

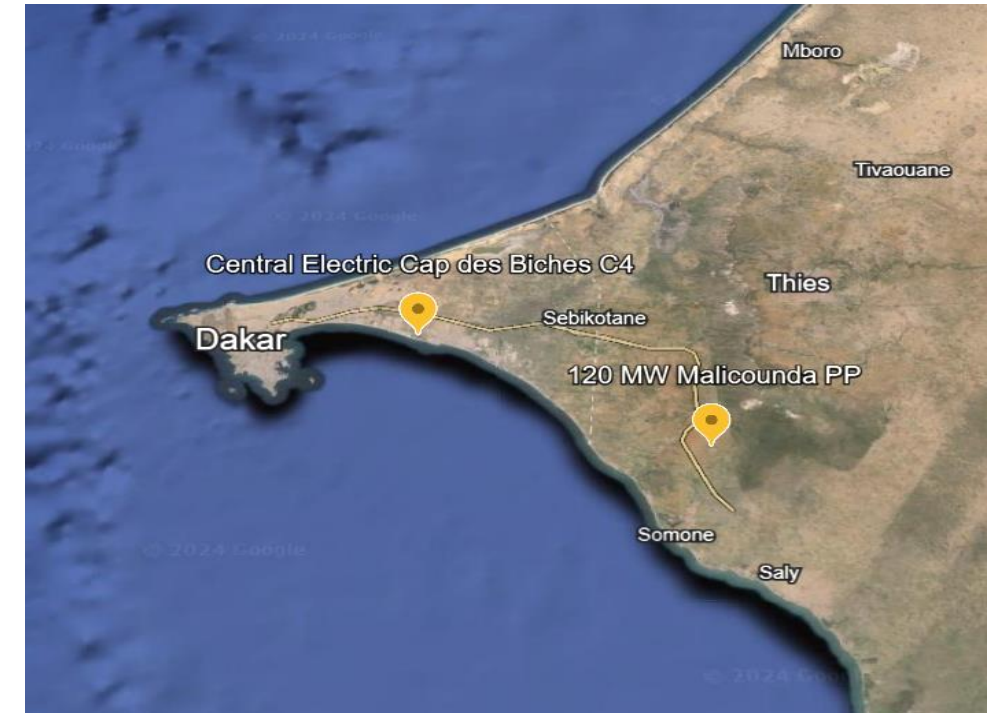
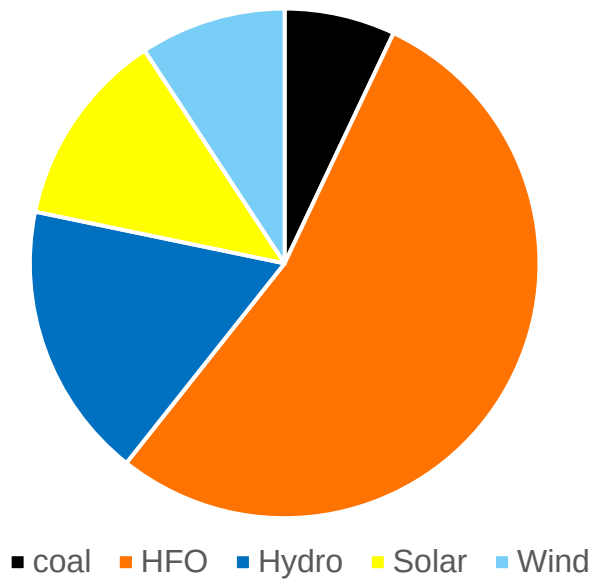


# Malicounda Case Study:

A flexible baseload Wärtsilä solution to help Senegal's energy transition



- National public utility: Senelec
- Total capacity: 1,8 GW
  - 75% thermal
  - 25% Re
  - Wärtsilä 400 MW
- Peak at 1 GW growing 6% yoy
- Malicounda IPP tender launched in 2017  
COD : 08/22
- Next: Just Transition Energy Partnership (JTEP) 40% Re in the energy mix



1. Malicounda Project Characteristics
2. Project calendar
3. Wärtsilä Engine & Flexicycle technology
4. Energy landscape in Senegal / Why flexibility is needed ?
5. Take-aways

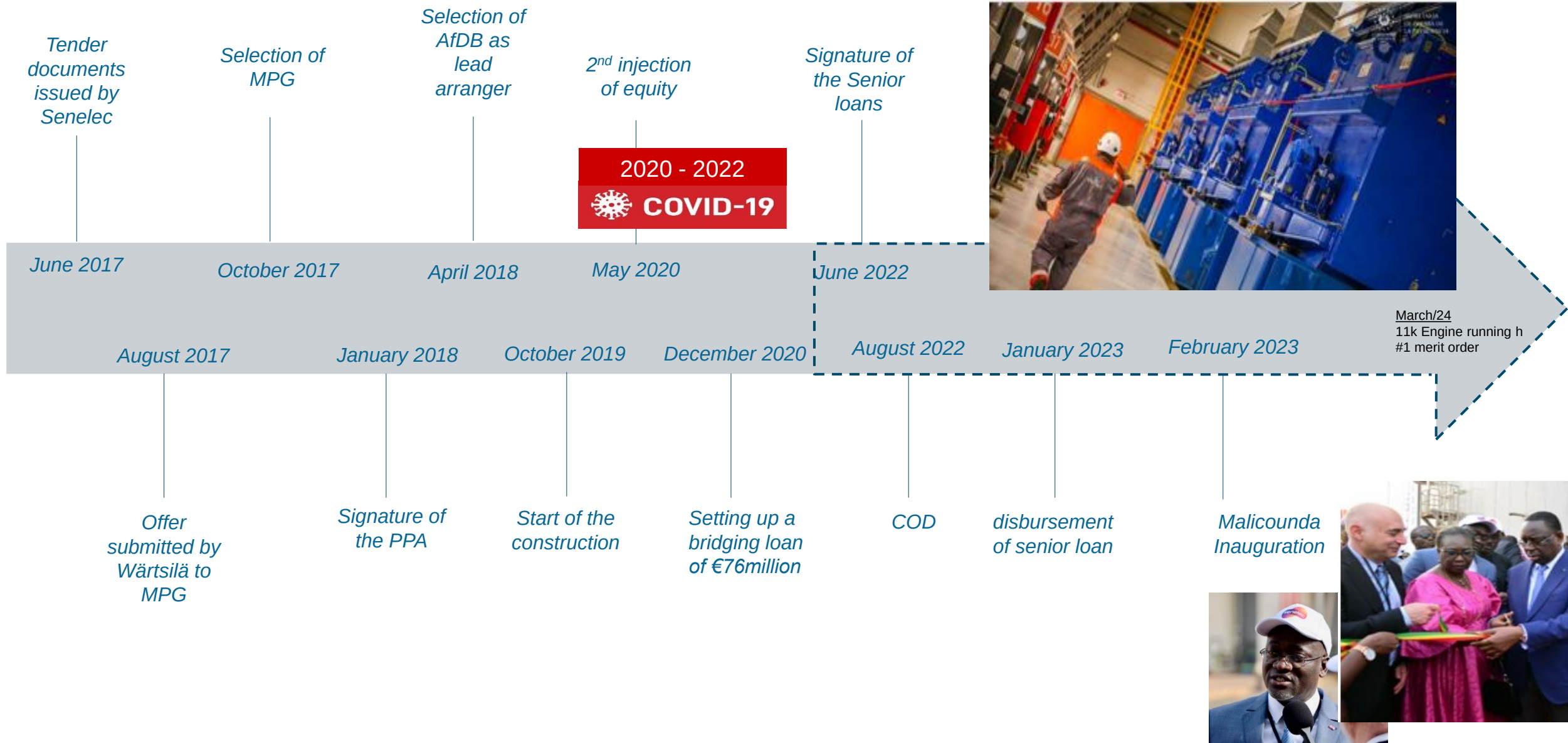
## Plant Profile

- Type: HFO converted power plant under a 20-year BOOT, convertible to gas
- Contracted capacity 120 MW with 91% availability
- Technology: 7 Wärtsilä reciprocating engines 18V50DF + 1 steam turbine  
Net Plant installed capacity 131 MW
- Financing: classic project finance structure with 75% long-term debt provided by DFIs and 25% equity (MPG/AF50/Senelec)
- 10 years maintenance agreement (renewable) with Wärtsilä which guarantees the performance guarantees (in relation to fuel consumption) and capacity guarantees in back-to-back for those provided for under the PPA
- 17% expected increase in Senegal's generation capacity

|                             | Name Plate | <u>Planned</u><br>Operation |
|-----------------------------|------------|-----------------------------|
| Maximum Load                | 100%       | 97%                         |
| Output of one engine (kW)   | 17,995     | 17597                       |
| Number of engines           | 7          | 7                           |
| Output of all engines (kW)  | 125,966    | 123179                      |
| Steam Turbine (kW)          | 9,038      | 7                           |
| Losses and auxiliaires (kW) | 3,182      | 3182                        |
| Net Plant Output (kW)       | 131,822    | 120,004                     |



120 MW HFO thermal power plant convertible to gas



Turbine

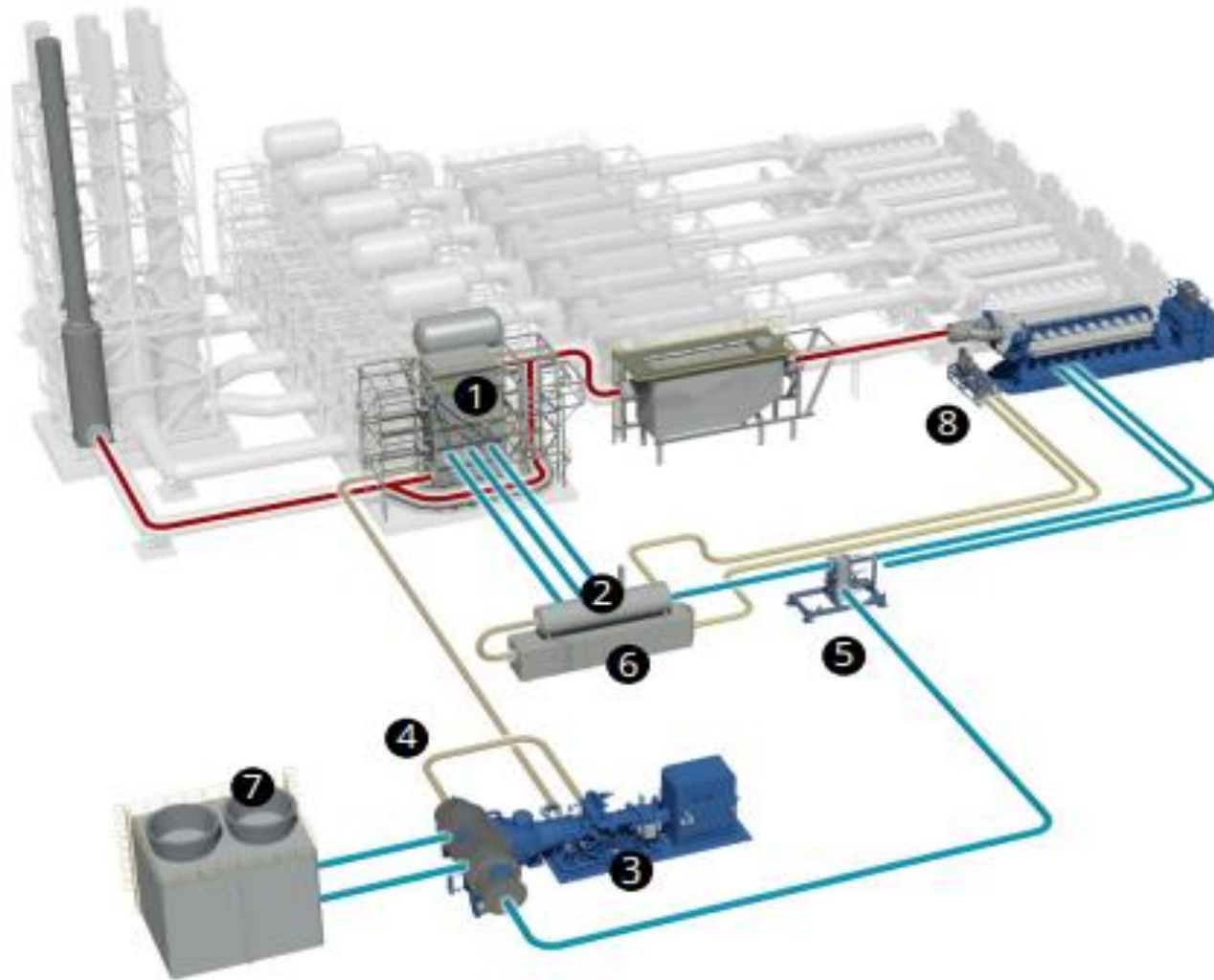


Side view of the 7 boilers



inside view of the engine hall  
(18V50DF engines)





- ① Exhaust gas boiler
- ② Feed water tank
- ③ Steam turbine
- ④ Water cooled condenser
- ⑤ Condensate preheater
- ⑥ Heat recovery container including auxiliary boiler
- ⑦ Cooling tower
- ⑧ Engine preheater

## INDICATIVE PERFORMANCES OF WÄRTSILÄ FLEXICYCLE

|                                        | 7 * 18V50DF + CC<br>running with HFO (42,7 kJ/kg) | 7 * 18V50DF + CC<br>running with gas | Compared to 7 open cycle engines |
|----------------------------------------|---------------------------------------------------|--------------------------------------|----------------------------------|
| output, engines (kW)                   | 126                                               | 123,7                                |                                  |
| Outout, ST (kW)                        | 9                                                 | 10,7                                 | + 9 MW gross output              |
| Own consumption (kW)                   | 3,2                                               | 2,6                                  |                                  |
| <b>Guaranteed Output, net kW at HV</b> | <b>131,8</b>                                      | <b>131,8</b>                         |                                  |
| Heat rate based on LHV                 | 7754                                              | 7328                                 |                                  |
| Efficiency, based on LHV               | 46%                                               | 49%                                  | +3% better                       |

Cos Phi 0,9 at site conditions

- Fuel flexibility with the DF – hedging against late gas arrival
- The plant is expected to help satisfy baseload, facilitating the integration of intermittent RE power into the country's network.
- When converted to gas the plant is expected to form part of the evolution of Senegal's energy mix from diesel (currently about 75% of total generation capacity) to renewables, thus considerably reducing emissions.

## MODULARITY ENABLES HIGH EFFICIENCY AT LOWER LOADS

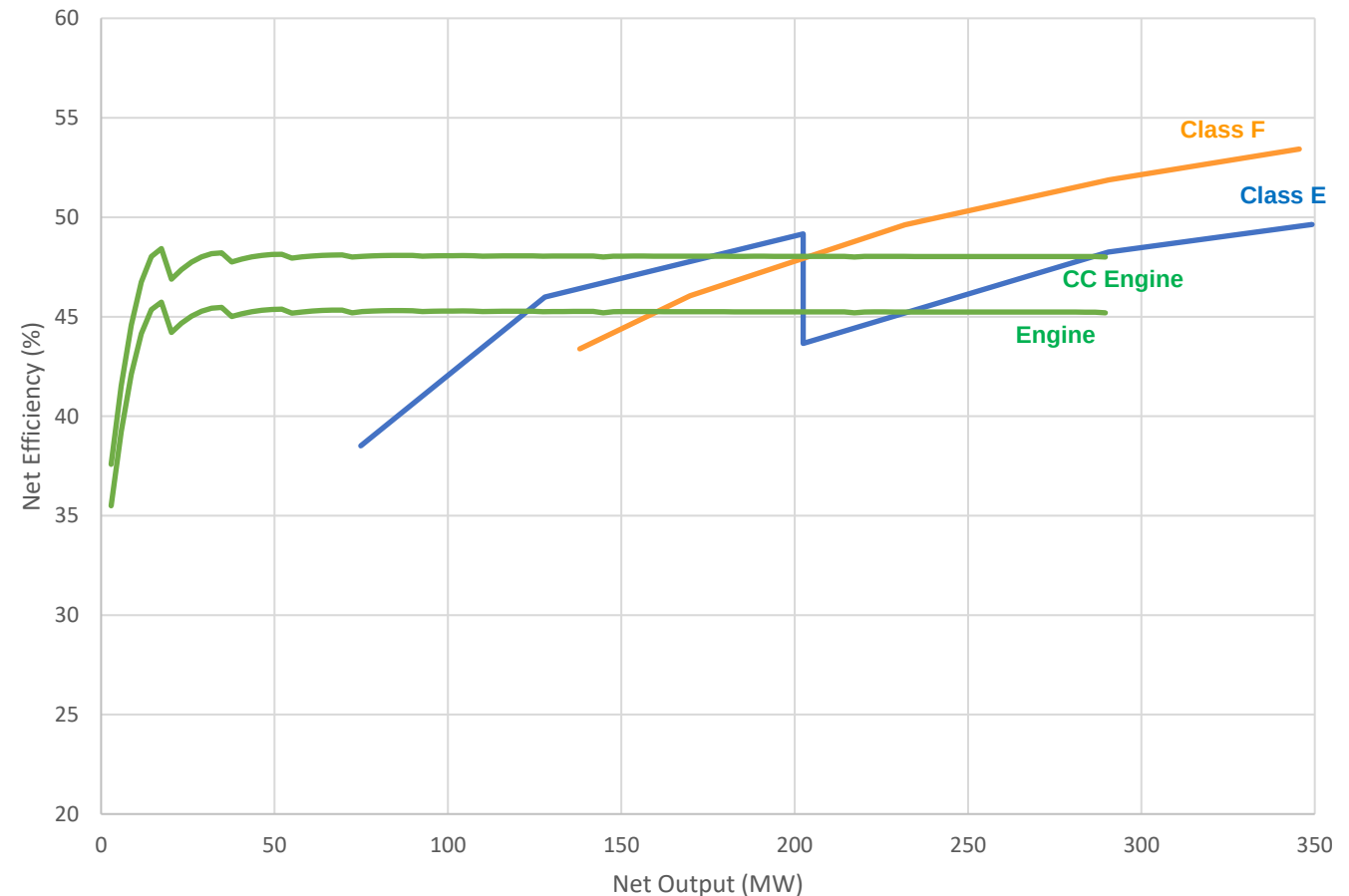


With increasing renewable on the grids, power plants must ramp up and down to match the varying demand.

### 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

Efficiency calculated at T°: 28°C ; Relative humidity: 60%

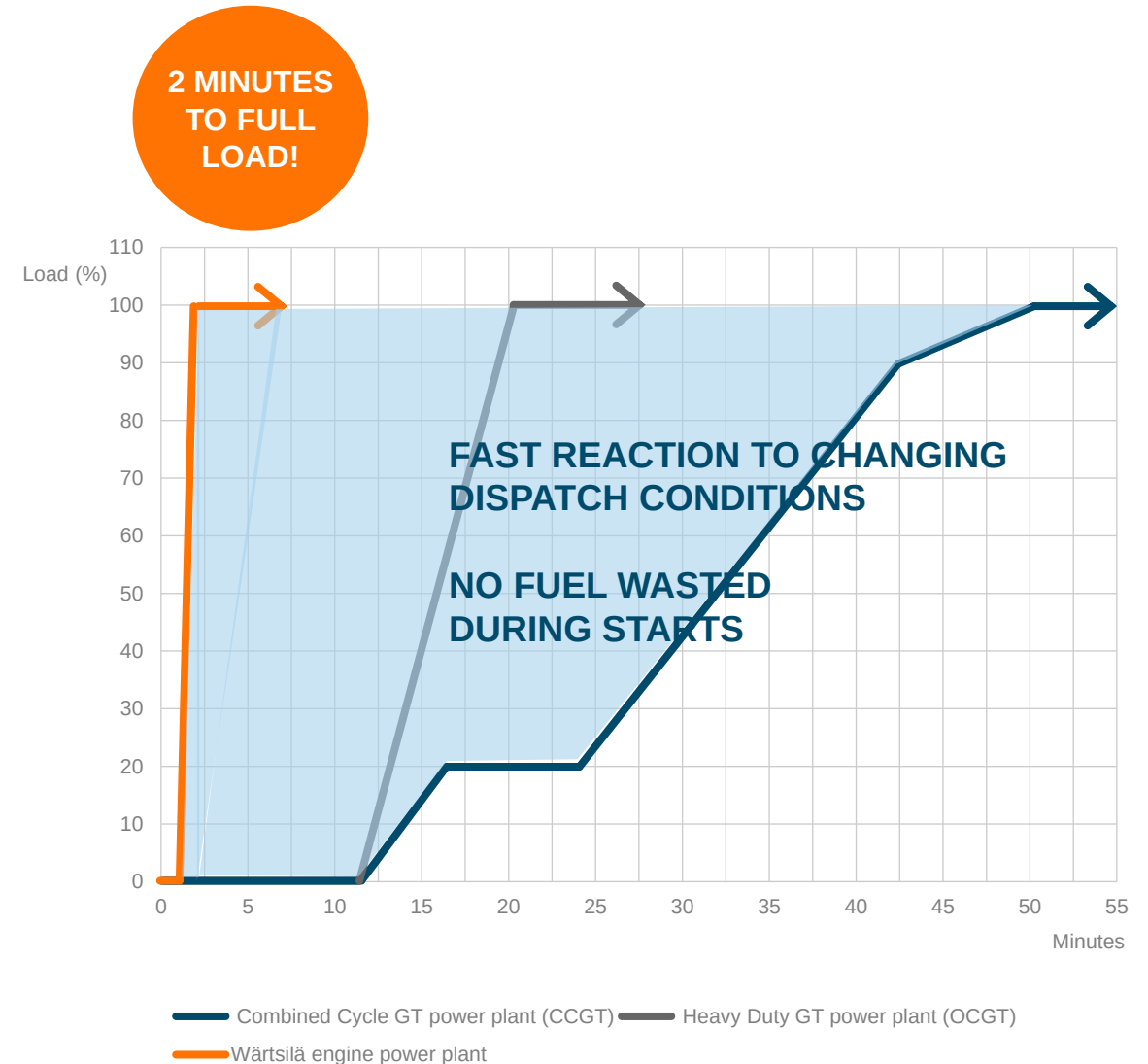


## WÄRTSILÄ QUICK START-UP HAS SEVERAL BENEFITS

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.
- **No start-up costs**

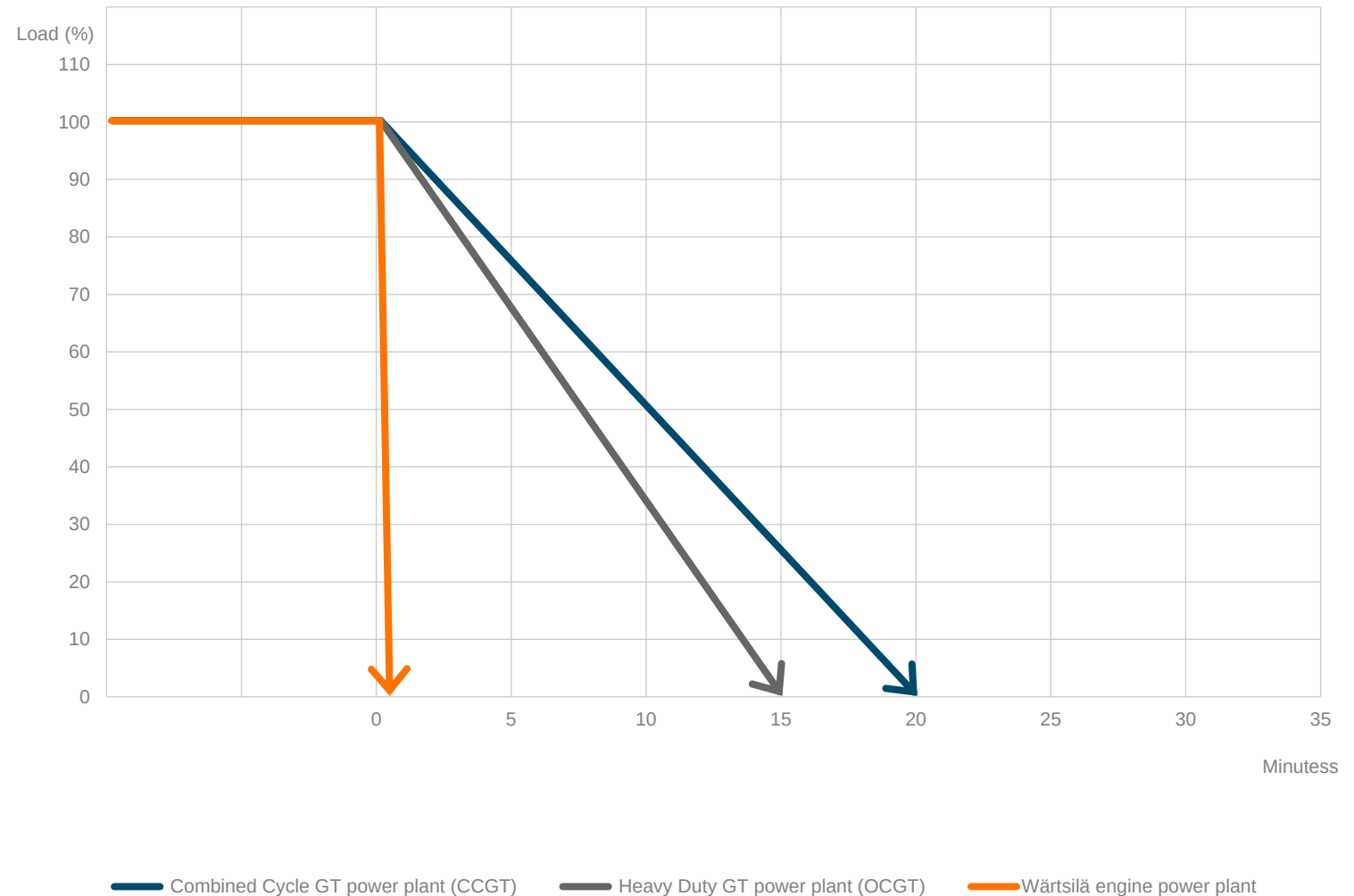
**Wärtsilä engines can ramp up at over 100%/minute, much faster than gas turbines, providing ultra-responsive power that is needed to integrate renewable energy and maintain the stability of the grid.**



## SWITCHING OFF ENGINES TAKES VERY LITTLE TIME

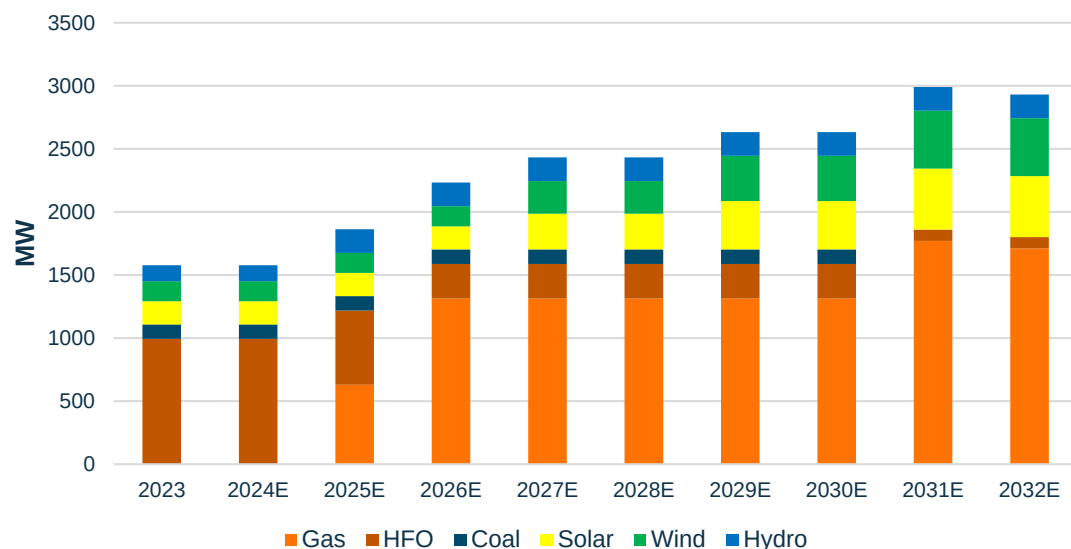
- Engine power plants can be switched off immediately after the wind starts blowing or the sun starts shining
- Enables reacting to sudden changes in the demand
- Allows for several start-ups and stops per day
- No fuel is wasted when power is not needed

**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.**



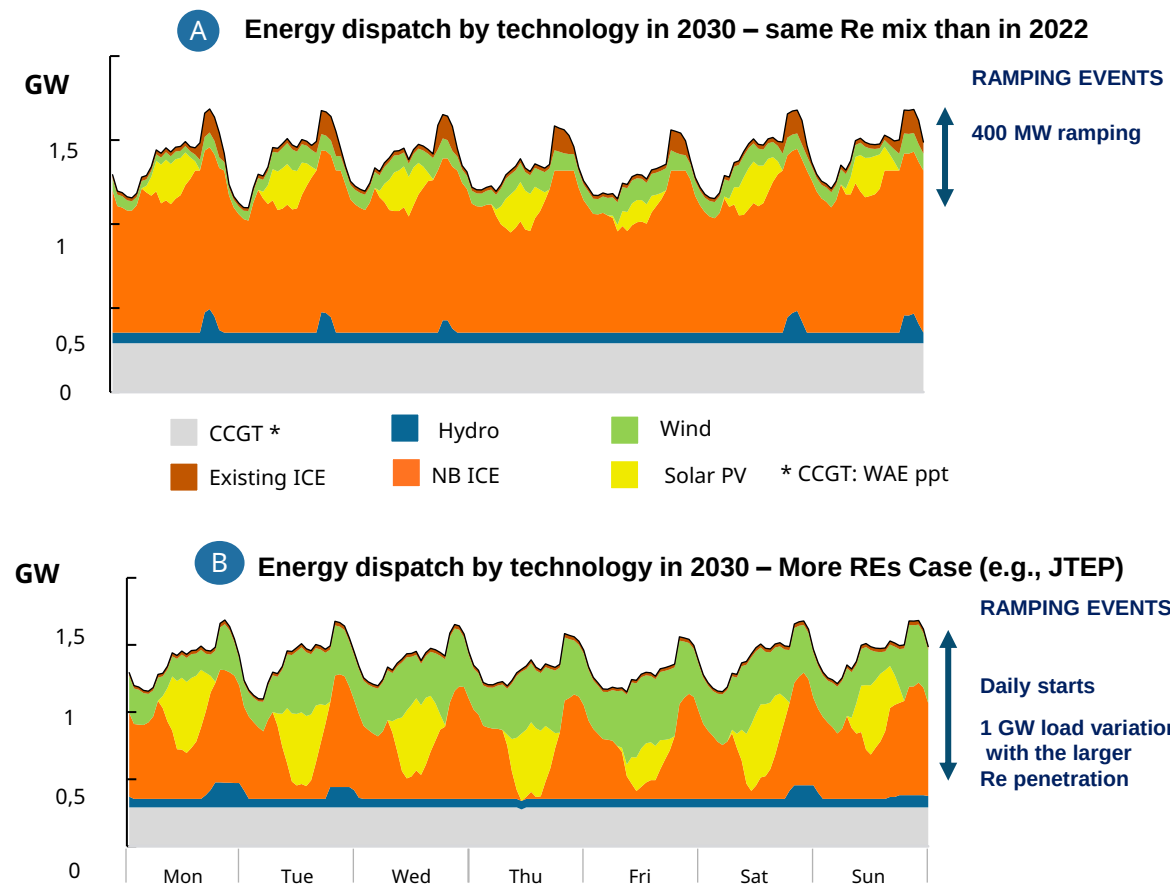
The more renewables are added, the more the flexibility is needed

Total Capacities deployed per energy form



- JTEP's target: 40% Re in the energy mix to cut CO2 emissions (30% less)
- Import of LNG & Large gas discoveries off the cost of Senegal
- Phasing out of HFO thanks to gas conversions of existing power plants & new gas power plants

Plexos modelling of Senegal's grid



- Experienced developer (Melec) with good local presence and strong local partner (Senelec) to drive through uncertain time (covid) with a long-term view
- Use of Wärtsilä's cost-optimized technology combining security of supply with a commitment to support the energy transition in Senegal:
  - Today, running base
  - Tomorrow, running with gas
  - **and with the engine flexibility features** well suited to supporting the Senegalese grid systems that will have a significant installed base of solar and other non-dispatchable power.

**MALICOUNDA HAS A PIVOTAL  
ROLE FOR THE ENERGY  
TRANSITION IN SENEGAL**





**WÄRTSILÄ**