



Pathway to a Competitive European
Fuel Cell micro-CHP Market

Environmental and Technical Performance

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Outline

- Results of the user survey on savings
 - Data reported by the end users of the installed FC μ CHP units
- Performance validation of the installed units
 - Data reported by the manufacturers of FC μ CHP units





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Results of the user survey on savings

Data collection

- Data was collected through a questionnaire
- Balance between complexity of the questionnaire and the expected response rate
 - Instructions and videos produced to make the users task as clear as possible
- All users are anonymized, only DTU has access to the data
- Data collected
 - 237 surveys started
 - Several respondents stop the questionnaire early
 - 95 surveys completed
 - inconsistent data removed
 - 39 contained valid responses

Limitations and advantages of the collected data

- Inaccurate data
 - Human errors in the reporting
 - Reporting periods not matching
- Several potential biases
 - Recent fluctuating energy prices
 - Reported data does not show the full picture
 - Not all energy use is necessarily replaced by the FC μ CHP unit
- The data is reported directly by the end user after one year of operation
 - Actual experienced savings, not a theoretical calculation

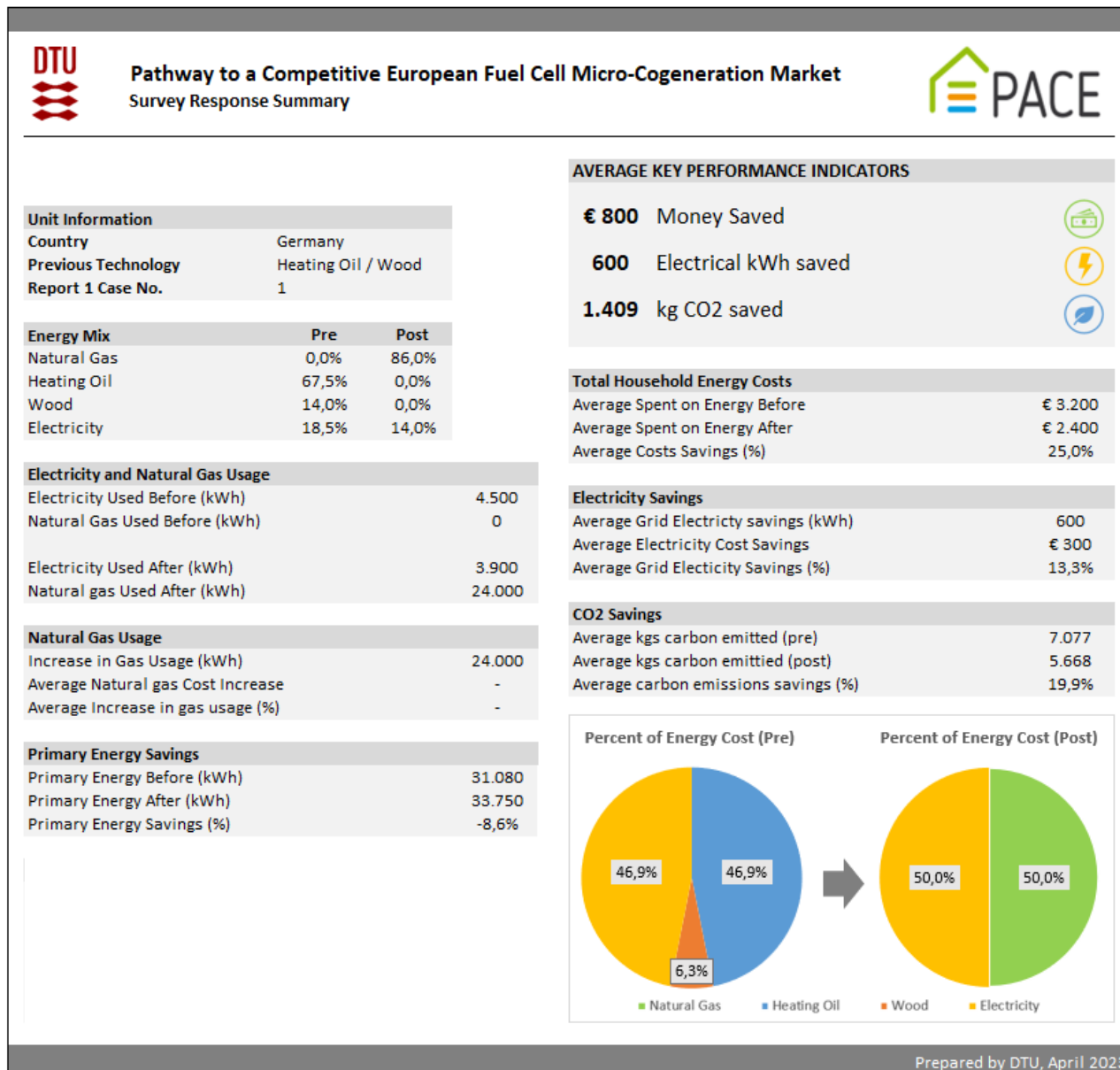
Example property 1

Previous technology was Heating Oil and Wood.

Savings and reductions

- Respondent saved € 800 annually (25%)
- Reduced grid bought electricity by 13.3%
- Reduced CO2 emissions by 19.9%

Data: Information on feed-in tariffs are missing from the data



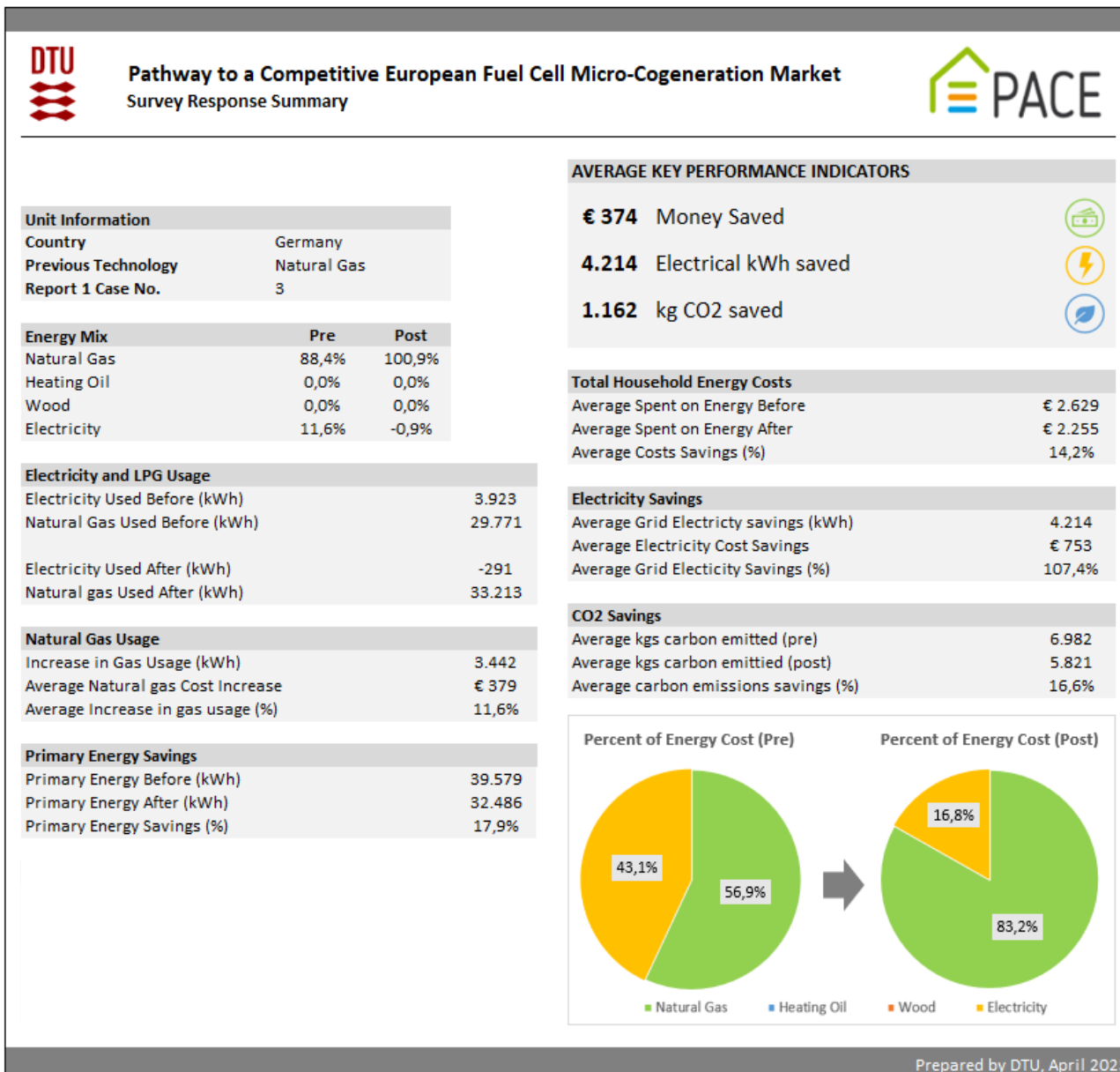
Example property 2

Previous technology was Natural Gas

Savings and reductions

- Respondent saved € 374 annually (14.2%)
- Reduced grid bought electricity by 107.4%
- Reduced CO2 emissions by 16.6%

Data: Producing more electricity than consumed. Still using electricity from the net.

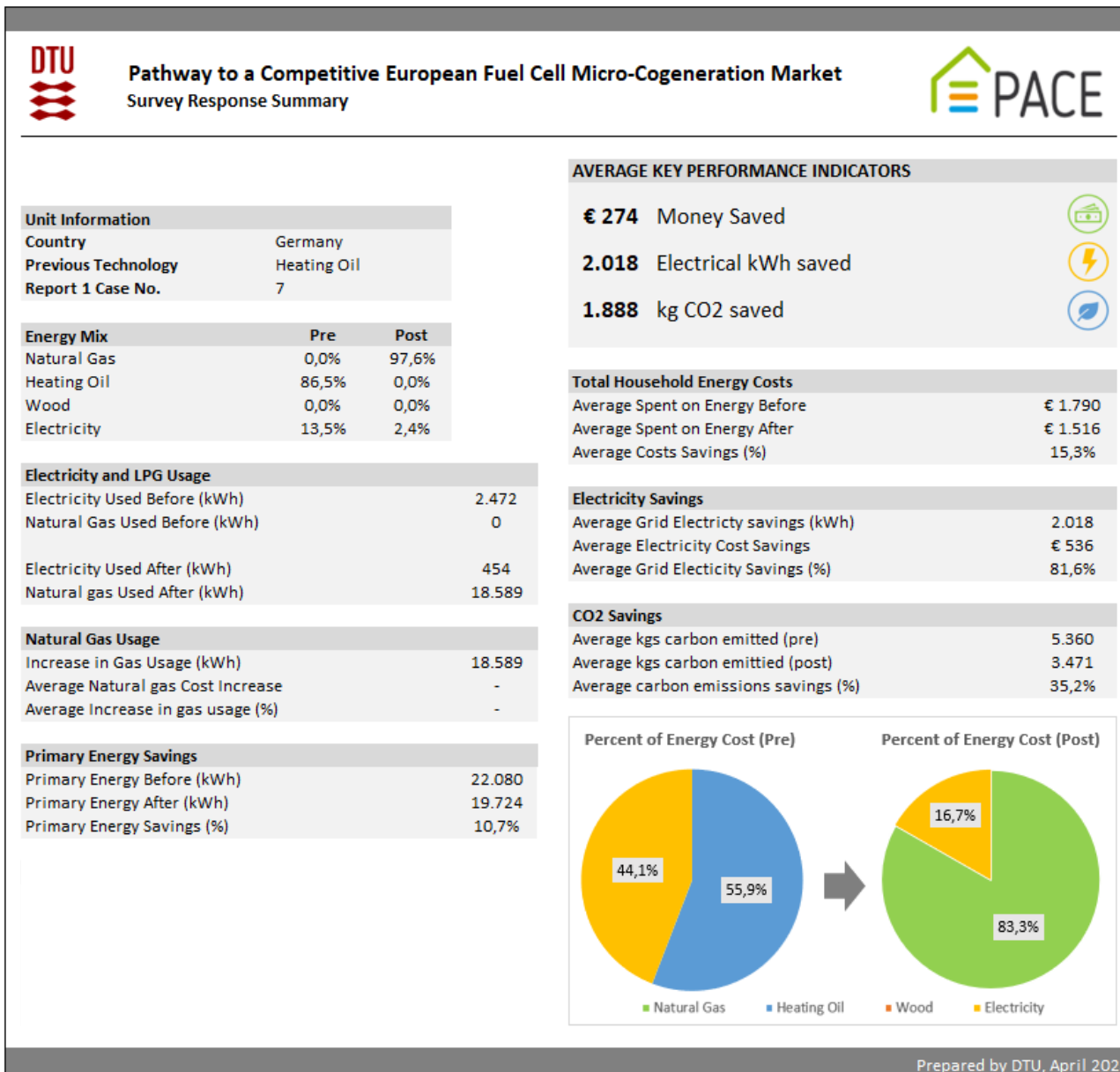


Example property 3

Previous technology was Heating Oil

Savings and reductions

- Respondent saved € 274 annually (15.3%)
- Reduced grid bought electricity by 82%
- Reduced CO2 emissions by 35%



Cost and CO₂ savings based on replaced technology

Replaced Oil burner

- CO₂ reduction: 36 %
- Cost savings: 27 %
- Primary energy savings: 12 %

Replaced Gas burner

- CO₂ reduction: 2 %
- Cost savings: 7 %
- Primary energy savings: 9%

Replacing an Oil burner with a FC μ CHP unit is particularly favourable

Overall savings

- CO2 reduction: 16 %
- Cost savings: 12 %
- Primary energy savings: 9%

Users experienced savings across the board

- Not possible to fully isolate the contribution of the FC μ CHP in this data
- The isolated actual contribution from the FC μ CHP unit is expected to be more significant
- The data, by its nature, contains several sources of potential bias



Performance validation of the installed units

Data

- Final collection and analyses of the most recent data are ongoing
- Collected by the manufacturers and sent to DTU for analysis
 - Gas consumption (m³)
 - Electricity produced (kWh)
 - Hours of operation (h)
 - Issues encountered (failures and duration)



Installation sites - April 2022

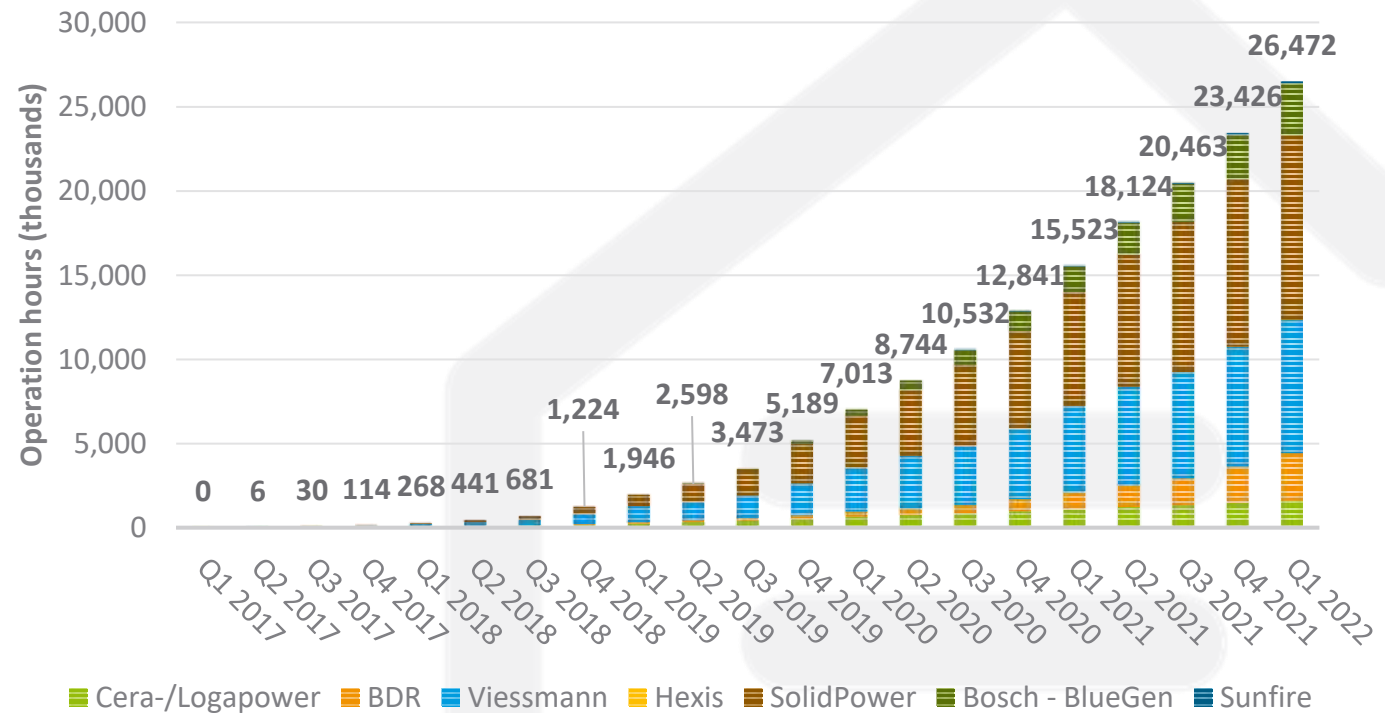


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Robust statistics

- Data from **30 million hours+** of operation
- **26 million kWh+** of electricity produced since the beginning of the project
 - Enough to cook 35 million pots of pasta
- Great data foundation for validating deployed performance of the CF μ CHP units

April 2022 HOURS IN OPERATION (CUMULATIVE)



Conclusions

Performance validated

- Gas utilization of each unit was calculated and compared with the manufacturers rating
- The analyzed gas utilization of the units corresponds well with the rated efficiencies by the manufacturers

Availability

- The overall availability of all units was calculated based on the reported failures
- Installed units have 95-99% availability



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