

TOWARDS A **100%** RENEWABLE ENERGY FUTURE

Roundtable B: Transforming Energy – Beyond the ‘Cheap vs Green’ Dilemma
SIEW 2018

Name: Nicolas Leong
Date: 1 November 2018

20%

60%
RES

80%
RES

100%
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

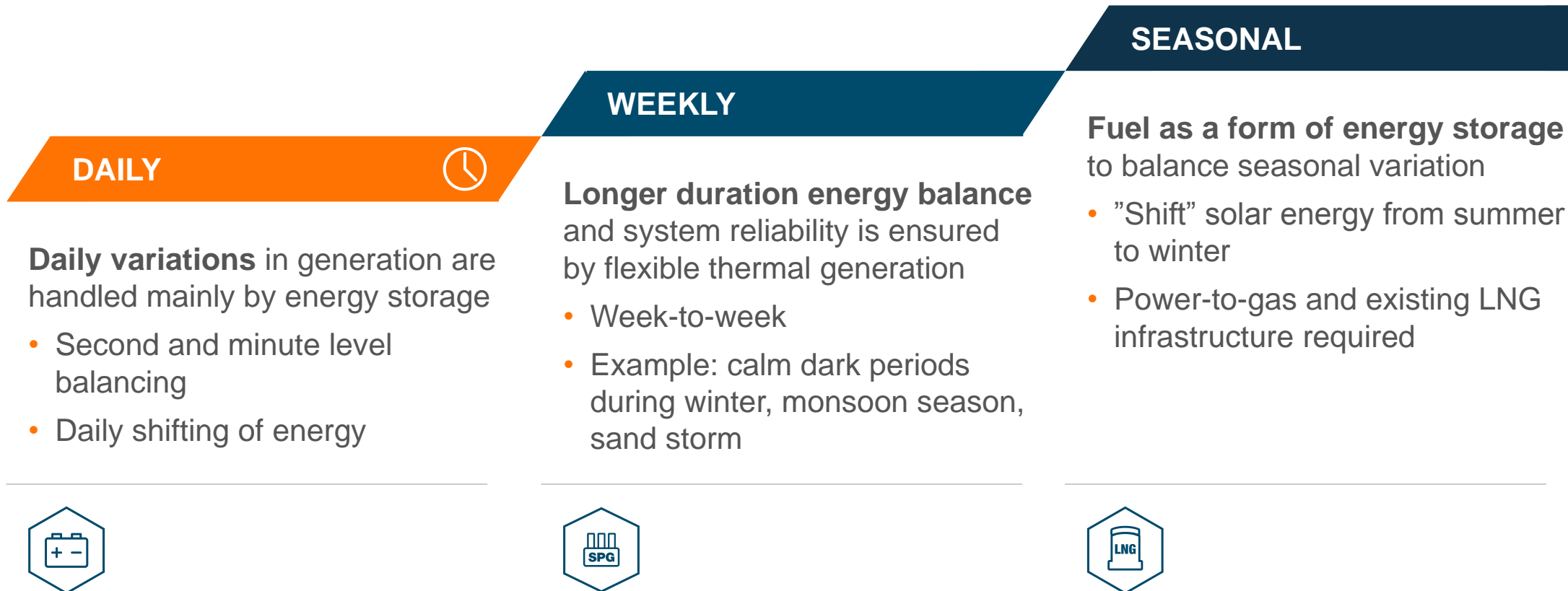
Energy storage becomes affordable, enabling increase in renewable energy

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



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RES

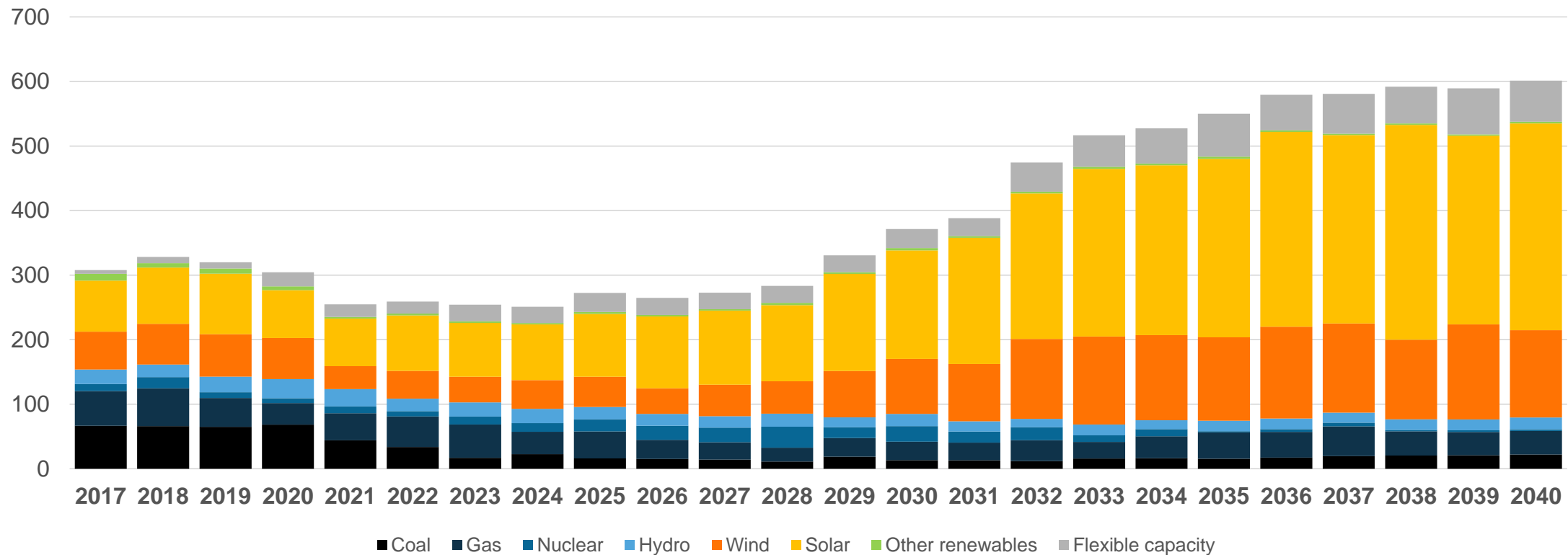
100%
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Wind and solar cumulative installed capacity will increase from 14% in 2017 to 48% in 2040

Engines and storage will enable the transition

Annual gross capacity additions (GW) 2017-2040

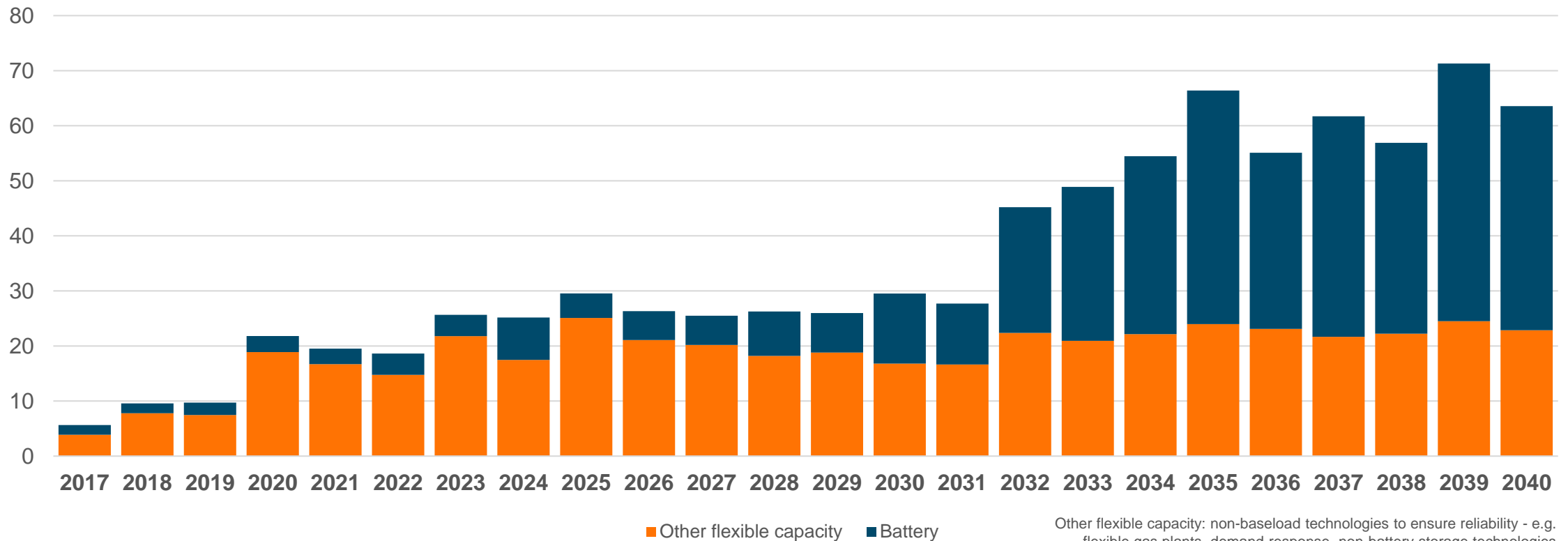
Source: Bloomberg New Energy Outlook 2017



Flexible capacity by application type

Annual gross capacity additions (GW) 2017-2040

Source: Bloomberg New Energy Outlook 2017

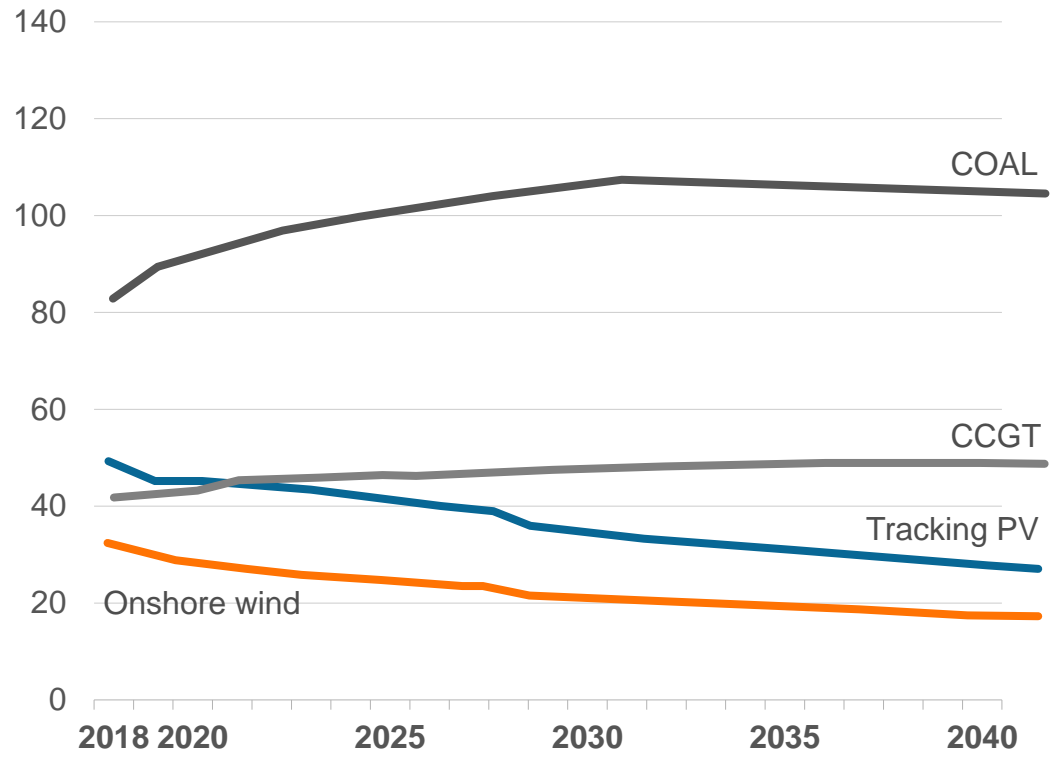


Price for renewable energy has reached a tipping point – all across the world

Prices of renewables continue to drop

UNITED STATES

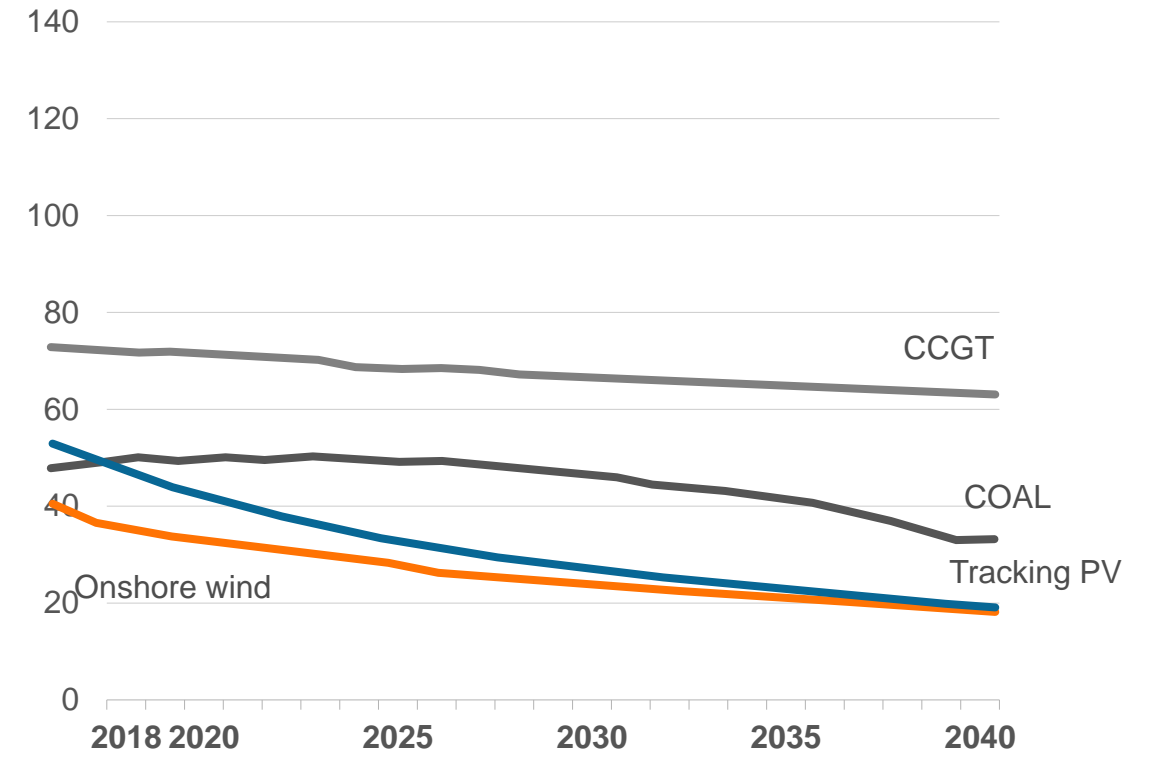
LCOE (\$/MWh, 2017 real)



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.

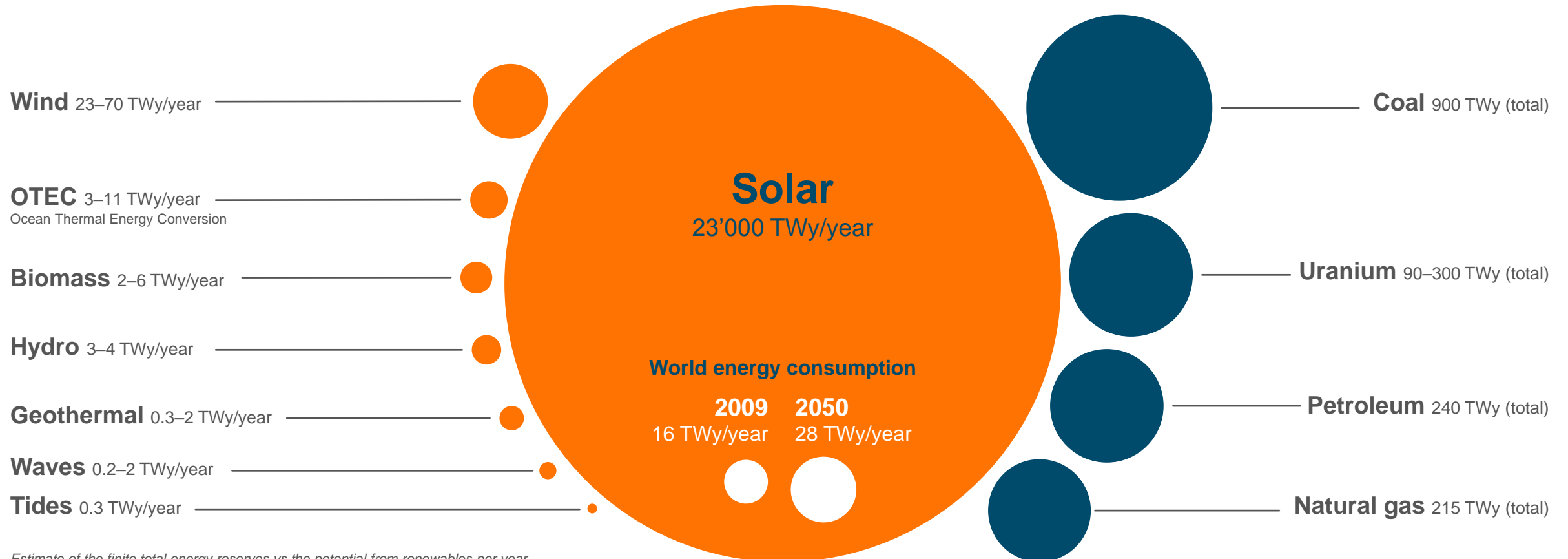
CHINA

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

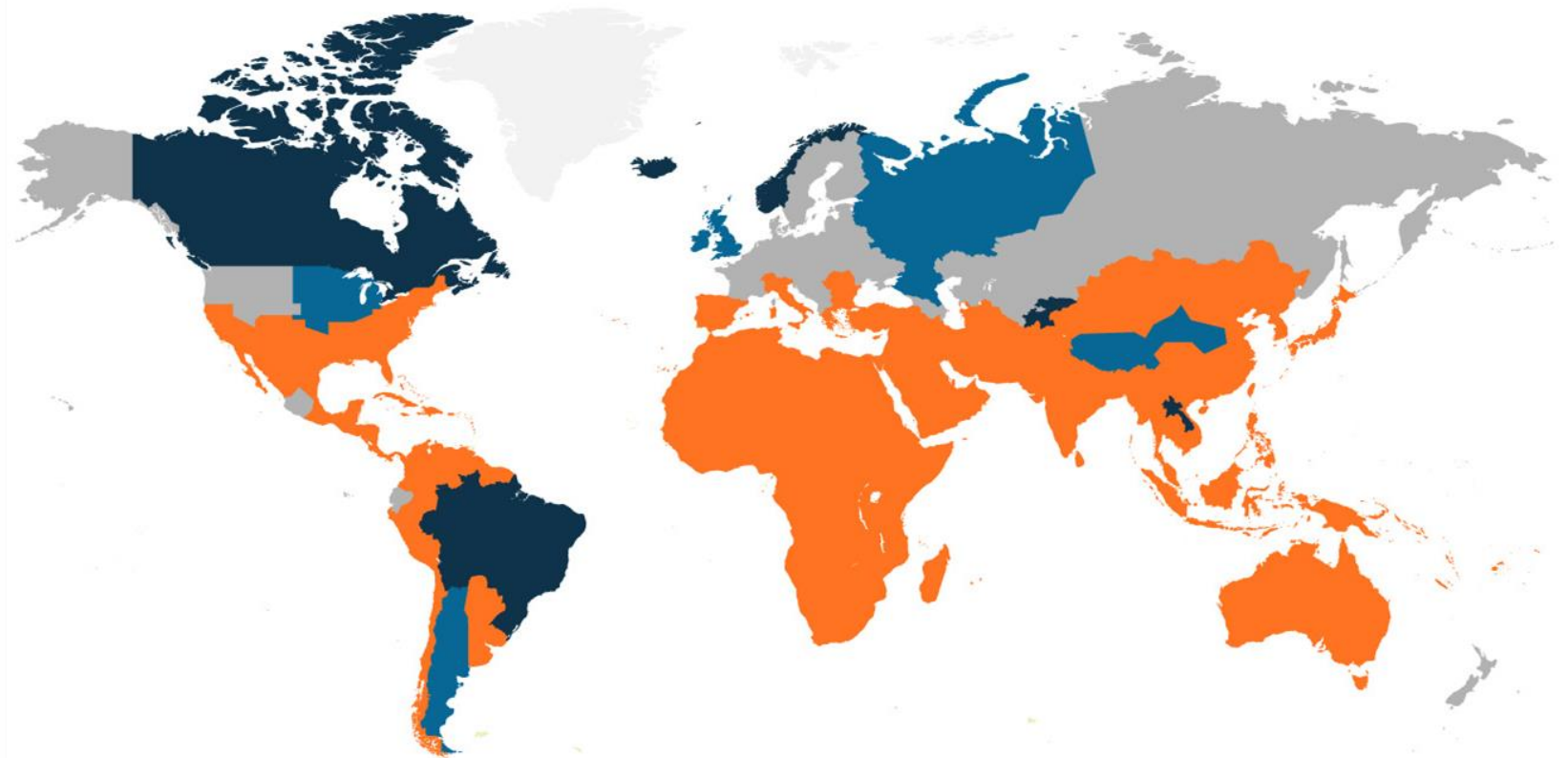


Estimate of the finite total energy reserves vs the potential from renewables per year.
 Source: Atmospheric Sciences Research Center, at the State University of New York at Albany, 2018

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

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

Updated: MAY 30, 2017 — 3:01 AM EDT

WE'RE HERE



ACTION

SELF-CONFIDENCE

Building the optimal path to a renewable world

I need to change – I know the path...

ACCEPTANCE

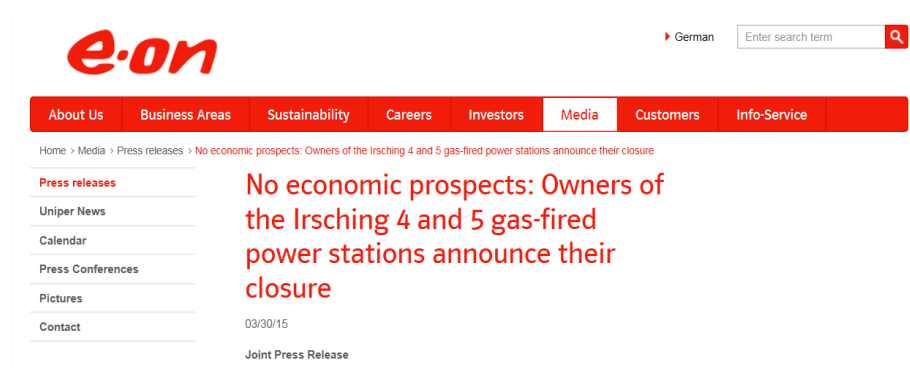
Our old business model doesn't work and we need to renew ourselves → old capacity leaving the market

UNDERSTANDING

Renewables are changing the power system and utility business model

DENIAL

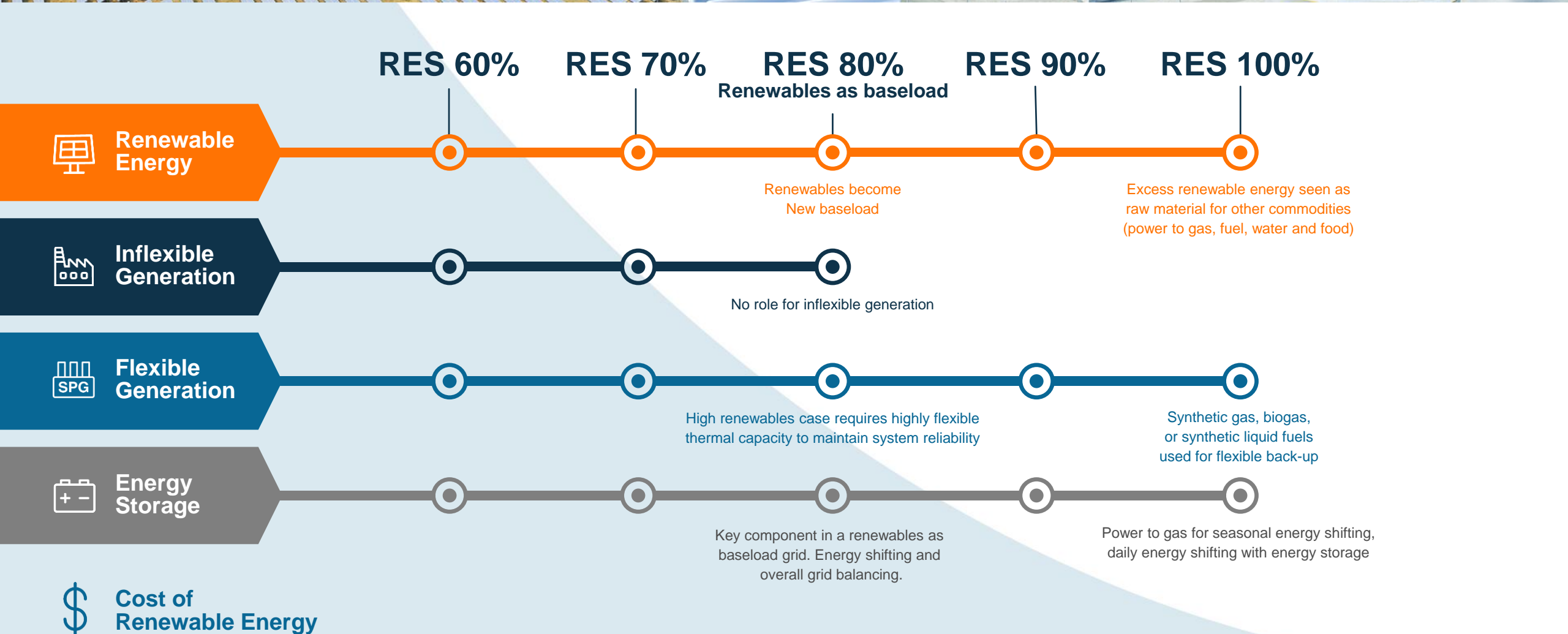
Renewables are not coming and they are always too expensive



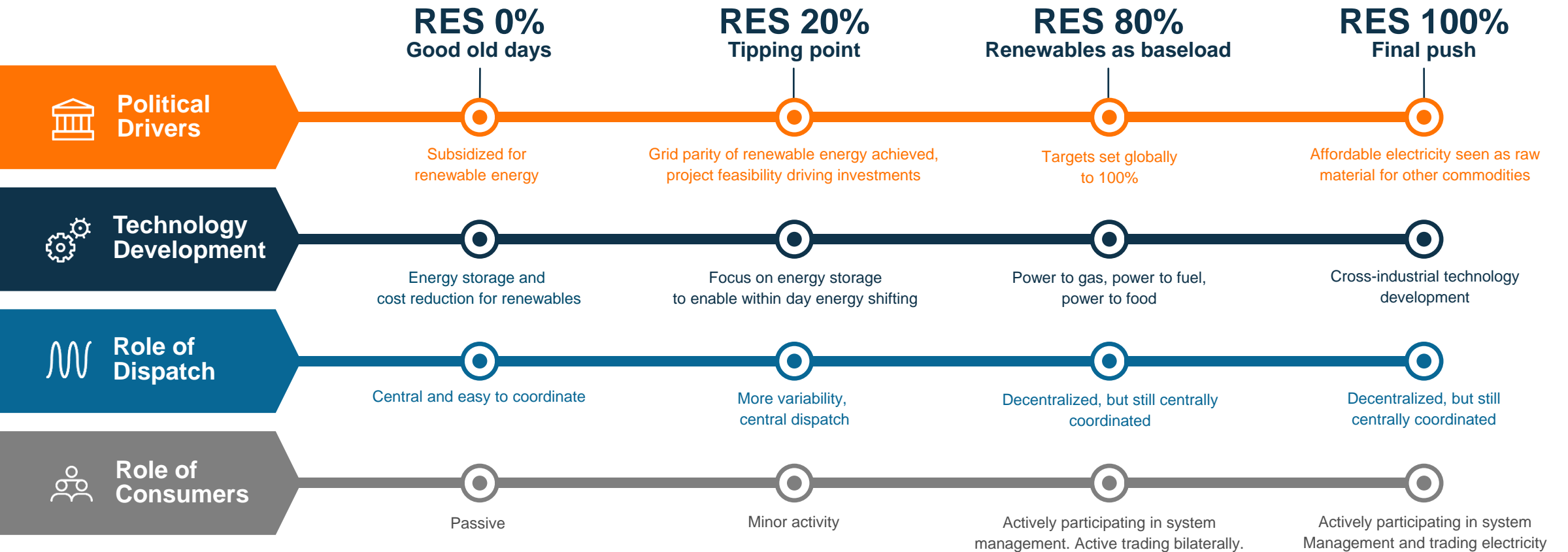
ROLE OF TECHNOLOGIES IN THE ENERGY TRANSITION



\$ Cost of Renewable Energy



HOW ENERGY SYSTEMS CHANGE WITH HIGHER SHARE OF RENEWABLES



WÄRTSILÄ'S ROLE AS THE ENERGY SYSTEM INTEGRATOR



80%
RES

100%
RES



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, solar-engine, storage+ hybrid solutions



GAS INFRASTRUCTURE

Small and medium scale liquefaction plants, terminals and distribution



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, 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.



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

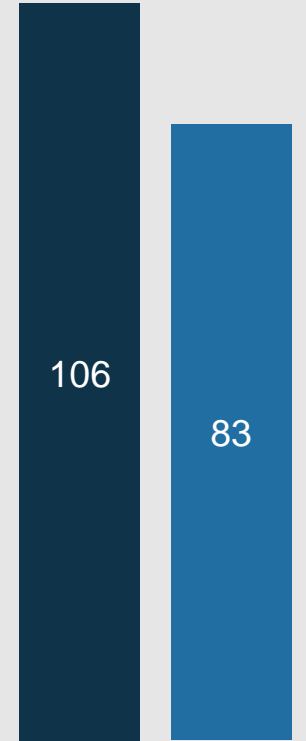
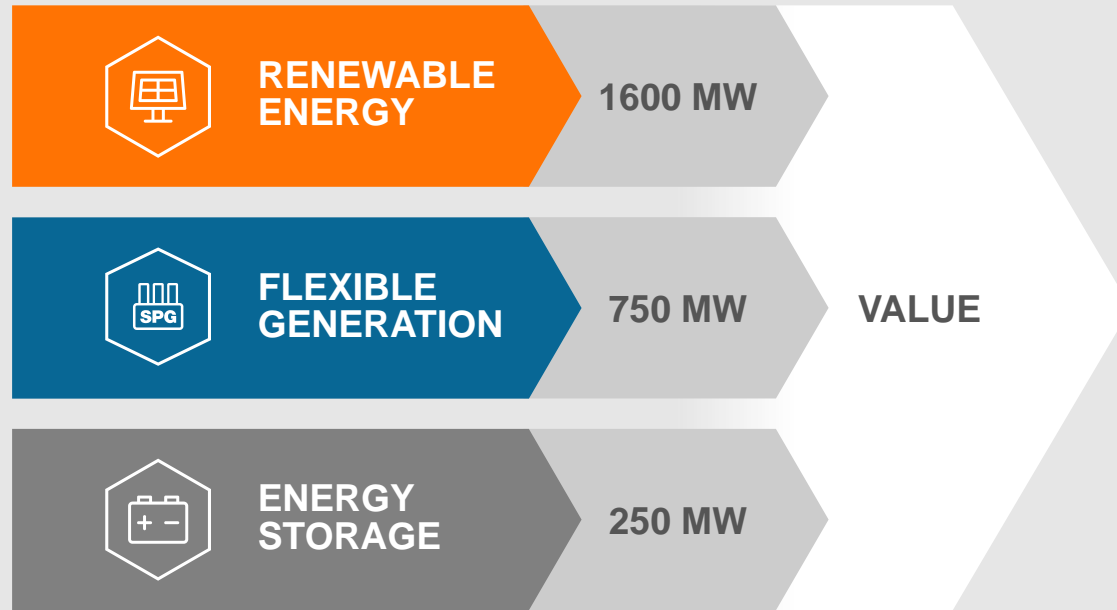


1000 MW



INFLEXIBLE GENERATION

TRANSITION



Coal Flexible

LEVELIZED COST OF ENERGY, \$/MWH

THANK YOU



WÄRTSILÄ

Nicolas Leong

Business Development Manager

Wärtsilä Energy Solutions

Nicolas.Leong@wartsila.com

+65 8339 5334