Powering Africa with Wärtsilä's Flexible Engine Technology

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AFRICA THROUGH THE ENERGY TRANSITION

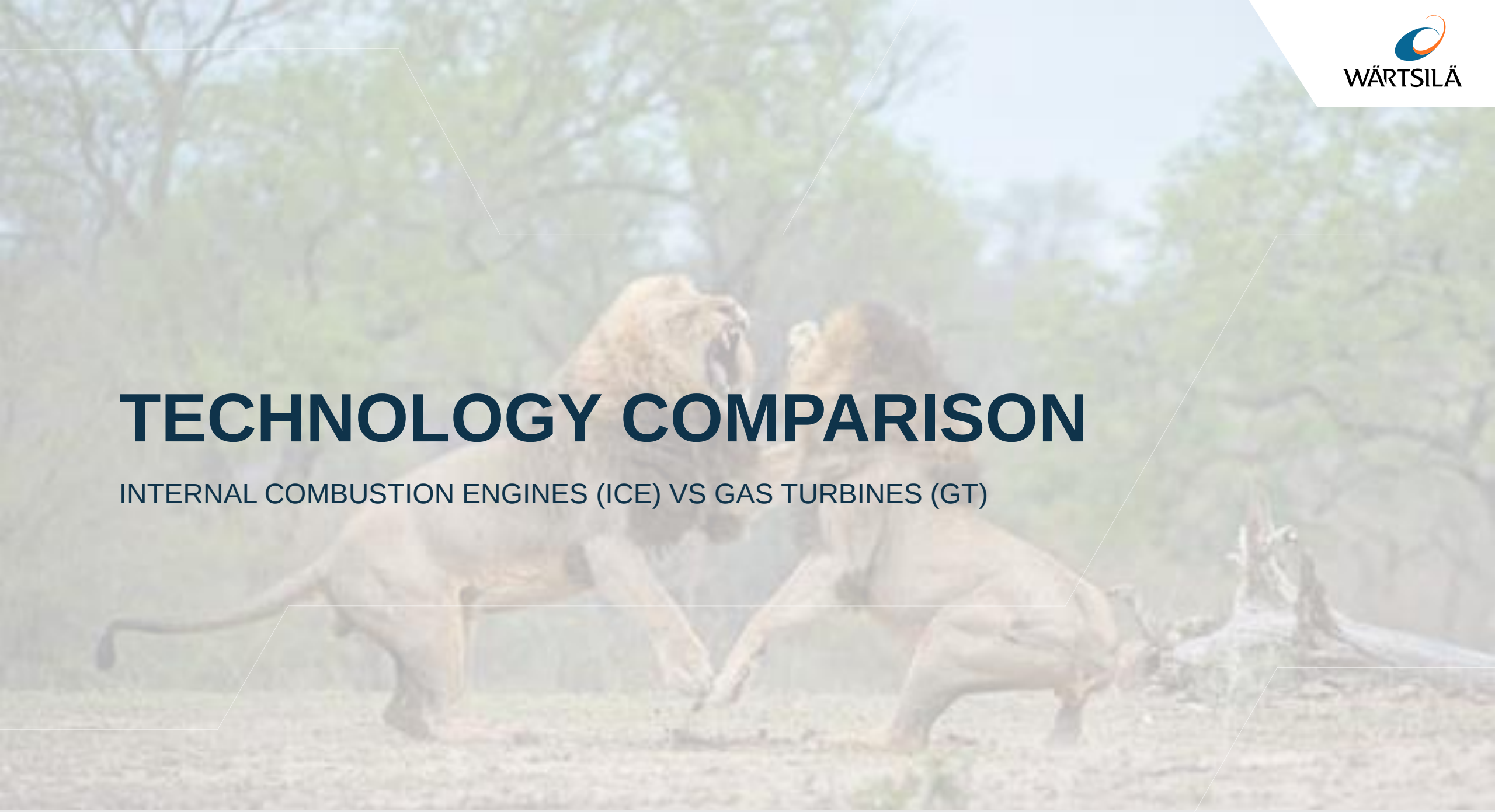
Universal access to electricity in Africa requires a **balanced energy mix**, combining renewables with flexible thermal solutions like Internal Combustion Engines power plants.

This approach ensures reliable, decarbonized, and cost-effective energy generation, supporting renewable integration and economic development.

TECHNOLOGY COMPARISON

WHY IS FLEXIBILITY NEEDED?

THE WÄRTSILÄ WAY



TECHNOLOGY COMPARISON

INTERNAL COMBUSTION ENGINES (ICE) VS GAS TURBINES (GT)

INTRODUCTION OF COMPARED TECHNOLOGIES

COMBINED-CYCLE GAS TURBINES

Heavy- Duty CCGT

CAPEX[1] at 15°C[2]: **1,300 EUR/kW**

Output at 15°C: **406 MW**

Variable O&M[3]: **4$/MWh**

Efficiency: **GT PRO by Thermoflow**

Modular CCGT 2-2-1 x 3

CAPEX at 15°C: **1,300 EUR/kW**

Output at 15°C: **463 MW**

Variable O&M: **4$/MWh**

Efficiency: **GT PRO by Thermoflow**

GAS ENGINES

Wärtsilä 24 x 18V50SG

CAPEX at 15°C: **1000 EUR/kW**

Output at 15°C: **437 MW**

Variable O&M: **6$/MWh** (incl. major OHs)

Efficiency: **Wärtsilä technology**

[1]CAPEX: Capital Expenditure estimate from level 0. [2]Other parameters considered: altitude 0m, methane number 100 for gas turbines, 80 for gas engines, cooling method for gas turbines is air cooled condenser.
[3]O&M: Operation & Maintenance.

AMBIENT CONDITIONS IMPACTS PLANT OUTPUT

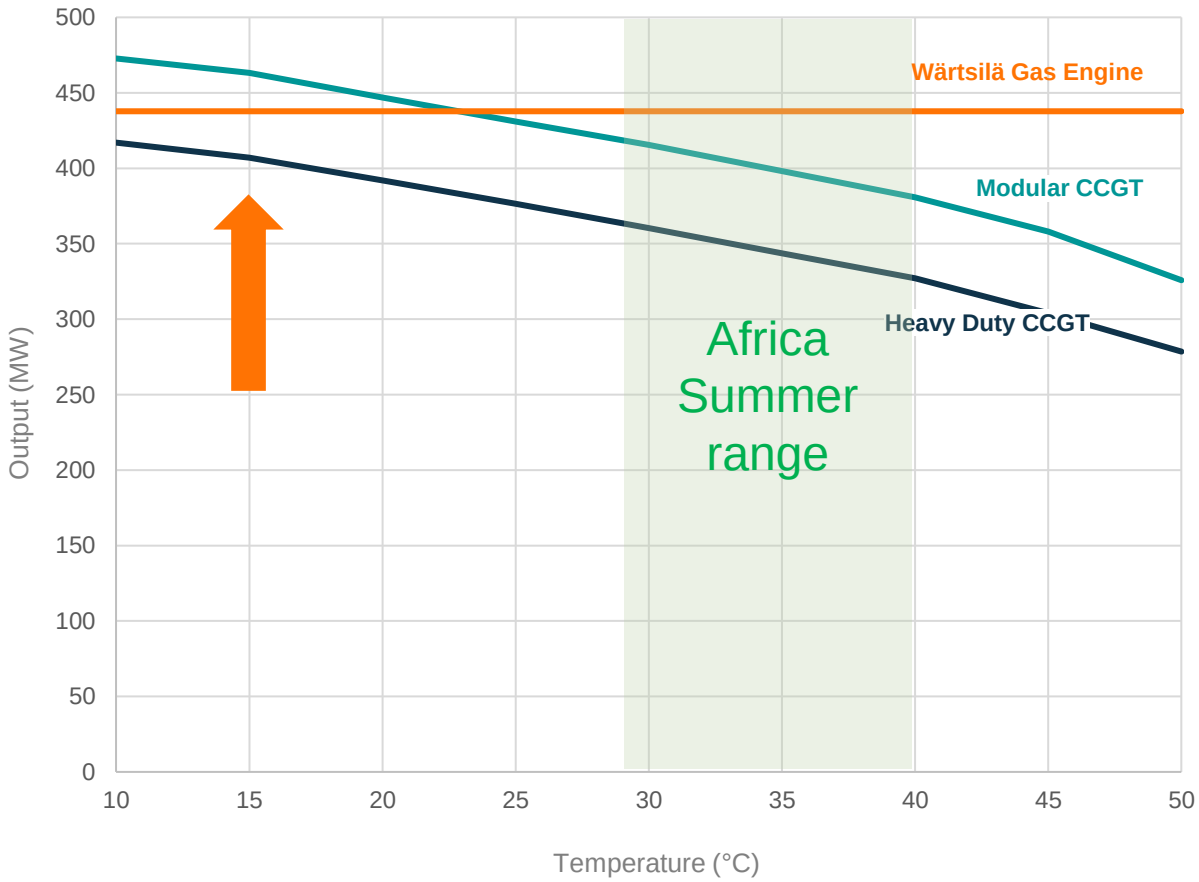
To properly assess technologies efficiency and actual cost, **they need to be compared in real ambient conditions**

ISO conditions

- Temperature: **15°C**
- Relative humidity: **65%**
- Load: **100%**

Engines' output tend to vary less than turbines' in higher temperature environment

Graph: Output variation according to temperature conditions



MODULARITY ENABLES HIGH EFFICIENCY AT LOWER LOADS

In addition to ambient conditions, plant load must be tailored to local context. Considering the strong ramping up of Renewables all over Africa, power plants will have to ramp up and down and start and stop to support renewable penetration.

Plant capacity factor are expected to be around 50-70%.

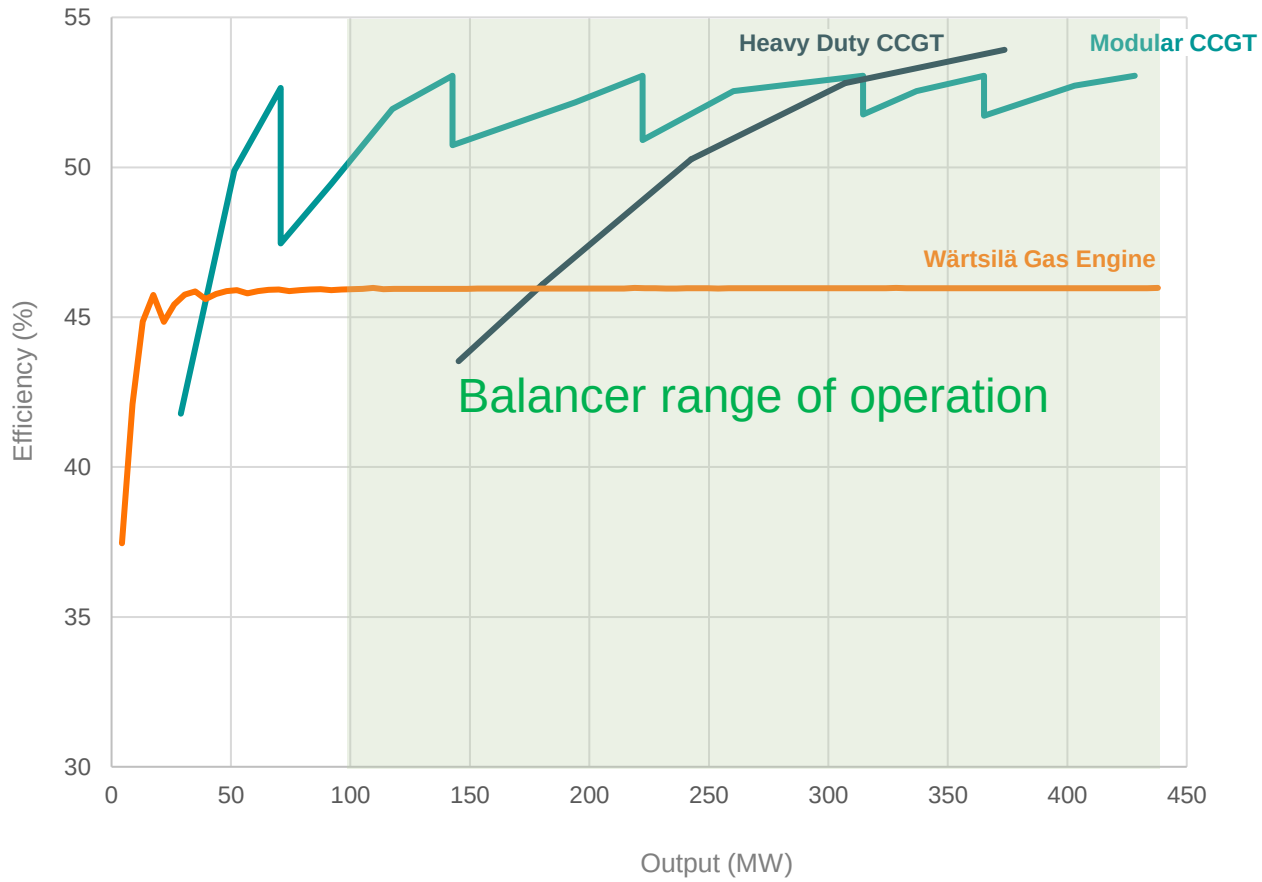
Ambient conditions used in the next slides:

- Temperature: **26°C**
- Relative humidity: **80%**
- Expected Capacity Factor: **40 - 65%**

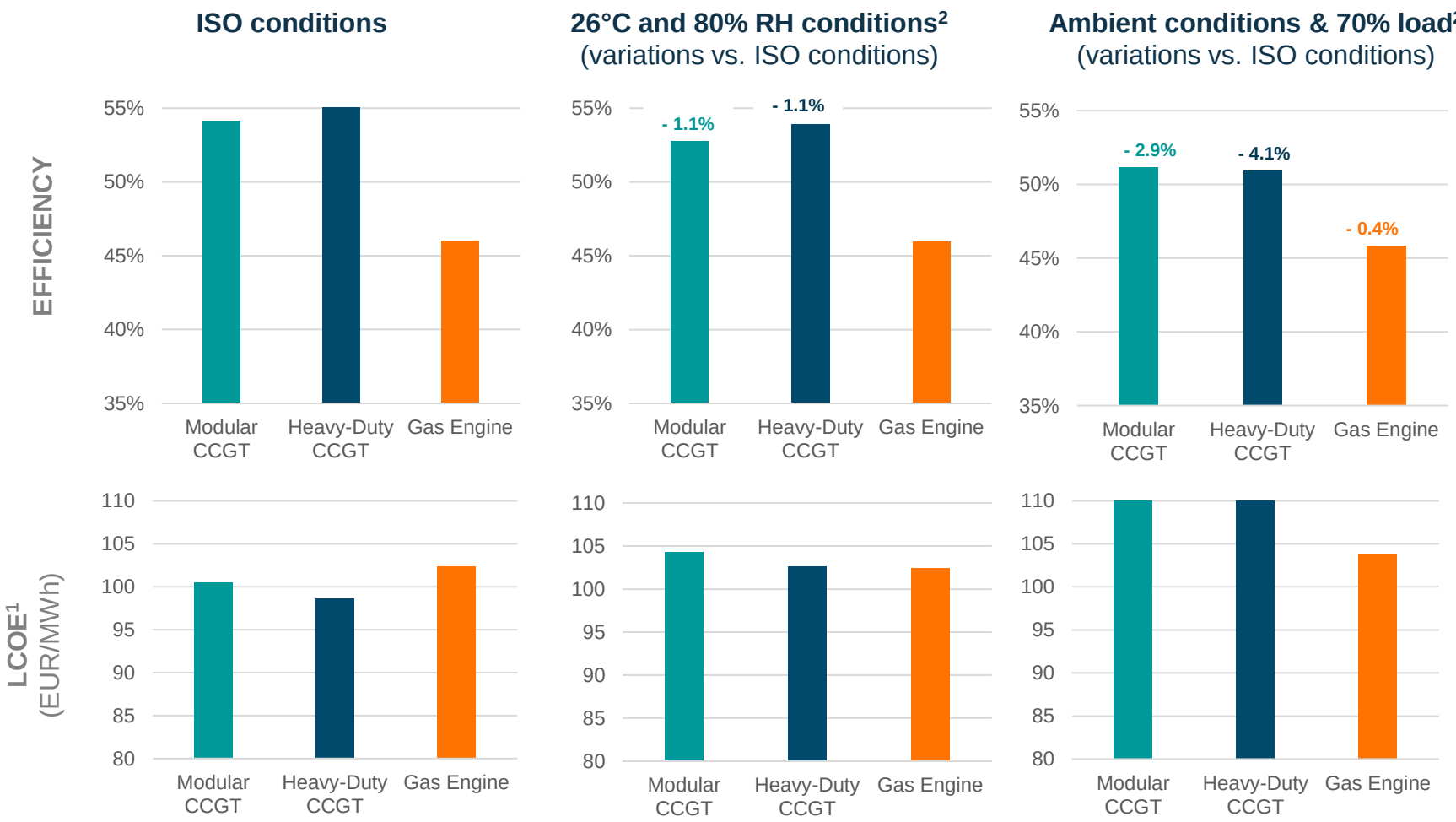
Benefits of modularity:

- Modularity enables **efficient operation** during partial loading as some units can be switched off completely instead of lowering the output of the all plant.
- Modular design increases the **reliability** of the power plant as a trip of one unit has only minor effect on the total output.
- High part-load efficiency supports the integration of renewables
- Modular engine power plants can be built in phases.

Graph: Efficiency variation according to output in Ambient African conditions



WÄRTSILÄ ENGINES ARE TAILORED FOR LOCAL CONDITIONS



For 400 MW Power station running at 70% load and 7,000 RH (56% C.F.)

Internal Combustion Engines (ICE) would allow an annual saving of 6 MEUR

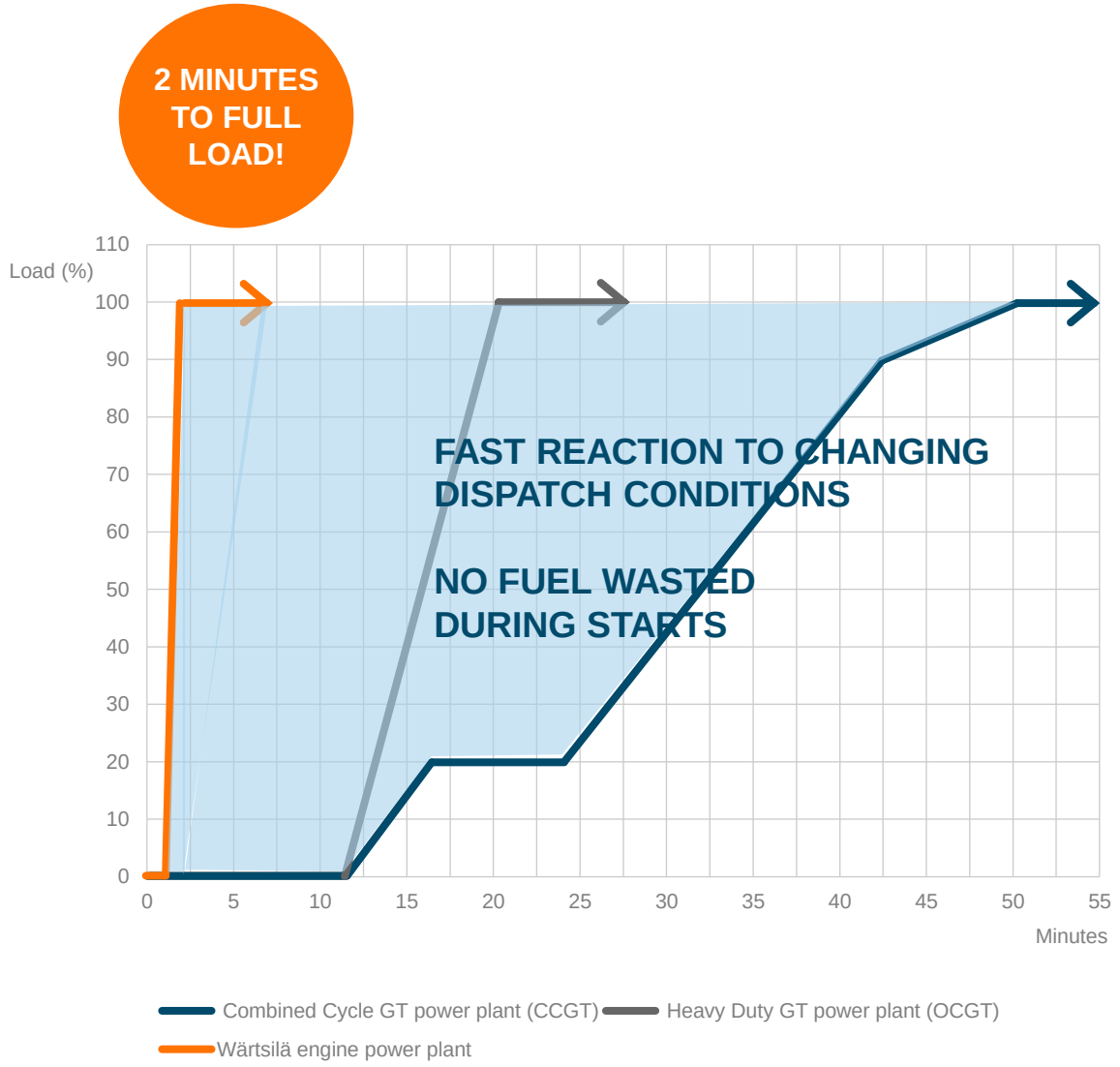
[1]LCOE: Levelised cost of Energy. Financial parameters used for LCOE: lifetime 20 years; WACC 11%; Fuel price 10 EUR/GJ; 7,000 running hours p.a.; gas turbine start costs not incl.
[2]All technical parameters for gas turbines optimised for temperature of 26°C. [3]p.a.: per annum.

WÄRTSILÄ QUICK START-UP HAS SEVERAL BENEFITS

Power plant flexibility is a vital to manage variability in electric loads and provide grid support services. One measure of this flexibility is ramp rate – the rate at which a power plant can increase or decrease output.

- Dispatch decisions can be postponed to get latest weather forecast data.
- Enable reacting to sudden changes in the demand.
- Quick response to forced outages of other power plants.
- Quick start-up can provide back-up for renewables in non-spinning mode.
- Low fuel usage during the start-up.

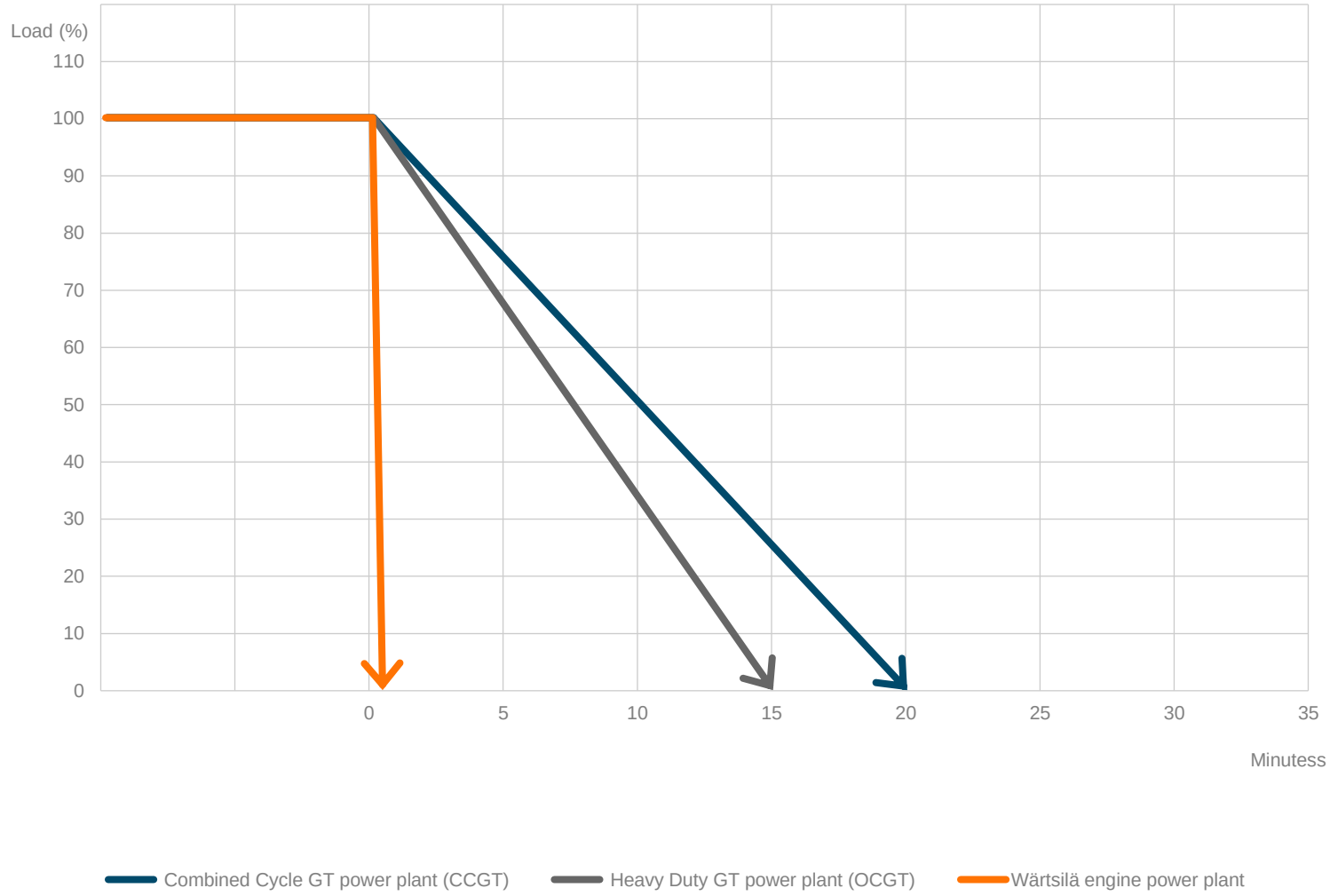
Wärtsilä engines can ramp up at over 100%/minute, much faster than gas turbines, providing ultra-responsive power that is needed to integrate renewable energy and maintain the stability of the grid.



SWITCHING OFF ENGINES TAKES VERY LITTLE TIME

- Engine power plants can be switched off immediately after the wind starts blowing or the sun starts shining
- Enables reacting to sudden changes in the demand
- Allows for several start-ups and stops per day
- No fuel is wasted when power is not needed

Wärtsilä engines can be switched off almost immediately, providing ultra-responsive power that is needed to integrate renewable energy and maintain the stability of the grid.



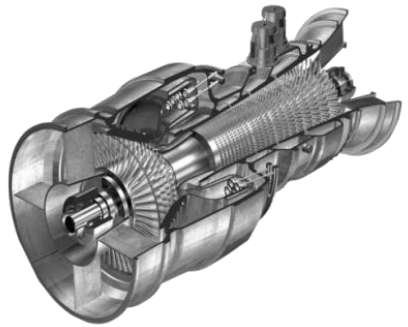
ENGINE POWER PLANT MAINTENANCE IS WELL SUITED FOR FLEXIBLE OPERATION

GAS TURBINES:

- GT maintenance needs are affected by several factors
- In steady base load operation on gas, maintenance schedule follows actual operating hours
- Factored hours & starts modify GT maintenance intervals → OPEX
- Equipment needs to be sent to OEM workshops for major overhauls – extra transportation and downtime

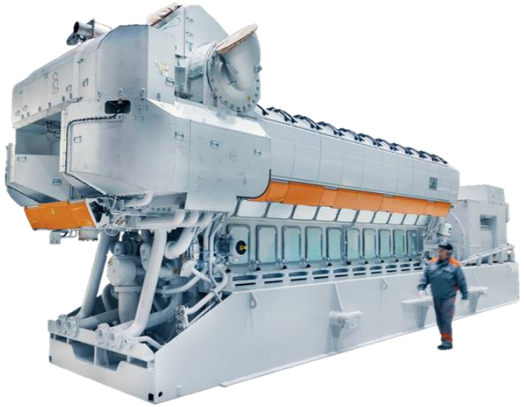
MAINTENANCE SCHEDULE IS AFFECTED BY:

- Starting & stopping
- Cyclic and peaking operation mode
- Liquid fuel operation
- Number of trips
- Cyclic operation with daily starts can result in significant maintenance cost increase



ENGINE POWER PLANTS:

- Cyclic operation and frequent starting have no impact on maintenance schedule and cost
- Multiple unit plant configuration enables sequenced maintenance of the units so that only 5-10% of the production capacity is lost
- All the maintenances can be done at site, no need to send the equipment back
- **No factored hours**
- **No factored starts**
- **No factored stops**
- **No factored trips**
- **No factored ramp-up**



OPTIMAL TECHNOLOGY DEPENDS ON RUNNING HOURS AND GAS PRICE

Table: Technology with lowest LCOE according to gas price and running hours, based on the assumptions presented on previous slides (70% load and African average ambient conditions – **500 start-up cost considered**)

RUNNING HOURS P.A.

GAS PRICE (EUR/GJ)	500	100	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000	8500
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30	Gas Engine	Gas Engine	Gas Engine	Gas Engine	Gas Engine	Gas Engine	Gas Engine	Gas Engine	Gas Engine	Modular CCGT	Modular CCGT	Modular CCGT	Modular CCGT	Modular CCGT	Modular CCGT	Modular CCGT	Modular CCGT

With today's gas prices and running conditions, **gas engines provide the lowest cost of electricity**

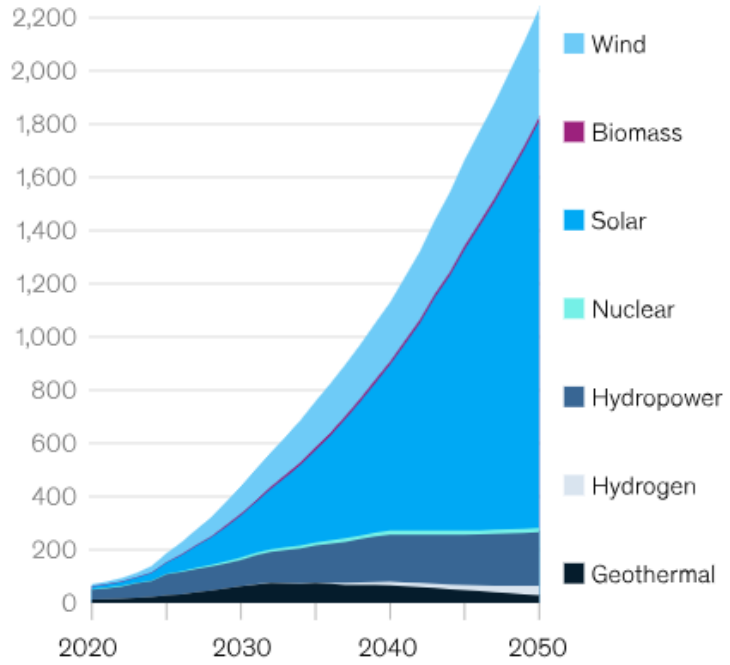
CCGT becomes competitive with gas prices above 18-20 EUR/GJ and high Running hours

WHY IS FLEXIBILITY NEEDED?

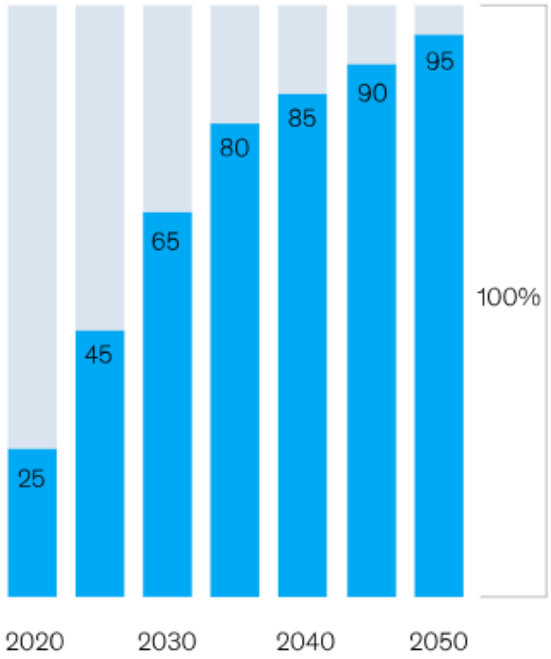
RENEWABLE CAPACITY ADDITION IS AT THE HEART OF AFRICAN ENERGY STRATEGY

Under an 'Achieved Commitments' scenario, the renewable capacity buildup in Africa would significantly accelerate in the next decade.

Projected installed renewable power capacity,[1] gigawatts



Projected installed renewable power,[2] % share of renewables



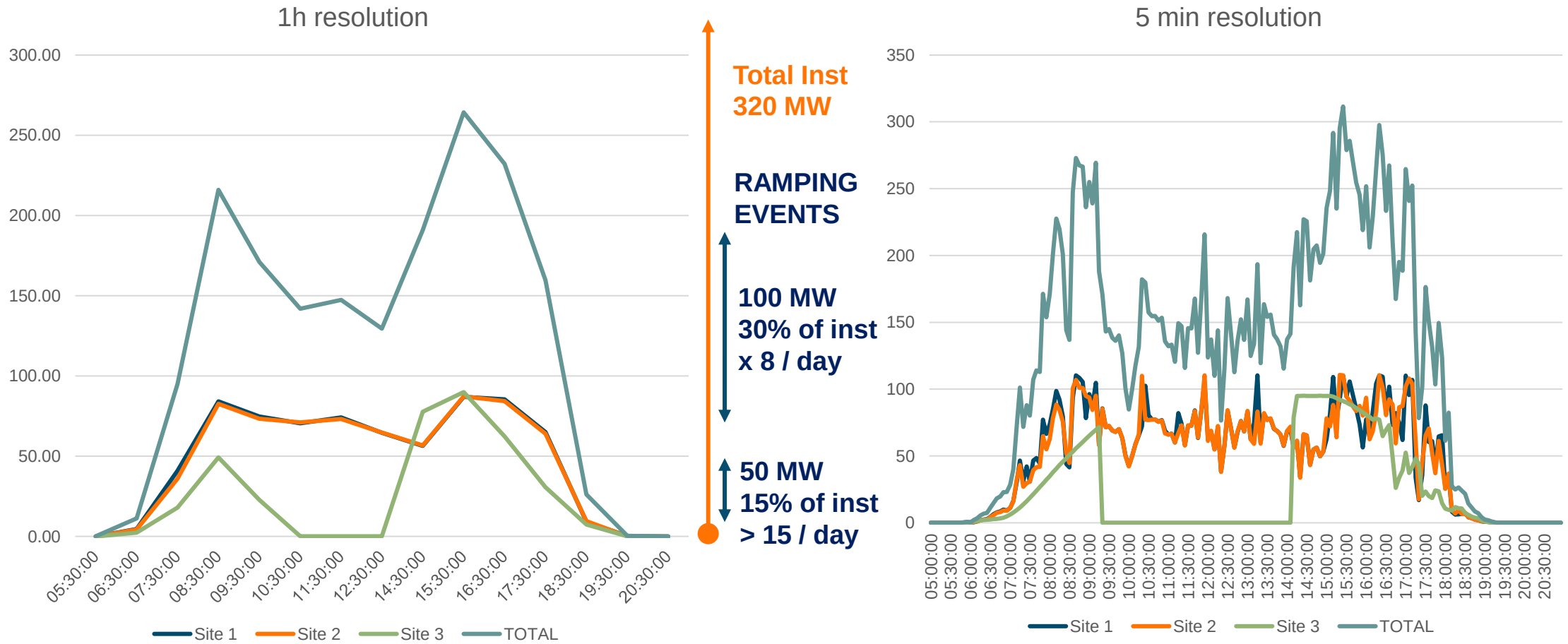
[1]In Africa in Achieved Commitments scenario.
[2]Includes solar, wind, hydropower, biomass, nuclear, geothermal, and hydrogen-fired gas turbines.
Source: Expert interviews; *Global Energy Perspective 2022*, McKinsey Energy Insights; McKinsey Power Solutions

McKinsey & Company

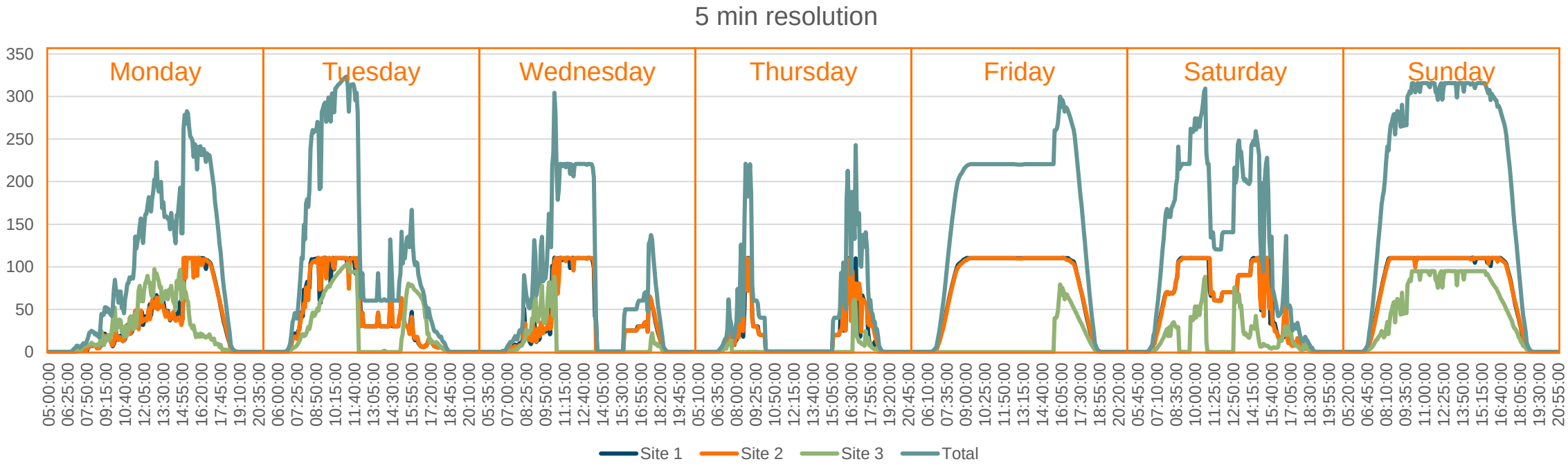
- **Growth in renewable is expected to be exponential within the next 25 years**
- **Solar deployment in Africa could reach 200GW by 2030 while Wind could reach 80GW**

TOTAL VARIABLE RENEWABLE CAPACITY SHOULD REACH 280 GW BY 2030 OVER THE CONTINENT

SOLAR PROFILES AND THE IMPORTANCE OF FLEXIBILITY



ILLUSTRATIVE WEEKLY SOLAR PROFILE



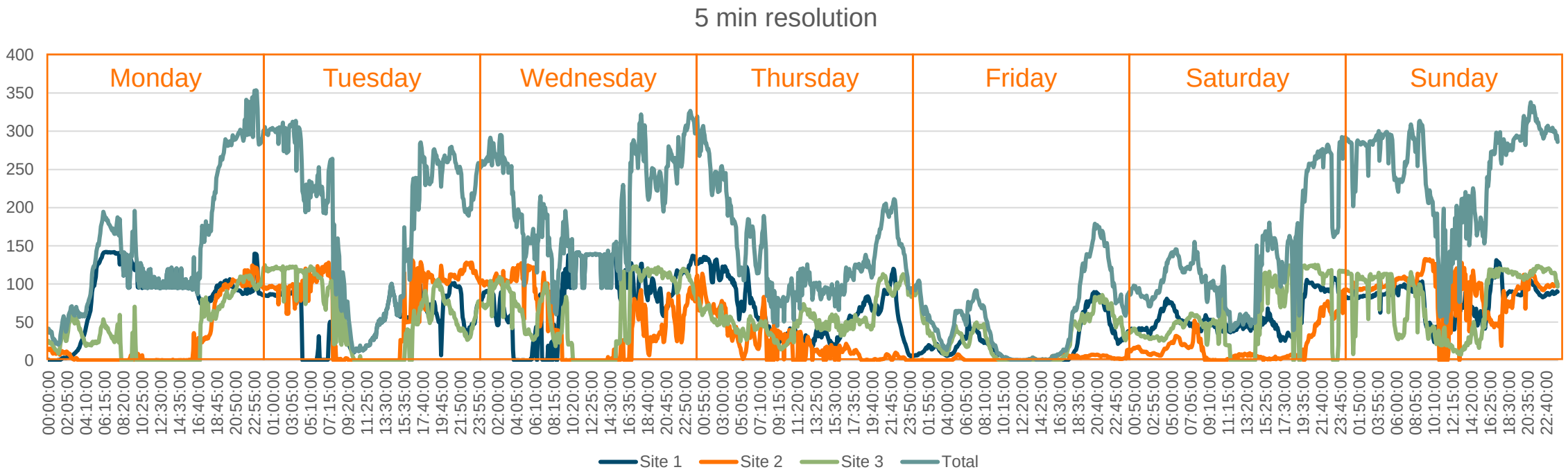
Analysis over a typical week :

Ramping event of 15% of total installed capacity (50MW) => ~30 per week

Ramping event of 30% of total installed capacity (100MW) => ~10 per week

520 - 1560 per year

ILLUSTRATIVE WEEKLY WIND PROFILE



Analysis over a typical week :

Ramping event of 15% of total installed capacity (50MW) => ~30 per week

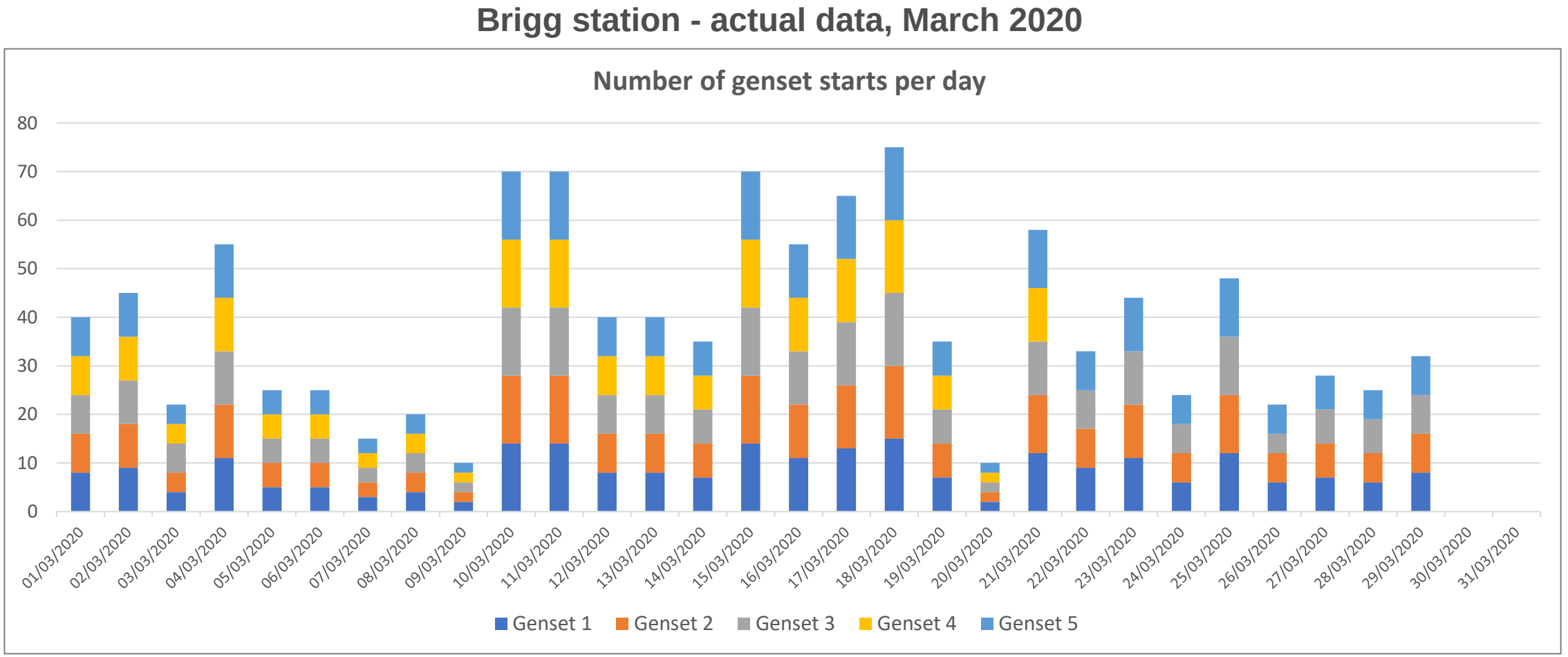
Ramping event of 30% of total installed capacity (100MW) => ~15 per week

780 - 1560 per year

EXAMPLE OF BALANCER IN OPERATION: UNITED KINGDOM

CENTRICA, UK: EACH GENSET STARTS UP TO 15 TIMES A DAY

On average – 7.3 starts per day per genset



AFRICA EXPECTED FLEXIBILITY NEEDS

By 2030 Africa expects to have renewable installed capacity of:

200 GW of Solar PV

80 GW of Wind Turbines

Based on previous slides Africa's need for **Ultra Flexible capacity should be:**

40-80 GW with 750-1500 starts per year

(15-30% of Renewable Capacity)

Source: *McKinsey 2023*

THE WÄRTSILÄ WAY

Wärtsilä Energy in numbers

Globally recognised leader

in engine power plant & energy storage installations

180

Countries delivered to

4 900+

Employees

79GW

Power plant capacity delivered

125+

Energy storage installations

18GW

Installations under service agreements

Engine power plants for reliable energy

Flexible operations

Wärtsilä engines offer superior single-cycle efficiency combined with fast loading and un-loading capability. Engines can quickly ramp up and down as needed to balance the intermittent nature of renewables like solar and wind.

Fuel adaptability

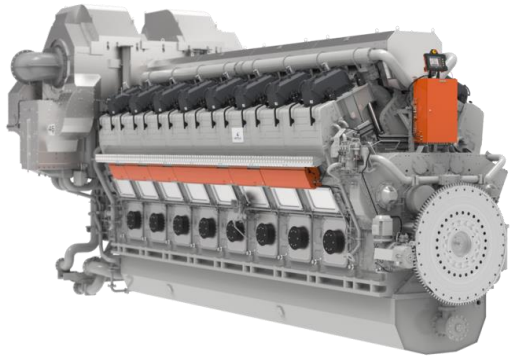
Our engines will operate on sustainable fuels of the future. We can take care of long-term energy storage needs for periods with persistently low wind or no solar conditions. Sustainable fuels
together with engines will enable the final step towards a 100% renewable energy future.

Future-proof solutions

Engine technology is adaptable for the needs of the future. We have successfully run 25 vol% hydrogen blend with an unmodified engine. We constantly evolve our solutions offering to include upgrades, conversions and modernisation options.

OUR ENGINE PORTFOLIO FOR VARIOUS APPLICATIONS AND INDUSTRIES

Wärtsilä 31 portfolio
Most Efficient medium speed Gas or DF engine
9.4 - 11.8 MW platform



Wärtsilä 46TS portfolio
Latest product in portfolio
Largest & most efficient medium speed Gas or DF Engine
20.8 MW platform

Wärtsilä 34 portfolio
Historical medium speed Gas or Dual Fuel engine
7.8 - 9.8 MW platform

Wärtsilä 32 portfolio
Historical medium speed Liquid Fuel engine
7.8 - 9.8 MW platform

Wärtsilä 50 portfolio
Historical medium speed Gas, Dual Fuel or Liquid Fuel engine
18 MW platform

Malicounda - Senegal

Combining the benefits of a flexible, simple-cycle plant with the outstanding efficiency of a combined cycle plant.

Wärtsilä Flexicycle™ power plants combine the benefits of a flexible, simple-cycle plant with the outstanding efficiency of a combined cycle plant. The Flexicycle™ solution is based on gas, multi-fuel, or liquid fuel power plants combined with a steam turbine.

7 x Wärtsilä 18V50, 130 MW output

Baseload power production for the national grid

A 10-year maintenance agreement

Paras Energy - Nigeria

Continuing and long-lasting partnership since 2008

Wärtsilä 34 SG based power plant

14 x Wärtsilä 34 SG medium-speed gas engines

132 MW

Paras Energy is a repeat customer of Wärtsilä. The journey together started back in 2008. Years later, the partnership was strengthened by a 5-year Optimised maintenance agreement (2021)

Sasol New Energy – South Africa

More efficiency and output with new power plant technology

Wärtsilä 34SG based CHP plant

Flexible baseload, steam cogeneration

18 x Wärtsilä 20V34SG - Total output 175 MW

The facility was built to meet SNE’s increased electricity needs while, at the same time, replacing old generating equipment with new and more efficient technology.

The gas engine technology allows SNE to reduce their carbon footprint by more than 40%.


WÄRTSILÄ