steward redqueen

Power and Jobs in Cape Verde

Final result

September, 2018

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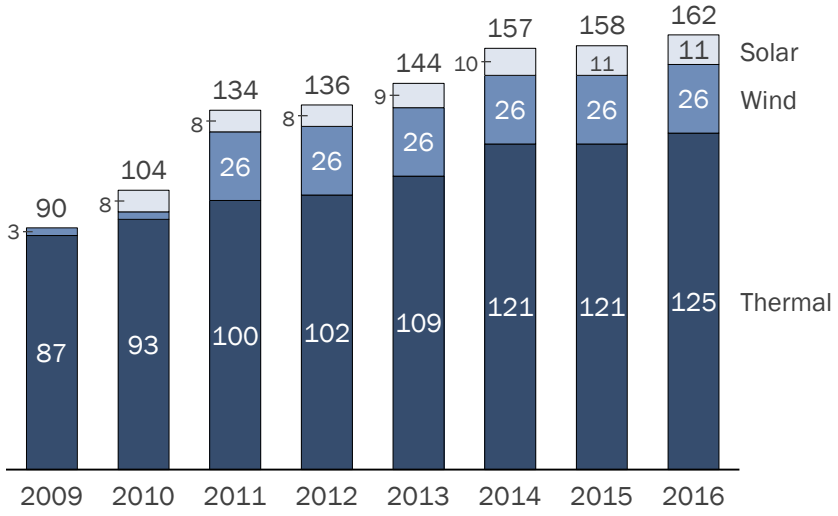
1	Power sector overview
2	Impact via price pathway
3	Impact via outage pathway
4	Impact from operations
5	Conclusions & recommendations

Renewable energy generation, in particular wind power, has changed the energy mix of Cape Verde

Installed capacity over time (MW)



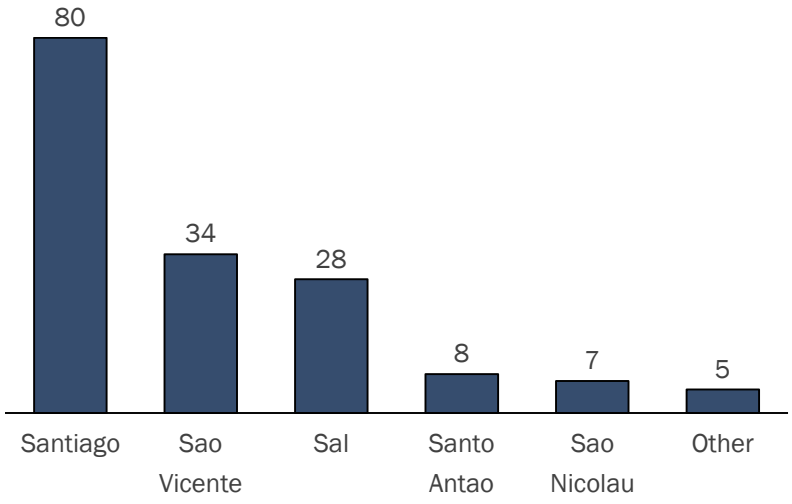
Total installed capacity in 2016 was 162 MW, while disposable capacity is 68 MW

Solar and wind power reached 23% of capacity in 2016

The increase is largely due to Cabeolica, the largest renewable energy producer with 25.5 MW wind capacity

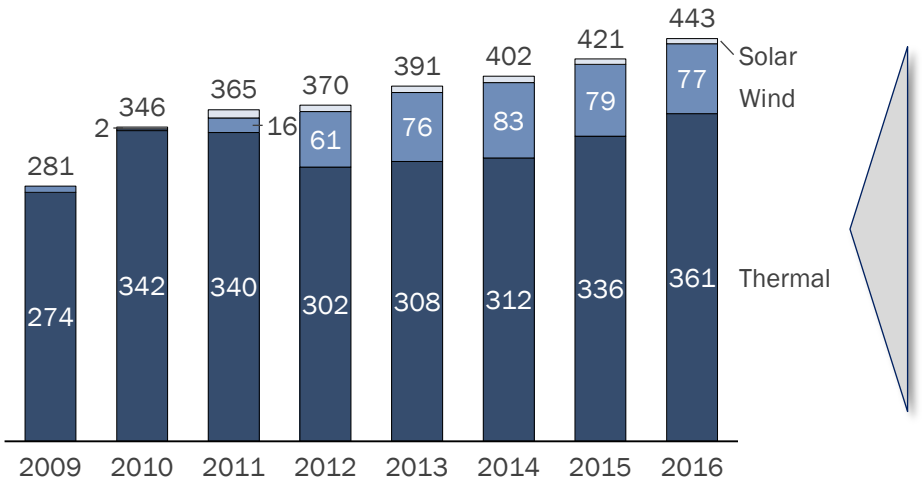
The majority of power is on the island of Santiago, where the capital, Praia, is situated and where more than half of the population live.

2016 Power Capacity by Island (MW)



While generation is growing, per capita growth has been relatively stable

Generation over time (MWh)



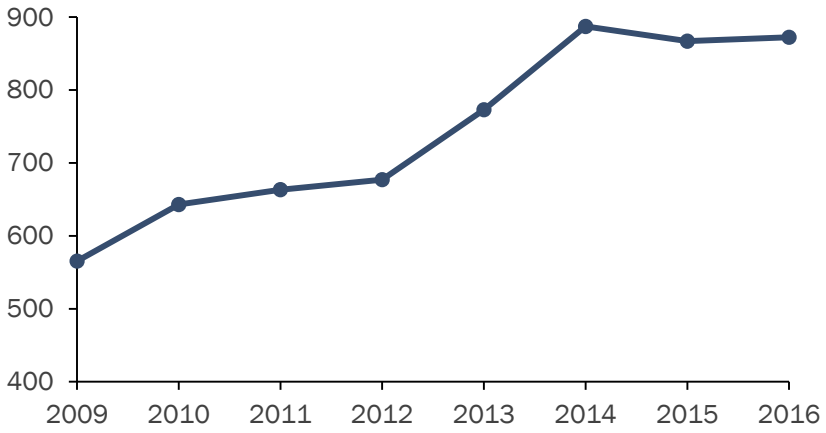
Total power generation was more than 440 GWh in 2016

Average annual growth has been about 5.3%

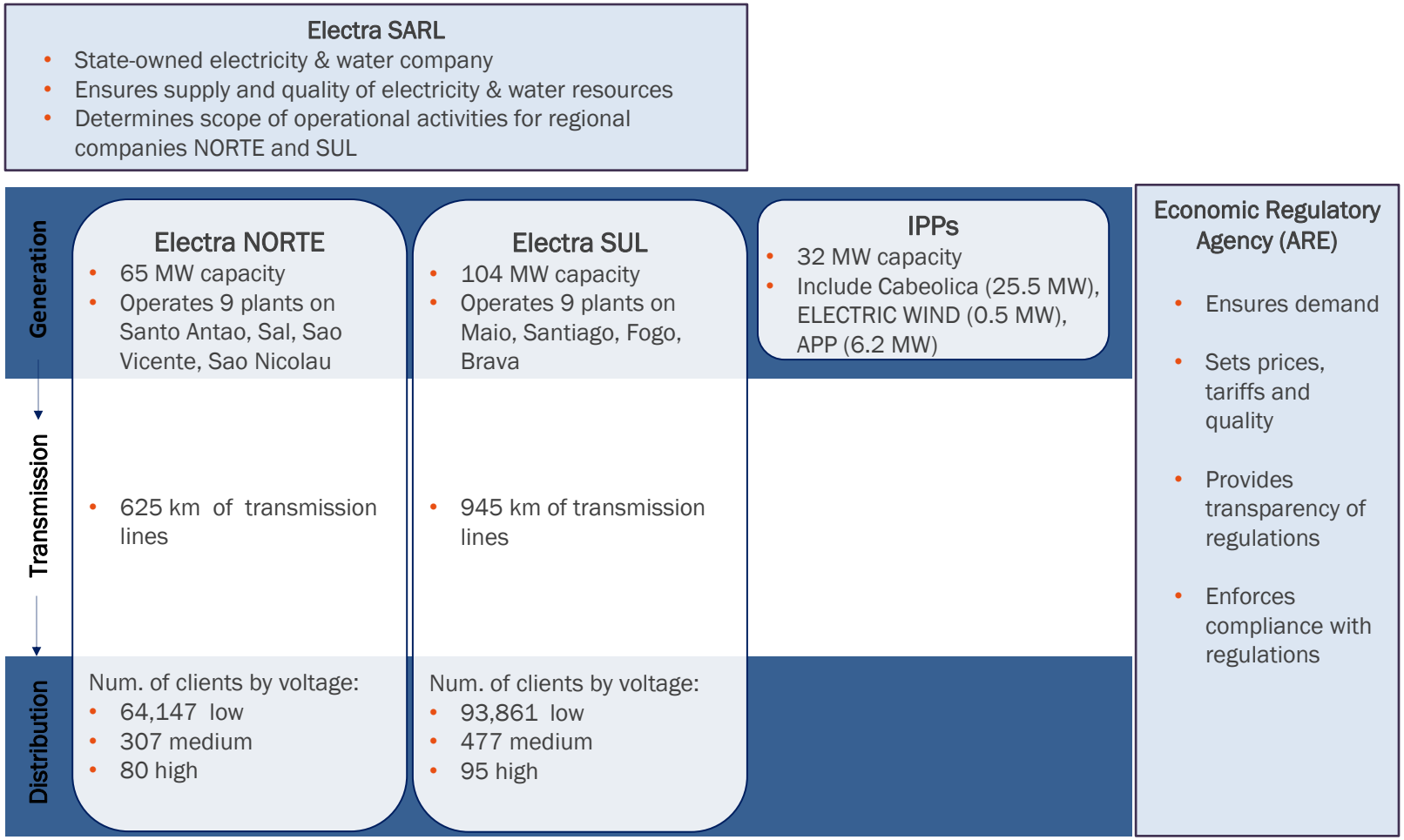
Per capita power consumption grew by more than 50% from 2009 to 2014 (from 565 to 887 kWh)

However, per capita consumption has been relatively stable since 2014

Power consumption per capita (MWh)



Electra is the dominant provider of electricity and water although each island operates an independent grid



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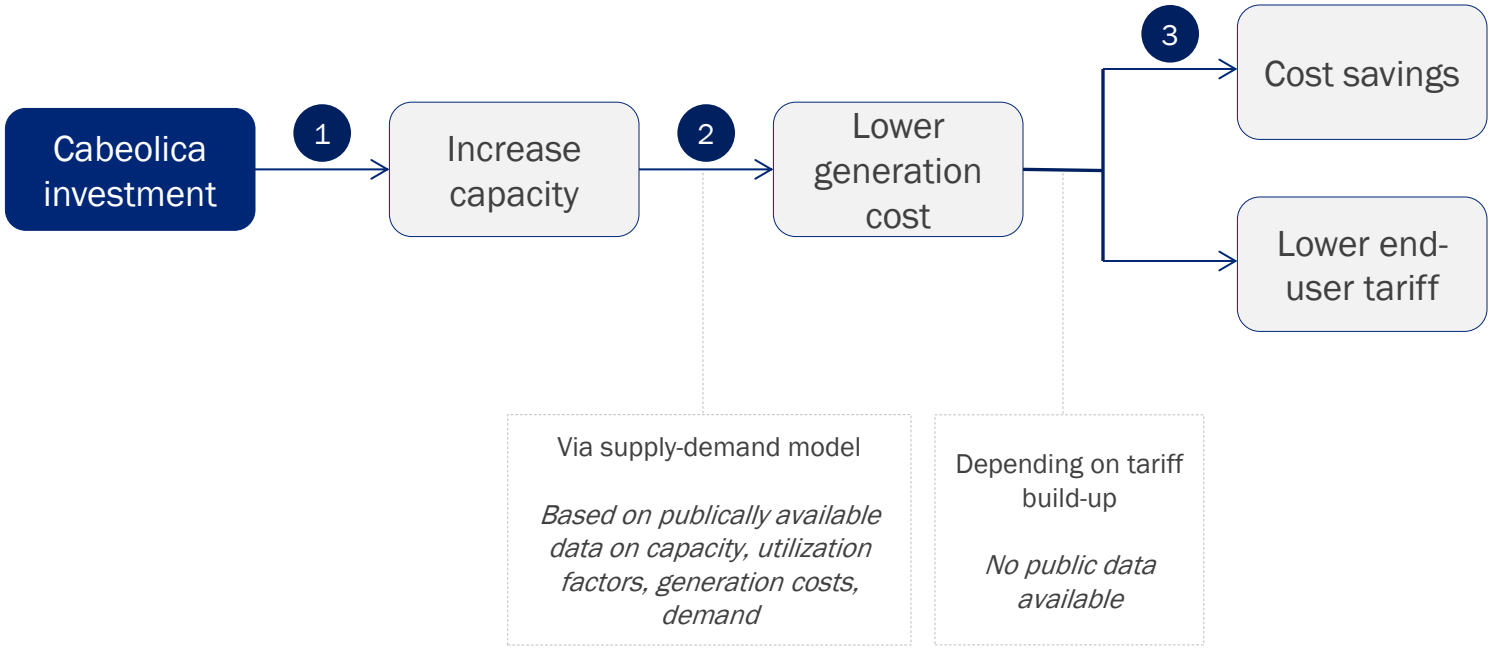
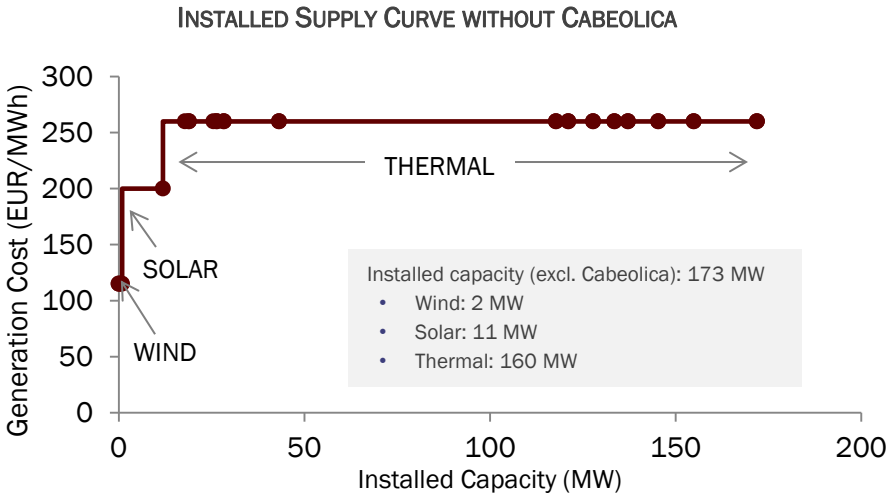
Decrease in electricity costs could alleviate costs for the government



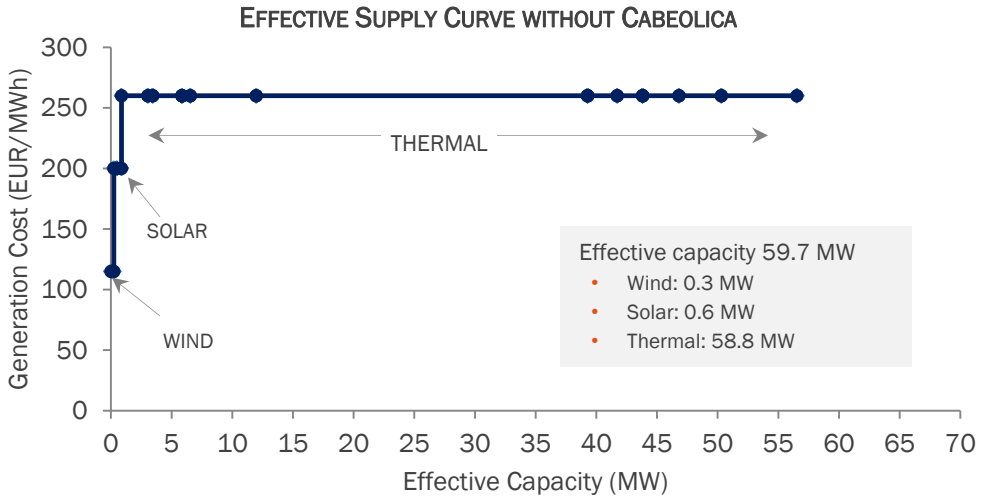
We start by constructing Cape Verde's supply curve in the absence of Cabeolica to establish a counterfactual



A power supply curve ranks all power plants side by side based on dispatch order commensurate with their capacity (in MW). It gives the cost of electricity generation for each plant based on technology.

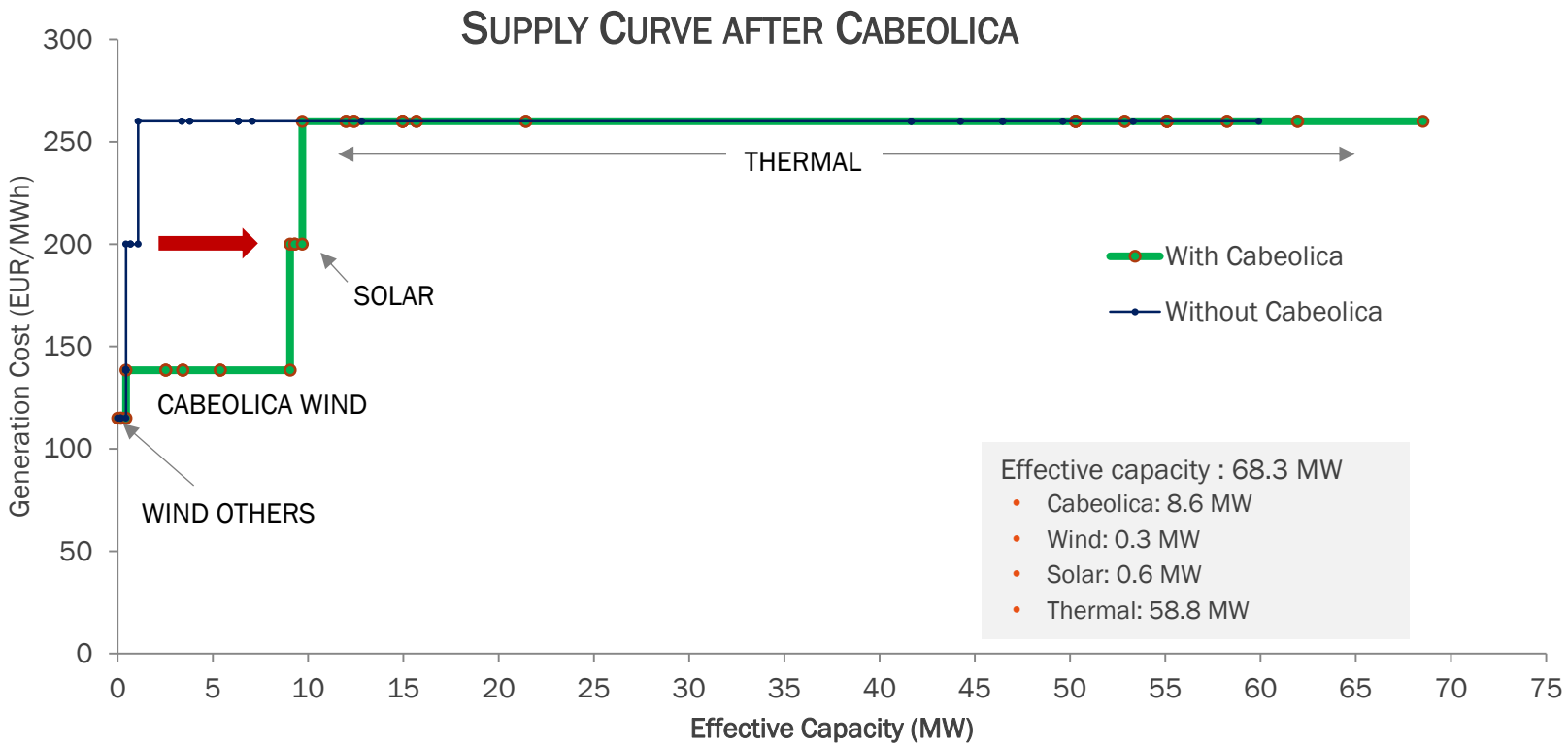
When adjusted for utilization rate, the supply curve shows the effective power generation fleet of Cape Verde.

Thermal accounted for nearly 98% of the effective capacity before Cabeolica.



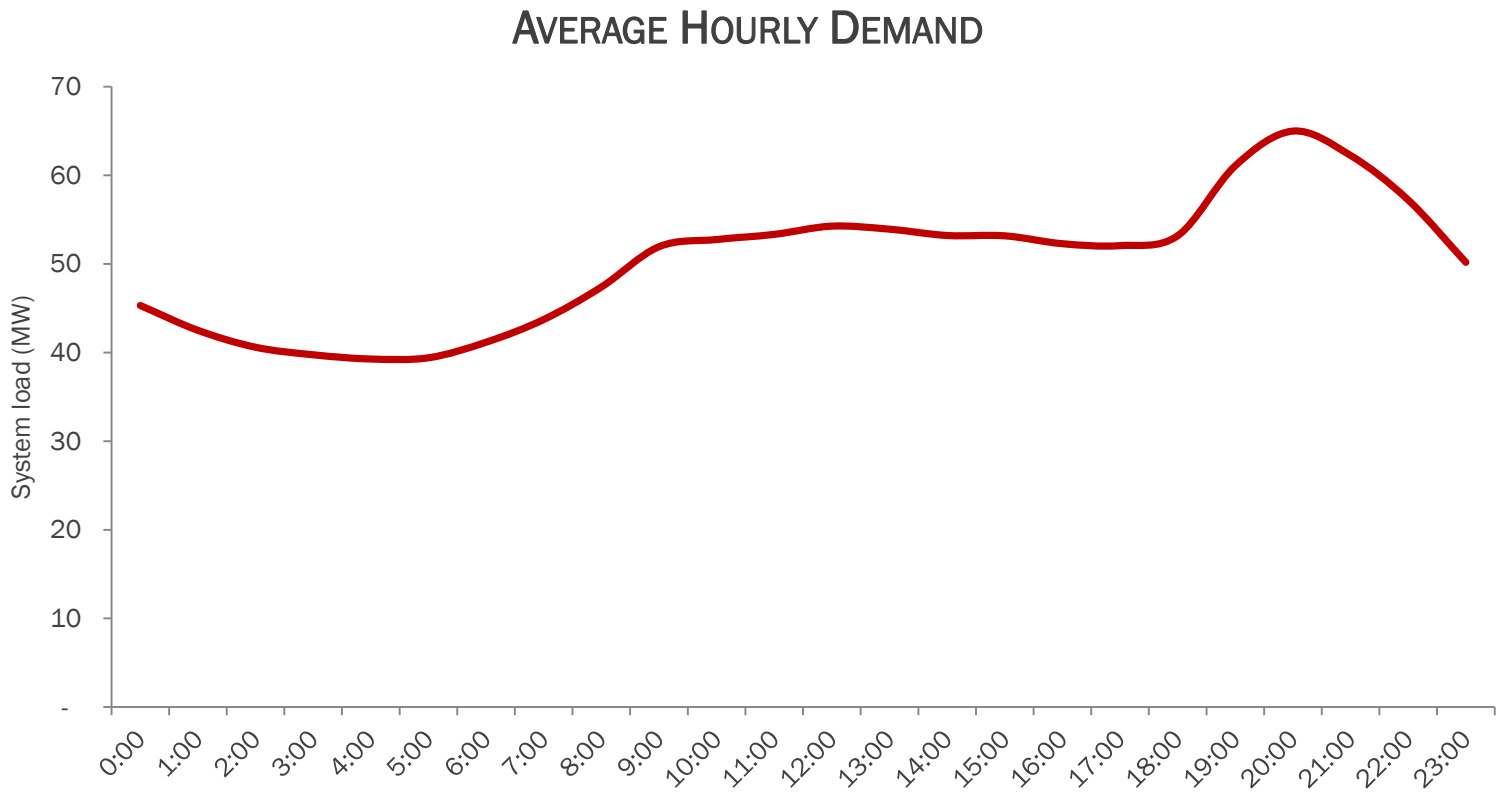
Note: Dots in the graph separate the various power plants

Cabeolica added 8.6 MW of effective capacity, reducing the relative share of thermal to 86%

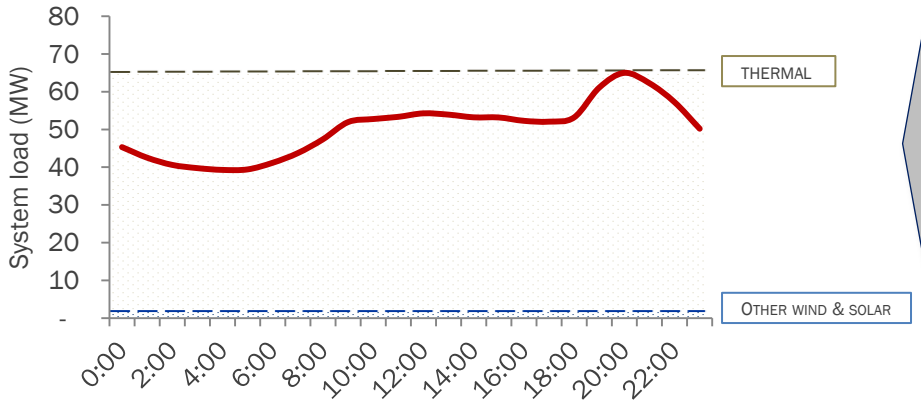


Note: Dots in the graph separate the various power plants

Average daily peak demand in 2016 was 68 MW



Juxtaposing 2016 demand to supply with and without Cabeolica shows the wind farms lowered gen. costs

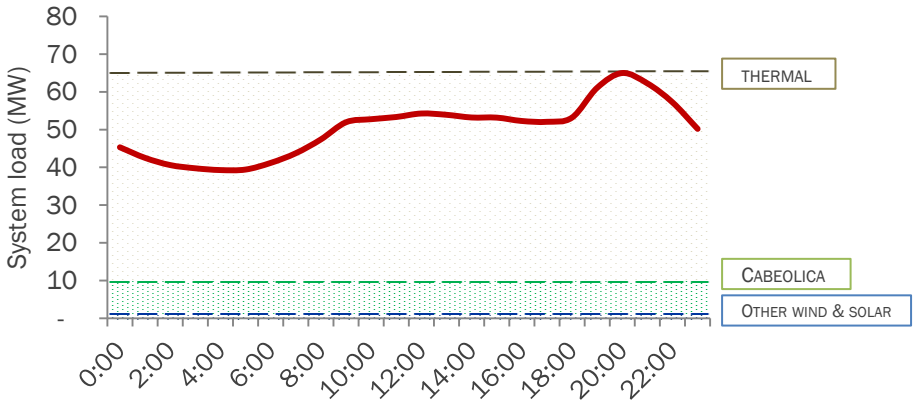


Without Cabeolica, the daily demand would be almost entirely met by thermal capacity, which results in high average cost of generation.

Estimated weighted average generation cost:
EUR 0.26 per kWh

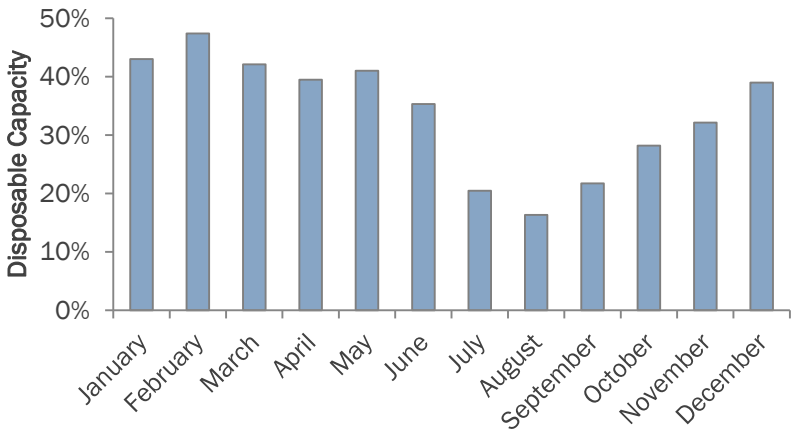
With Cabeolica, a larger part of demand is met by wind capacity. Cheaper renewable technology replaces parts of the expensive thermal supply.

Estimated weighted average generation cost:
EUR 0.24 per kWh



The Cabeolica capacity is estimated to decrease the weighted average generation cost by 7.7%
(from EUR 0.259 per kWh to EUR 0.239 per kWh)

The price effect is more pronounced in the months with the highest wind intensity

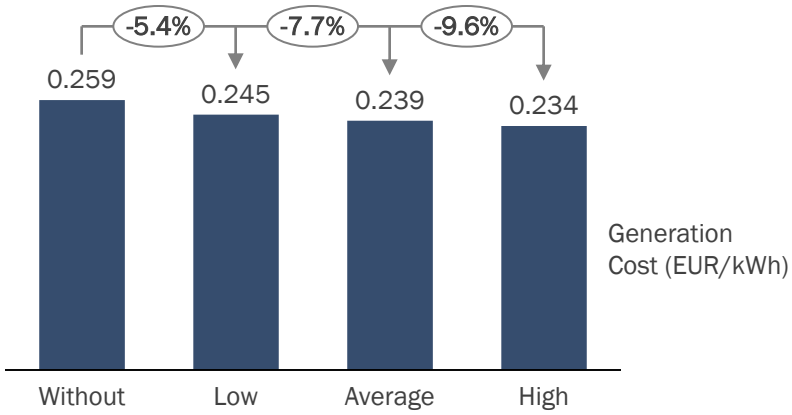


Source: Cabeolica, average for all wind farms

During the months with high wind intensity (Dec- Jun), the capacity factors of Cabeolica's wind farms are higher, meaning that the disposable capacity is higher (and v.v. during the low wind intensity months).

Disposable capacity goes from 6.0 MW in the low-wind months to 10.7 MW in the high-wind moths.

As a result, the generation cost effect in low-wind months is -5.4% versus -9.6% during the high-wind months.



Despite decrease in generation cost, it is questionable if and to what extent end-user tariffs will come down

2
3

The end-user tariffs are set by Economic Regulation Agency (ARE) and are below cost-recovery levels

There is little data on the exact structure of the tariff (such as T&D margins, level of subsidies), making it impossible to determine if and how end-user tariffs will decrease following a decline in the generation costs

Nevertheless, the decrease of unit generation prices of €0.26 to €0.24 means final tariffs have come closer to cost-reflective levels. This improved the financial situation of Electra, by reducing the financial burden on the state.

In addition, the replacement of thermal by wind capacity has the following effects:

- Displacement of approximately 17 million litres of fuel used for thermal generation in 2016, valued at €10.6 million (22.2% of total fuel imports, or 2.1% of the country's trade balance)
- Avoidance of 58.7 kt CO_2 emissions in 2016, or approximately 12% of Cape Verde's total emissions

[1]Based on 2015 tax revenues of CVE 30,043 million, or EUR 271.8 million (OECD)

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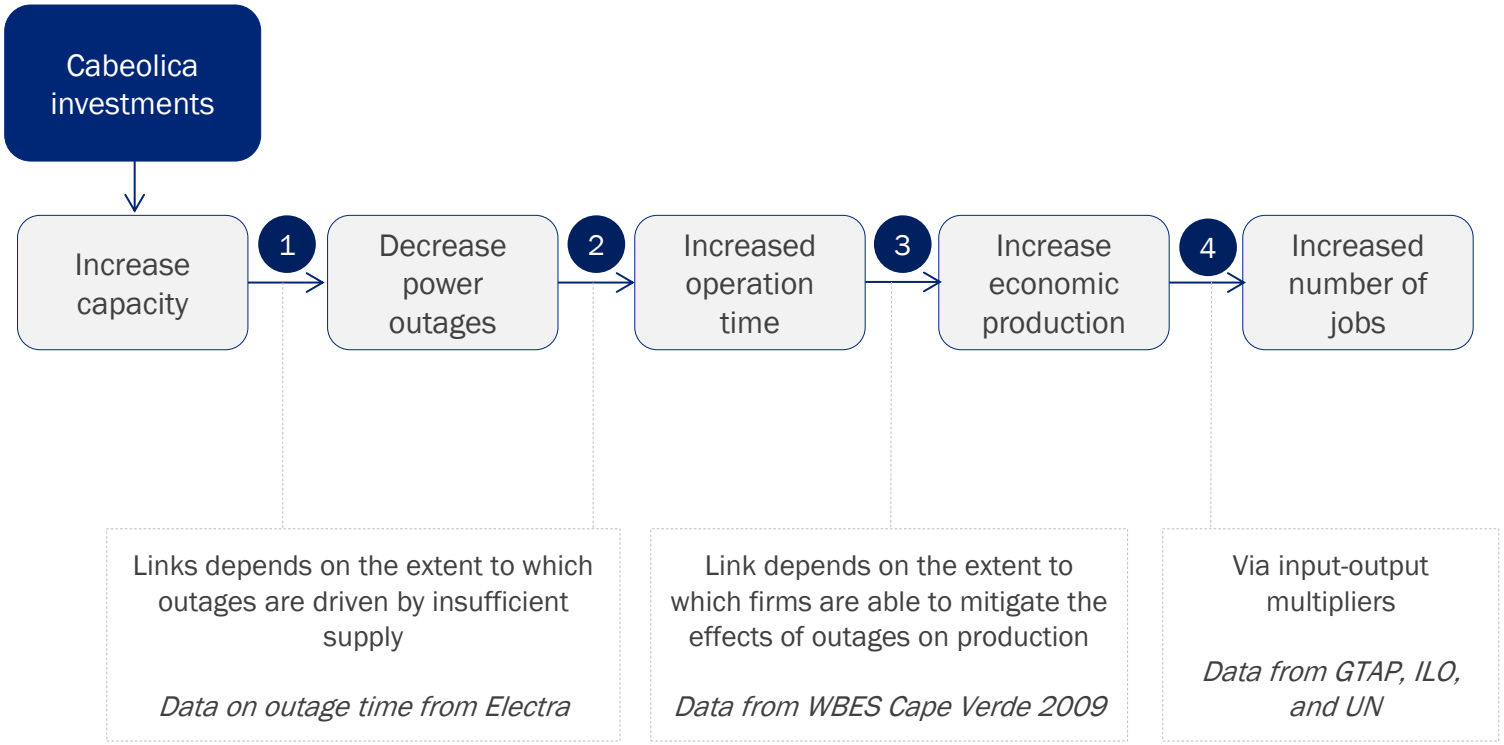
New capacity can decrease outage time, allowing firms to increase operation time and production



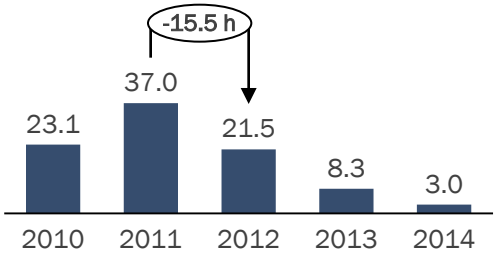
Due to lack of detailed outage data, we attribute the change in outages to Cabeolica in two ways

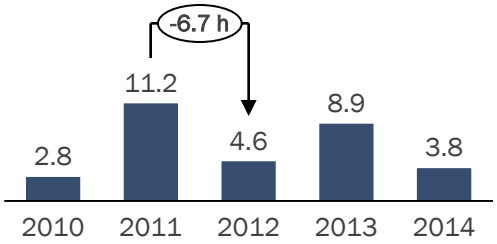
REASONS FOR OUTAGES	Outages occur for different reasons (insufficient capacity, T&D maintenance, network faults)
COMPLICATION	There is no available data detailing the share of and change in outages from load shedding
SOLUTION	Hence changes in outages (and the resulting change in operation time) are attributed to Cabeolica in two ways
SAO VICENTE, SAL, BOA VISTA	Changes are entirely attributed to Cabeolica given • The large share of total capacity added by Cabeolica • The fact there were no other substantial developments in the power sector
SANTIAGO	Changes cannot be entirely attributed to Cabeolica given • Completion of the expansion of a thermal plant in Palmerejo by Electra (22 MW) in mid-2012 • Investments in refurbishment/extension of substations and transmission lines done by Electra

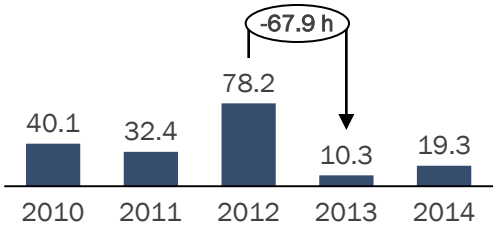
These interventions make the attribution to Cabeolica in Santiago complex. In absence of precise data on outages by cause, we use a range of 25% to 46%[1] to attribute the change of outages to Cabeolica

[1]The upper limit (46%) is based on the contribution of Cabeolica to the new supply on the island in 2012, taking into consideration that the thermal plant was only completed in mid-2012, therefore we only take 11MW of capacity as added in that year

Electra reports on the annual total number of outages experienced per island







DATA NOT AVAILABLE

Santiago

- Cabeolica's wind farm started operations at the end of 2011
- The farm added 12% to the island's disposable capacity
- Outages decreased from 37 to 21.5 hours between 2011 and 2012, of which between 4 and 7.2 hours (5.5 on average) can be attributed to Cabeolica.
- The decrease in outage hours translates into an increase in operation time between 0.14% and 0.25% (an average of **0.19%** used in this report) for firms which can be attributed to Cabeolica.

Sao Vicente

- Cabeolica's wind farm started operations at the end of 2011
- It added 20% to the island's disposable capacity
- Outages decreased from 11.2 to 4.6 hours between 2011 and 2012
- The nearly 7 hours drop in outages translates into **0.23%** increase in operation time for firms

Sal

- Cabeolica's wind farm was inaugurated in Feb 2012, but 2013 was the first year of full commercial operations
- The farm added 24% to the island's disposable capacity
- Outages decreased from 78.2 to 10.3 hours between 2012 and 2013
- The 68 hours decrease in outages translates into **2.4%** increase in operation time for firms

Boa Vista

- Cabeolica's wind farm was fully operational since July 2012
- The farm accounts for half of the island's power generation capacity
- There is no available data on outage time since the island's network is under private administration
- Therefore for Boa Vista we apply a multiplier on increase in operation time resulting from 1% increase in capacity from the other islands (0.05%), resulting in **5.25%** increase in operation time

[1] Average increase of operations time from other islands in 0.052% per 1% increase in capacity; calculation is 100%*0.052/1%

The relationship between increase of operation time and sales growth varies per sector

For the analysis, we will work with the average of the operation time increase of the four islands (weighted for their GDP contribution to the national economy), estimated at 0.58%[1]

The extent to which firm output is affected by changes in outages/operation time can vary between firms

- *Gain in sales > gain in operation time* if firms incurred extra costs from outages, e.g. restart costs, equipment damage, spoilage of raw materials
- *Gain in sales < gain in operation time* if firms are able to mitigate the effects of outages, e.g. by working without electricity or rescheduling production

We estimate average mitigation factors using reported firm data from the World Bank Enterprise Survey

- Manufacturing firms: 0.4
- Service firms: 0.3

$$\text{FACTOR} = \frac{\%\ \text{SALES LOST}}{\%\ \text{OUTAGE TIME}}$$

This means that the increase in operation time of 0.58% translates into increase of economic output of

- Manufacturing: 0.23%
- Services: 0.19%
- Agriculture entities are not included in the analysis since the sector is a minor used of electricity; therefore changes in outage time is taken not to impact agri-producers

[1] Weighted average of the operation time increase of the four islands based on their GDP contribution

The output increase, equal to €3.8 million, leads to the creation of 370 direct and 20 indirect jobs

Economic output

Overall economic output in Cape Verde increases by an estimated €3.8 m, of which

- €0.5 million in the manufacturing sector
- €3.2 million in the services sector
- €0.1 million in the agricultural sector[1]

Incomes

The increase in output leads to €1.9 m of value added, of which

- €0.2 million in the manufacturing sector
- €1.7 million in the services sector
- €0.05 million in the agricultural sector

Jobs & livelihoods

The increase in output corresponds to the creation of on average 390 direct jobs, of which

- 55 in the manufacturing sector
- 315 in the services sector
- 20 in the agricultural sector[1]

Note on jobs

The number of jobs is not in full-time equivalents but refers to people who work for more than 1 hour/week, permanently or temporarily (i.e. not corrected for underemployment)

[1]The agricultural sector is not a major user of electricity, but benefits indirectly from increased procurement from other sectors.

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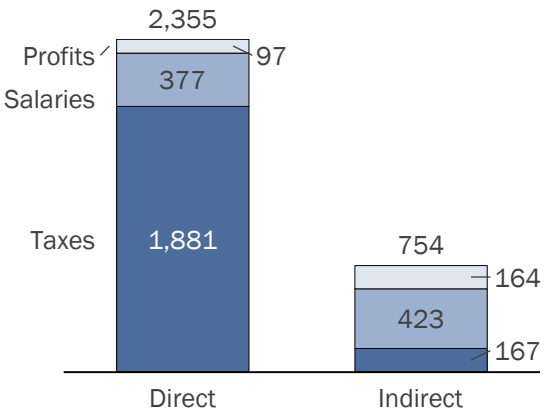
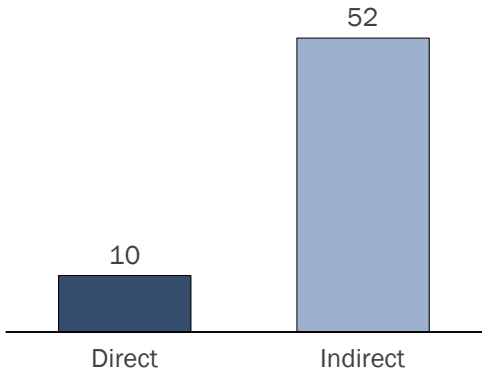
Indirect impact of Cabeolica's operation is 77 jobs and EUR 3.1 million in incomes



Incomes

- Cabeolica generates EUR 2.4 million in direct value and supports additional EUR 0.8 million indirectly
- Total taxes supported were EUR 2.0 million, salaries 0.8 million, profits 0.3 million
- The direct and indirect income contribution equals 0.32% of Cape Verde's GDP



Employment

- Cabeolica has 10 employees and supports additional 52 jobs through its value chain
- For each job at Cabeolica, there are 5.2 jobs supported elsewhere in Cape Verde's economy

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What can we learn from the study?

This study, along with others we have conducted in the power sector, shows that the impacts from investments in power vary depending on certain characteristics of the local energy sectors

When it comes to the economic impact of power projects, a few factors need to be considered

- Reserve margins – the lower the margins, the higher the outage reduction effect would be
- Dependency on thermal capacity – the higher the dependency, the higher the fuel displacement and CO_2 avoidance impact
- Cost of thermal generation
  - When fuel price are high, investing in cheaper (renewable) capacity will have a high impact on the generation cost
  - However, some thermal could still be cheaper than renewable from feed-in-tariffs
- Tariff structure
  - When tariffs are non-cost reflective, lowering the generation cost drives the end-user tariff closer to cost reflective levels, reducing the need for government support
  - When tariffs are cost-reflective, lower generation cost leads to lower end-user tariff, benefitting electricity users

Furthermore, we make the following recommendations to Finnfund and AFC

- Achieving Cape Verde's goal of 100% renewable energy by 2025 will require innovative technologies. Given batteries' vast potential and decreasing cost, this could be a potential area of investment
- Given the geothermal potential of the country, supporting geothermal generation projects might be an opportunity for investors to help lower electricity costs while reducing import dependence

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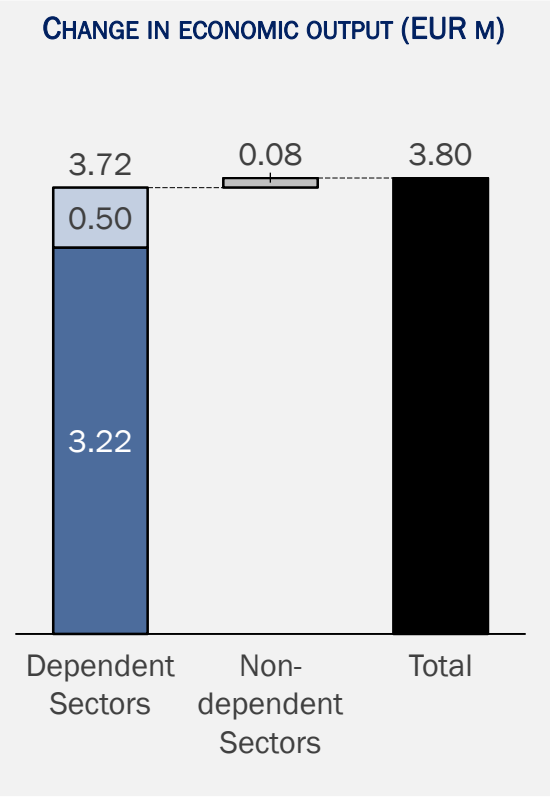
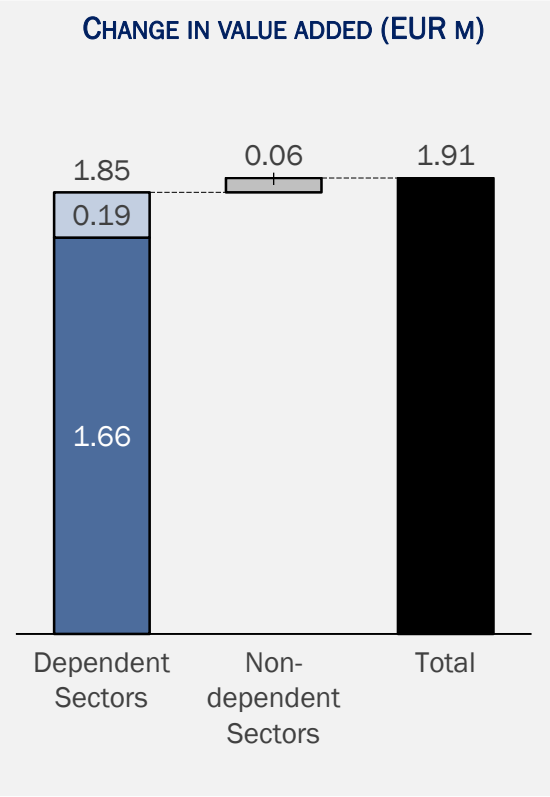
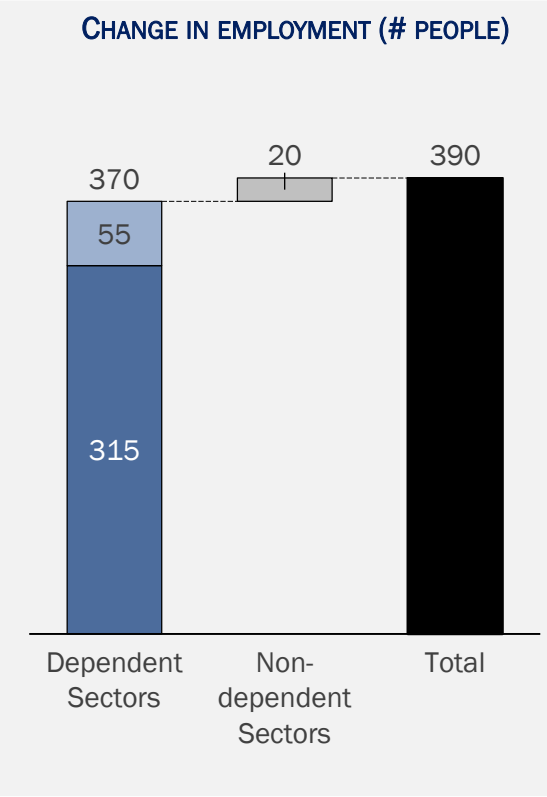
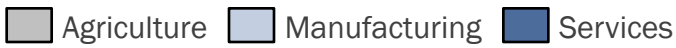
Annex 1: Outage impact results graphs (slide 19)









Annex 2: Outage impact results table (slide 19)

Sector	Δ Output (EUR m, %)	Δ GDP (EUR m, %)	Δ Employment (Number, %)
Agriculture (non-dependent)	0.08 (0.06%)	0.06 (0.02%)	19 (0.06%)
Manufacturing (dependent)	0.49 (0.3%)	0.19 (0.23%)	55 (0.23%)
Services (dependent)	3.22 (0.19%)	1.66 (0.19%)	313 (0.00%)
Total	**3.79**	**1.91**	**387**