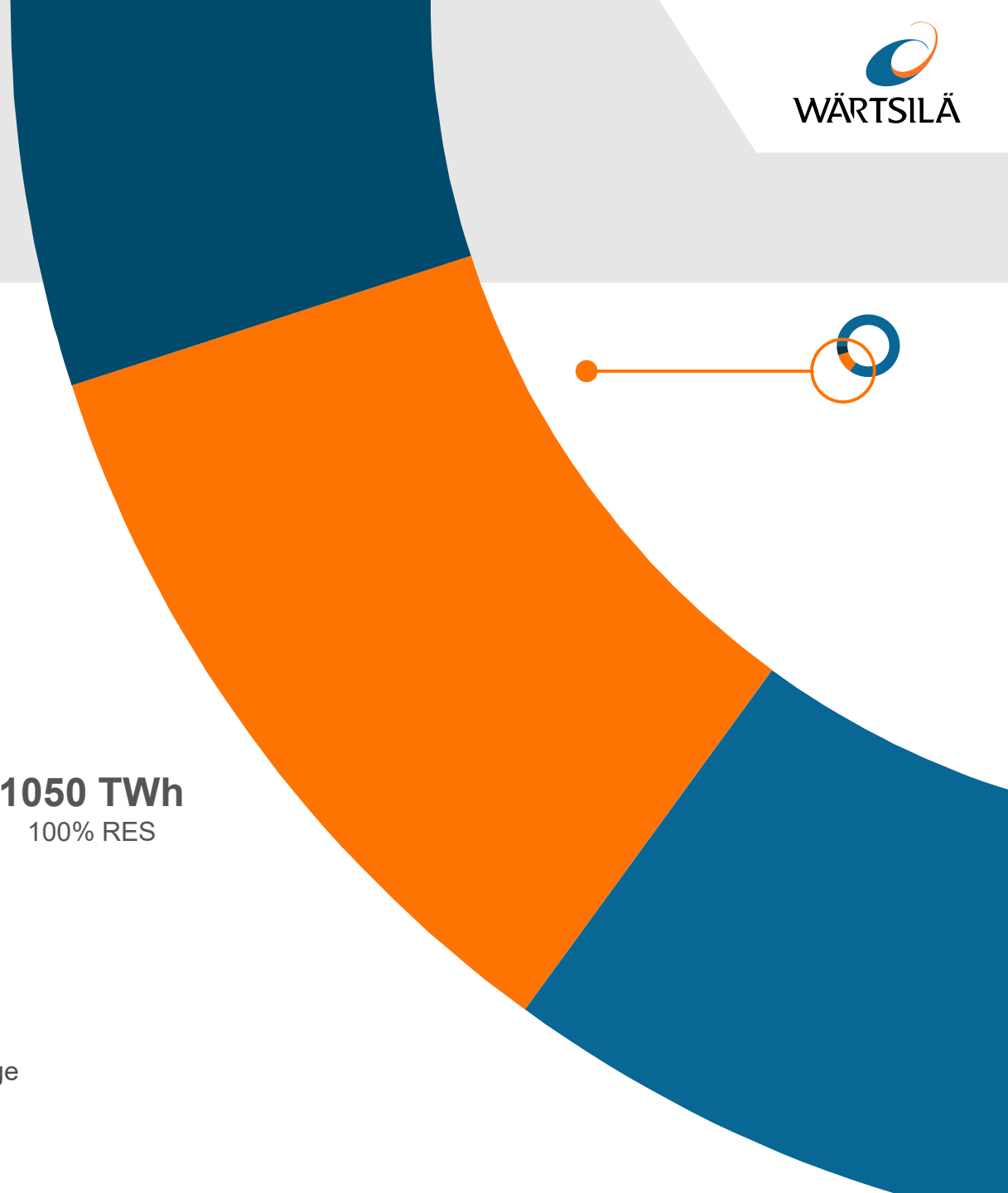
STORAGE ENERGY CAPACITY



1,3 TWh
TODAY

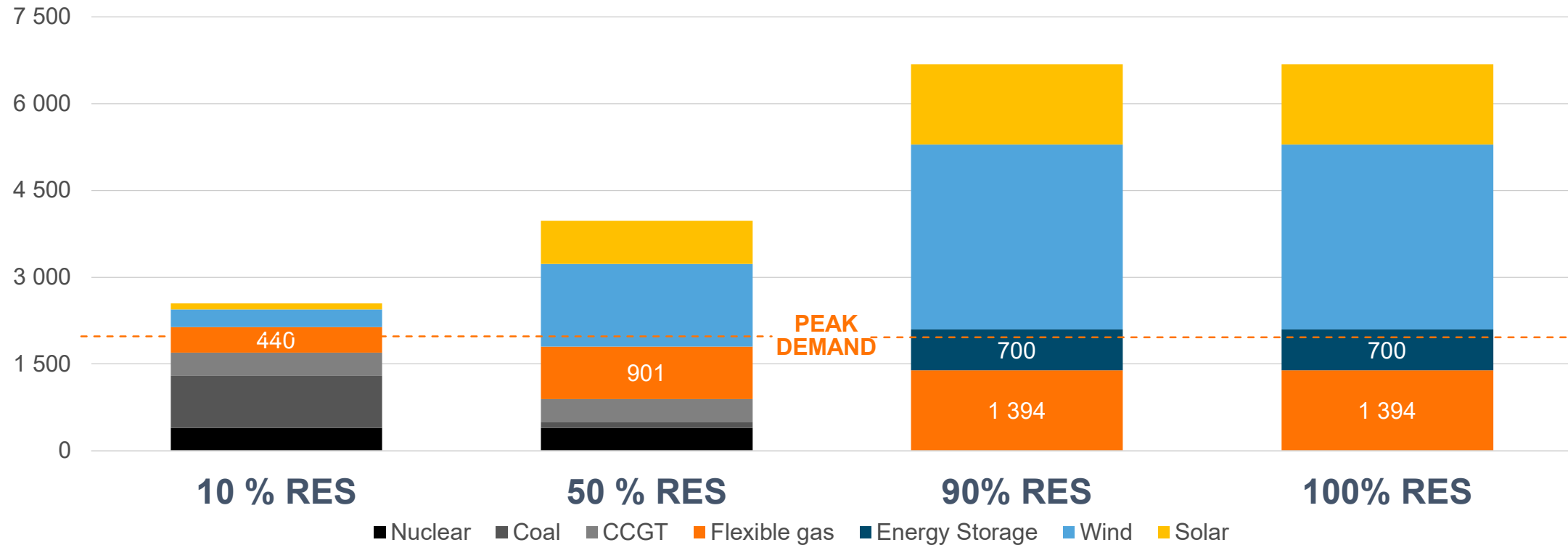
1050 TWh
100% RES

- Battery
- Power-to-gas
- Pumped hydro storage



- New Mexico in the USA is one of the best location for 100% renewables due to good wind AND solar resources
- Modelling results showing the optimized path towards 100% renewable energy system
- Significant increase in flexible gas capacity and energy storage compared to the current portfolio (10% case)

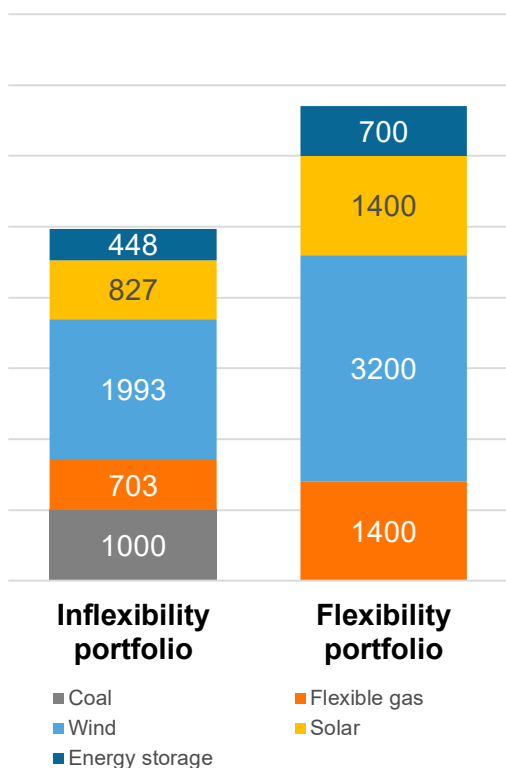
MW, MWh for storage



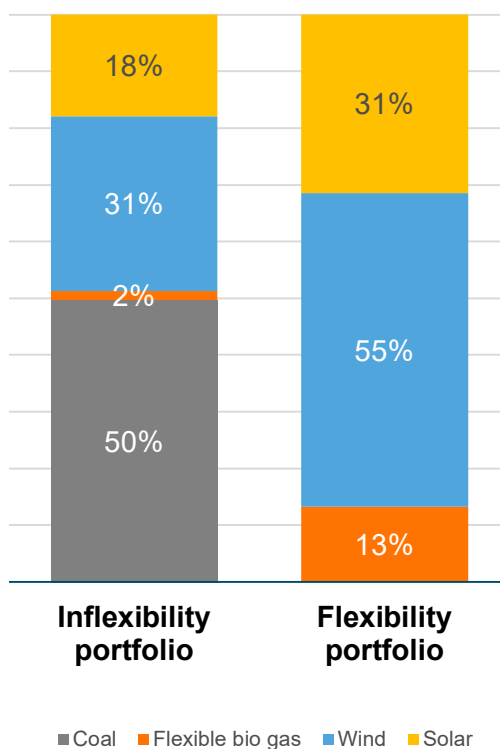
Comparing two alternative scenarios in an energy system with good wind and solar conditions

What if you choose the optimal path vs. still investing in inflexibility

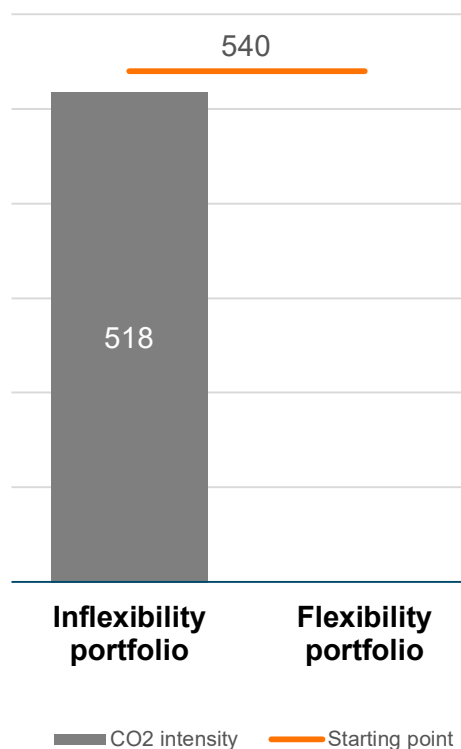
ALTERNATIVE CAPACITY MIXES, MW



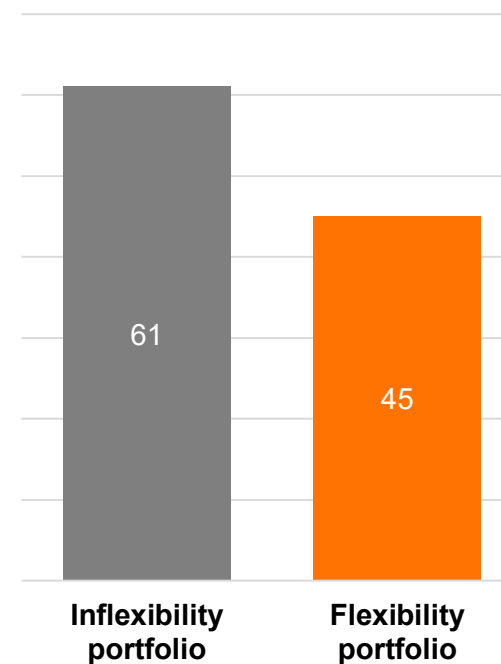
ENERGY MIX, %



CO₂ INTENSITY, G/KWH



LEVELIZED COST OF ELECTRICITY, \$/MWH





LARGE INVESTOR-OWNED UTILITIES ARE INVESTING IN SMART POWER GENERATION TOGETHER WITH ENERGY STORAGE



Wärtsilä was selected to provide a **Smart Power Generation** natural gas power plant with up to 200 MW of capacity



Greensmith Energy provided 10 MW/2.5MWh **energy storage system** to Tucson Electric Power in 2016

- Improved overall **efficiency** of the plant, reduced **emissions** of nitrogen oxides by approx. 60% → about 350 tons p.a.
- Engines require **minimal amounts of water** for cooling
- Ability to respond quickly and reliably to the variable production of **renewable resources**



THE FIRST UTILITY-SCALE RECIPROCATING ENGINE POWER PLANT IN AUSTRALIA'S NATIONAL ELECTRICITY MARKET



Wärtsilä will deliver a 211 MW **Smart Power Generation** power plant to AGL



AGL is planning to **replace Liddell coal plant** with renewables and additional 750 MW of flexible gas capacity

- Flexibility of our power plants is a **key enabler** for utilities in an electricity market with high share of renewable energy
- Flexibility rewarded in the National Electricity Market, which drives **investment in flexible gas as well as energy storage**
- The new power plant will improve the **reliability and security** of supply in South Australia

AGL is planning to replace Liddell coal plant with renewables and additional 750 MW of flexible gas capacity

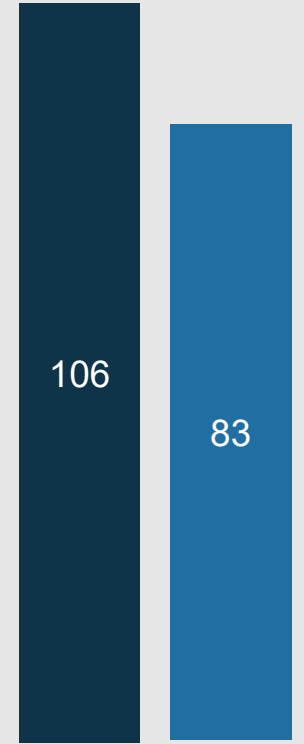
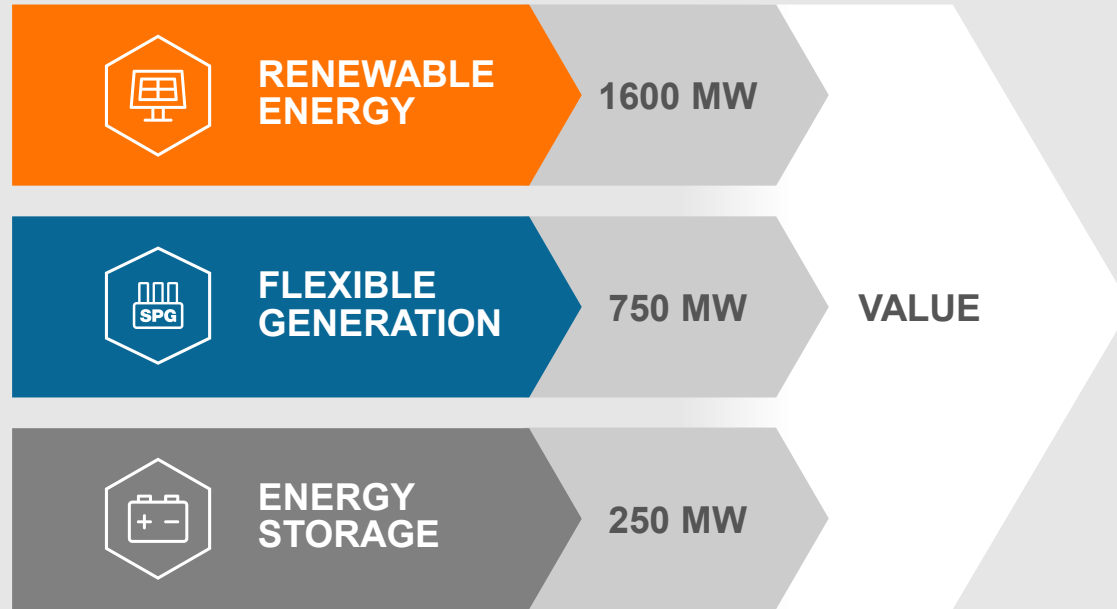


1000 MW



INFLEXIBLE GENERATION

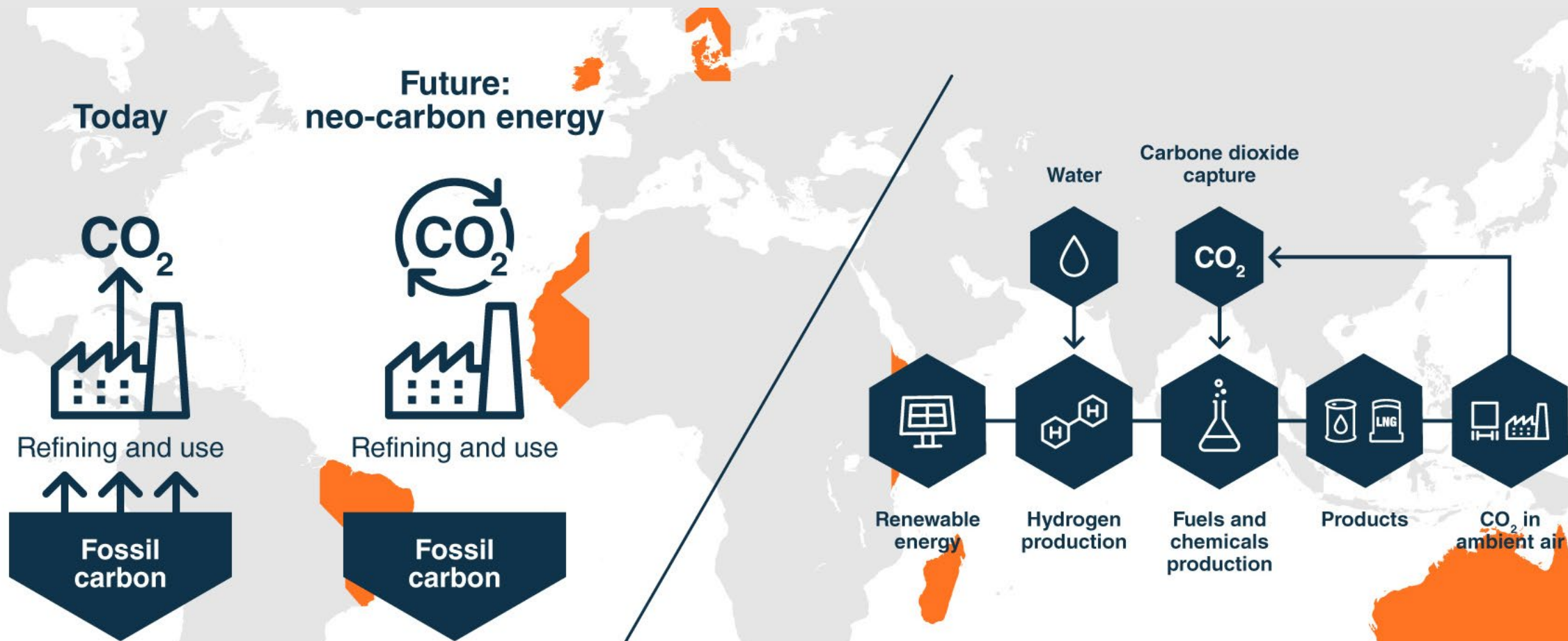
TRANSITION



Coal Flexible
LEVELIZED COST OF ENERGY, \$/MWH

Potential energy – Power to Gas

And the impact to the role of gas in the future





WÄRTSILÄ