Bio-FlexGen

List of KPIs

D3.12

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[1] PU = Public

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Summary

This deliverable aims at describing a set of key performance indicators (KPIs) to evaluate the contributions and impact of the project. These KPIs are defined in four different dimensions: technical, economic, environmental, and social, to enable a comprehensive assessment of the overall impact of the project. Technical and economic KPIs are described regarding their relevance and computation method, including mapping with the business use cases investigated for economic KPIs. For environmental and social KPIs, different impact categories are considered.

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1 Introduction

The Bio-FlexGen project is mainly aimed at developing a renewable energy-based combined heat and power (CHP) system characterised by increased efficiency, cost effectiveness, as well as flexibility and robustness in response to the challenging requirements of an energy system with high share of variable renewable energy. This is realized by means of the flexible Biomass-fired TopCycle (BTC) plant technology developed in the project. In this regard, it is essential to identify and formulate key metrics to quantify the competitiveness and performance of the developed technology in a methodical manner. Therefore, a set of key performance indicators (KPIs) are proposed in this task to evaluate the impact and contributions of the project. These have been categorised into technical, economic, environmental, and social KPIs as below.

1. Technical KPIs evaluate the performance and characteristics of the flexible BTC technology developed in the project.
2. Economic KPIs evaluate the contributions of the BTC technology to the different use cases and the benefits for the electricity and gas system.
3. Environmental KPIs assess the impact of the BTC technology on reducing emissions directly as replacing fossil-fuel based technologies or because of indirect effects by providing services to the electricity system such as firm capacity and ancillary services.
4. Social KPIs estimate the social impacts of the BTC technology as local employment creation, increasing environmental awareness, etc.

1.1 WP3 objectives

The overall objective of this work package is to prepare and provide all the input data; regulatory and technical requirements, an overview of the electricity markets and grid service markets, scenarios corresponding to the identified electricity markets, business use cases for application of top cycle CHP technology and criteria needed for the model developments and analyses that are described in WP4.

The specific objectives of the task are describing a set of key performance indicators (KPIs) to evaluate the contributions and impact of the project. This deliverable is directly linked to Task 3.1, where the performance of the BTC plant in different operating modes is evaluated and Task 3.4, which describes the business use cases in Sweden and Spain (summarised in the deliverables 3.7 and 3.8 respectively) and to WP4, where some of the described KPIs will be computed.

1.2 Deliverable objectives

This deliverable aims at formulating and describing a set of key performance indicators (KPIs) to evaluate the contributions and impact of the project. These KPIs have been defined along four different dimensions: technical, economic, environmental, and social, as explained in the introduction. Technical and economic KPIs are described regarding their relevance and computation method, including mapping with the business use cases investigated for economic KPIs. For environmental and social KPIs, different impact categories are considered.

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1.3 Workflow of the deliverable

The remainder of this report is organised as follows. Sections 2 and 3 describe the technical and economic KPIs respectively, while environmental KPIs are listed in Section 4. Section 5 presents the social KPIs considered, and Section 6 provides the conclusion.

2 Technical KPIs

Technical KPIs are aimed at evaluating the characteristics and performance of the flexible BTC technology developed in the project. For an organised analysis, these KPIs have been divided into 3 categories: (Technical) Flexibility KPIs, Energy Efficiency KPIs and Operation, Maintenance and Reliability KPIs. It is to be noted that the CHP plant developed in this project consists of two variants, namely the Flex-BTC and the HyFlex-BTC plant, along with different operation modes characterised by a combination of products and inputs. As a result, many of these KPIs listed will be different for the two BTC types, also depending on the operation modes that are relevant.

2.1 (Technical) Flexibility KPIs

These are technical characteristics and parameters, resulting from design and operating principles of the plant, that contribute to flexibility in operation. These KPIs, when benchmarked against those from other typical plants or conventional solutions, help to describe the competitiveness of the developed BTC technology. However, the impact of this flexibility on the energy system and in different use cases concerns a separate analysis. Technical flexibility KPIs are listed in Table 1.

Table 1 Technical Flexibility KPIs.

KPI Name	KPI description	Unit of measurement
Operating range	Feasible range of operation, as percentage of plant capacity, for e.g., 30% - 100%. A wider operating range implies greater flexibility and plant utilisation.	---
Ramp rate	Feasible increase or decrease in generation in a given time. Ramp rates indicate the capability of the plant to follow changes in the demand.	MW/min
Start-up time	Time taken to reach desired production level when started. Fast-start capability is characterised by low start-up times. However, the start-up time also depends on how long the plant has been off-line and if the operating temperature is maintained, being minimum for a hot start and maximum for a cold start.	Minutes or Hours

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2.2 Energy Efficiency KPIs

Energy Efficiency KPIs are the metrics for evaluating the basic energy conversion performance of the plant. Energy efficiency KPIs are listed in Table 2.

Table 2 Energy Efficiency KPIs

KPI Name	KPI description	Unit of measurement
Total Efficiency	In general, it is the ratio of the net useful energy output to the total energy input, with respect to the Lower Heating Value (LHV) of fuel. However, this depends on the BTC type and operation mode under consideration.	%
Power-to-Heat Ratio	Ratio of generated electrical energy to the amount of useful thermal energy produced [1].	---
Net Electrical Efficiency	Ratio of electrical energy output from the plant, after accounting for its internal consumption, to the total energy input based on the Lower Heating Value (LHV) of fuel.	%
Net Hydrogen Efficiency	Ratio of energy output as hydrogen production to the total energy input consisting of biomass energy (LHV based) and electrical energy consumed.	%

2.3 Operation, Maintenance and Reliability KPIs

The optimal production or scheduling plan to be developed in WP4 will be based on several aspects such as demand and market prices, uncertainties, etc. This will however impact the utilisation of the plant. The KPIs in this category reflect the level of utilisation obtained as a result, including measures that indicate the plant reliability and maintenance needs. Table 3 below lists these KPIs.

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Table 3 Operation, Maintenance and Reliability KPIs

KPI Name	KPI description	Unit of measurement
Percent Runtime (planned)	Percentage of scheduled operation time over a given period, e.g., a day, week or month [2].	%
Capacity Factor (planned)	Ratio of planned production rate to the maximum rate over a given period [2].	%
Preventive Loss Indicator	Indicates impact of planned maintenance; defined as ratio of estimated energy loss due to planned interruptions, to the maximum energy that can be produced over a given period [3].	%
Forced Outage Rate	This is a reliability indicator defined as the probability that the plant will not be available for production when needed, due to equipment failures, disruption in fuel supply chain, etc. [4].	%

3 Economic KPIs

The list of KPIs and the mapping with the Business Use Cases is presented in Table 4. The economic KPIs aim to evaluate the costs and benefits of the BTC adoption by each of the companies which are considered in the Bio-FlexGen project. The considered costs are divided into Operational Expenditure (OPEX) and Capital Expenditure (CAPEX). Table 4 presents the Use cases where the KPIs will be computed.

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Table 4 Economic KPIs and mapping with the Business Use Cases

KPI Name	KPI description	Unit of measurement	BUC				
			ES-CEMEX-01	ES-CEMEX-02	ES-CEMEX-03	ES-SUL-01	SE-TVAB-01
fOPEX - fixed operational expenditures of BTC operation	This indicator calculates the fixed recurrent costs that are required in order to operate and maintain the BTC.	M€/year	X	X	X	X	X
vOPEX - variable operational expenditures of BTC operations	This indicator calculates the variable operational costs that depend on the unit of produced electric and thermal energy.	€/kWhe and €/kWht	X	X	X	X	X
hOPEX - hydrogen fuel operational costs	This indicator calculates for the hourly production cost of hydrogen if used in combination with BTC technology	€/kWhH			X		
CAPEX- Capital Expenditures of BTC adoption	This indicator calculates the recurrent costs that are required in order to operate and maintain the installed equipment.	M€/year	X	X	X	X	X
Cost effectiveness of BTC solution in comparison with current alternative conventional solution from the user point of view	Annualized cost, of the traditional solution vs the BTC cost.	M€/year	X	X		X	X

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Increase in revenue of the flexibility provider	Calculation of the total increase in revenue by providing new services (e.g. balancing services) with a specific set of resources compared to traditional solutions. The revenue is calculated by multiplying the provided power by the price of the service summed over a set of resources and a set of markets/services.	M€/year					X

4 Environmental KPIs

The preliminary KPIs listed in Table 5 will help to assess the environmental impact of the Bio-FlexGen project. The proper estimation of these KPIs directly depends on the availability of required data and many more uncertain factors. Furthermore, the suggested KPIs in Table 5 are in line with the impact categories selected in WP5, Task 5.1 which through Life Cycle Analysis (LCA) quantifies the environmental impacts of the conversion of raw materials to heat and power.

Table 5 Environmental KPIs.

KPI Name	KPI description
RES generation	Increase in production volume from Renewable Energy Sources (RES) due to promotion of Bio-FlexGen technology
Air pollution	Promotion of Bio-FlexGen technology: Flex-BTC and the HyFlex-BTC plant (decrease in SO_2, NO_x, emissions)
GHGs	Promotion of Bio-FlexGen technology: Flex-BTC and the HyFlex-BTC plant (decrease in CO_2 emissions)

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5 Social KPIs

The social KPIs considered in the project, are detailed in WP5, specifically in D5.4 on the "Selection of social impact indicators and methodology for measurement" and are expected to be measured in D5.5 "Potential social impact report".

6 Conclusion

A set of key performance indicators (KPIs) have been proposed and described to understand the performance of the flexible BTC technology developed and the contributions of the Bio-FlexGen project. Therefore, these KPIs have been defined along four different dimensions: technical, economic, environmental, and social, to facilitate a comprehensive evaluation of the overall impact of the project.

7 References

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