Implementation of renewable energy and smart solution technologies to pre-existing energy system; A Cost Benefit Analysis Case Study: InteGRIDy

Bjarnhedinn Gudlaugsson [1, *], Tariq Ahmed [2, *], Huda Dawood [1], Chris Ogwumike [1]

[1] School of Computing, Engineering, and Digital Technology, Teesside University, TS1 3BX , United Kingdom

[2] Chemical Engineering , Lancaster University, Bailrigg, Lancaster LA1 4YX , United Kingdom

Presenters email: b.gudlaugsson@tees.ac.uk & T.Ahmed5@lancaster.ac.uk

Teesside University

SUSTAINABLE PLACES 2021
Sep. 29 - Oct. 1, 2021 | Rome, Italy

integRIDy

The Problem Statement

- The implementation of smart and renewable technology to the pre-existing energy system has the opportunity to provide beneficial economic gains to the internal stakeholder such as energy system operators, alongside achieving other additional improvements in terms of environmental and social aspects.

- Therefore, the analysis focused on examining each pilot site's monetized costs and economic benefits to highlight the economic benefits obtained from implementing smart and renewable energy technologies.

The concept and overall objective of the inteGRIDy project - *"inteGRIDy aims to integrate cutting-edge technologies, solutions and mechanisms in a Framework of replicable tools to connect existing energy networks with diverse stakeholders, facilitating optimal and dynamic operation of the Distribution Grid (DG), fostering the stability and coordination of distributed energy resources and enabling collaborative storage schemes within an increasing share of renewables." [1]*

Teesside University

SUSTAINABLE PLACES 2021
Sep. 29 - Oct. 1, 2021 | Rome, Italy

inteGRIDy

Pilot Sites (Cases)

Barcelona

- **Scenario A** – Conventional energy system without the implementation of any smart solution technology.
- **Scenario B** – Smart solution implementation that includes PV system with battery storage technology and the Integrated Energy Platform (IEP) that deals with the participation in the electricity market as a flexibility provider to the grid in addition to the conventional energy system.

St Jean

- **Scenario A** – based on the assumption that the energy supply from pre-existing energy systems only comes from conventional fossil energy resources without any localized energy technologies.
- **Scenario B** – based around the introduction and implementation of renewable energy technologies and smart technology solutions to the pre-existing energy system from scenario A

Teesside University

SUSTAINABLE PLACES 2021
Sep. 29 - Oct. 1, 2021 | Rome, Italy

inteGRIDy

Research Approach

Input from other InteGRIDy Work Packages

Indicator Selection and CBA Modelling Design

- Stakeholder Engagement

Data Collection

- Stakeholder Engagement
- Data Validation and Cleaning
- CBA Calculations

Analysis

- CBA Calculation
- Stakeholder Engagement
- Analysis results validation

Results and Outcomes

Teesside University

SUSTAINABLE PLACES 2021
Sep. 29 - Oct. 1, 2021 | Rome, Italy

inteGRIDy

Data Input and Indicators

KPI	Domain	Units
Average Cost of Energy	Economic	(€ / year)
Average cost of Energy Consumption	Economic	(€ / year)
Cost of Energy Consumption	Economic	(€ / year)
Energy Payback Time (EPBT)	Environmental	(€ / year)
Energy Consumption (Yearly, Monthly, Daily …)	Technical	(MWh / year)
Energy Imports	Technical	(€ / year)
Savings gained from Flexibility	Technical	€

KPI	Domain	Units
RES Generation	Technical	(MWh / year)
Energy Consumption Reduction (Demand Flexibility)	Technical	(MWh / year)
Energy Mismatch	Technical	(MWh / year) (€ / year)
Share of RES	Technical	(MWh / year)
Cost of Flexibility	Economic	€
Investment Costs	Economic	€
Operation and Maintenance Costs	Economic	€
Energy Price per MW	Economic	€

Teesside University

SUSTAINABLE PLACES 2021
Sep. 29 - Oct. 1, 2021 | Rome, Italy

inteGRIDy

Results - Barcelona

Over the 20-year period considered for this evaluation;

- Scenario A with no smart solution implementation (baseline), require a total of 47 MWh of electricity and 24 MWh of gas which amounts to € 5,731,156.
- Scenario B - The incorporation of the technologies will require electricity demand of 47 MWh and a gas demand of 20 MWh making a reduction of 4 MWh of gas amounting to a capital investment (CAPEX) of € 80,709 an operating cost of € 65,000.
- The overall cost of the smart solution technologies implemented in the Barcelona pilot adds up to € 5,662,921.

Teesside University

SUSTAINABLE PLACES 2021
Sep. 29 - Oct. 1, 2021 | Rome, Italy

inteGRIDy

Results - Barcelona

Sensitivity Analysis for Barcelona

Discount Rates	2.00%	3.50%
Total Energy Costs Scenario A	€ 5,618,780.00	€ 5,537,348.41
CAPEX Scenario B	€ 79,126.05	€ 77,979.29
OPEX Scenario B	€ 5,472,757.24	€ 5,393,441.92
Total Cost Scenario B	€ 5,551,883.29	€ 5,471,421.21
Revenue Scenario B	€ 314,259.30	€ 309,704.82
NPV Scenario B	€ 32,839.10	€ 32,363.17

- Overall, the analysis indicated that implementation of smart solution tools for the Barcelona Pilot are economically viable with a payback time of 8.2 years.
- The technologies were also able to save over 53 tonnes of carbon dioxide emission just within the first year.
- The low income is generated through the participation in DR events which is a consequence of the electricity market framework.

Teesside University

SUSTAINABLE PLACES 2021
Sep. 29 - Oct. 1, 2021 | Rome, Italy

inteGRIDy

Results – St. Jean

The transition towards an energy system where the energy generation is entirely based on renewable energy technology

- seem to be economically viable for DSO stakeholders within the St-Jean energy system, with DSO obtaining a total economic gain of **€ 1,127,344.46 (NPV)** over the whole simulation period from 2019 to 2039.
- holds a social impact since the transiting to a fully renewable-based energy system enables a shift towards greener energy consumption.
- improves the system's energy security and stability, with a higher degree of flexibility to meet demands within the system (*see flexibility figure*).
- Table illustrate results from the economic assessment concerning the investments, income, and economic benefits gained from flexibility for both scenarios.

Teesside University

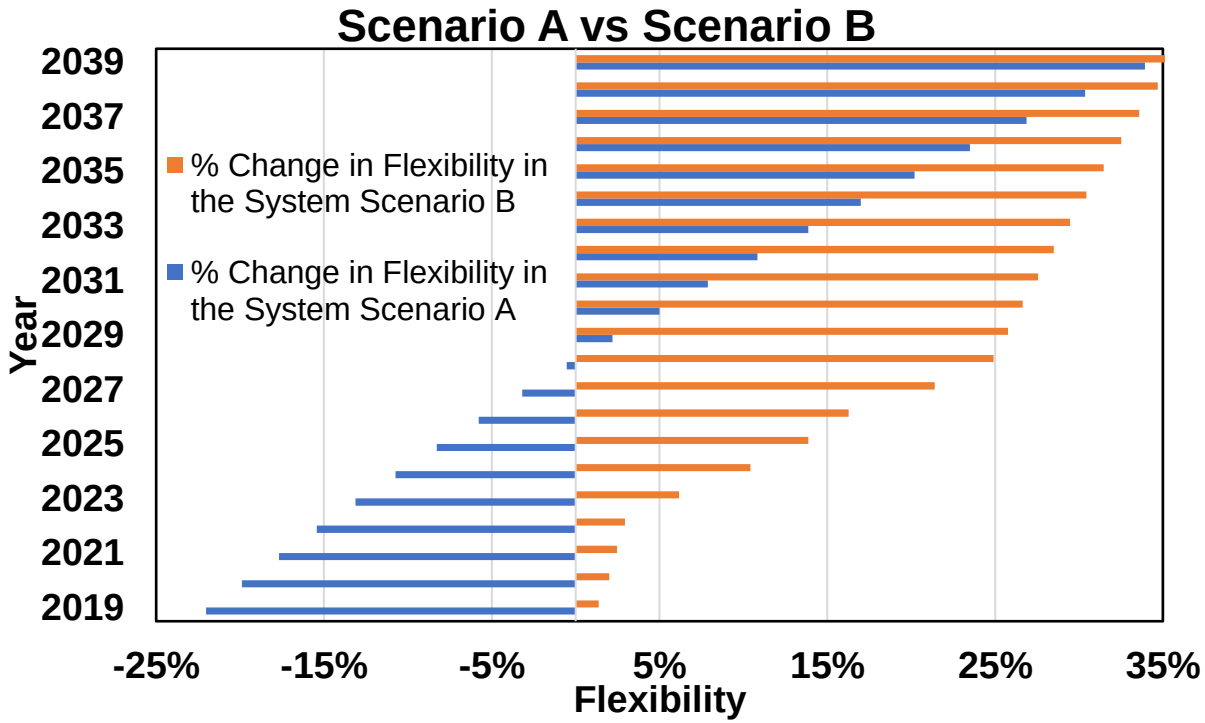
SUSTAINABLE PLACES 2021
Sep. 29 - Oct. 1, 2021 | Rome, Italy

inteGRIDy

Results – St. Jean

Sensitivity Analysis for St Jean Pilot

Variables (€)	2.80%	3.50%
Total Energy System Investment (Scenario A)	29,681,906.61	29,481,159.42
Total Investment (Scenario B)	63,883,765.23	63,451,701.11
Economic benefits from the Flexibility (Scenario A)	5,127,606.75	5,092,927.29
Economic benefits from the Flexibility (Scenario B)	65,058,511	64,618,502
Total Income (Scenario A)	€ 552,954,300	549,214,512
Total Income (Scenario B)	€ 628,648,656	624,396,926



Teesside University

SUSTAINABLE PLACES 2021
Sep. 29 - Oct. 1, 2021 | Rome, Italy

inteGRIDy

Outcome – Policy Recommendation

- The implementation is economically positive for both pilot sites and provide stakeholder with economical gains.
- The implementation does provide environmental positive results with decease in GHG emission.
- Improved energy security in terms of increase energy flexibility through improve energy production capacity and implementation of smart technology solutions.
- **Policy recommendation** – Set forward clear energy transition pathways.

Teesside University

SUSTAINABLE PLACES 2021
Sep. 29 - Oct. 1, 2021 | Rome, Italy

inteGRIDy

Thank you for your attention!

Any Questions?

Teesside University

SUSTAINABLE PLACES 2021
Sep. 29 - Oct. 1, 2021 | Rome, Italy

inteGRIDy

REFERENCE

[1] inteGRIDy webpage (2021), Concept - Statement and Objective, http://www.integridy.eu/node/2 [Accessed: 28.09.2021]

ACKNOWLEDGEMENTS

This project has received funding from the European Union's H2020 research and innovation programme under the grant agreement No 731268

The authors wants to thank all the partners in inteGRIDy project for all their insightful comments and good discussion during the work on this research project.

Teesside University

SUSTAINABLE PLACES 2021
Sep. 29 - Oct. 1, 2021 | Rome, Italy