POTENTIALS

RFCS AM PROJECT

Synergistic potentials of end-of-life coal mines and coal-fired power plants, along with closely related neighbouring industries: update and re-adoption of territorial just transition plans

101034042-POTENTIALS-RFCS-2020

Deliverable 4.3

Specifying scenario outputs and result indicators

European Commission

Research Fund for Coal & Steel

Authors

Prof Pedro Riesgo Fernández, University of Oviedo (Spain)
Dr Gregorio Fidalgo Valverde, University of Oviedo (Spain)
Prof Alicja Krzemień, Central Mining Institute (Poland)
Mr Aleksander Frejowski, Central Mining Institute (Poland)

Deliverable 4.3	
Due date of Deliverable	31.03.2023
Start - End Date of Project	01.07.2021 – 30.06.2023
Duration	Two years
Deliverable Lead Partner	UNIOVI
Dissemination level	Public
Work Package	WP 4
Digital File Name	D4.3 Business models outputs and result indicators
Keywords	Business models, results indicators, portfolio of options

Disclaimer

Table of contents

List of Figures

List of Tables

Executive summary

In this deliverable, business model outputs and result indicators for the most suitable and exciting business model choice, which is Eco-industrial parks (with virtual power plant), are estimated. As Eco-industrial parks (with virtual power plant) may be complemented with green hydrogen plants, molten salt plants, batteries and biofuels production or combustion, all these options were considered in the analysis.

The direct result indicators were selected considering the targets set by the European Green Deal and related taxonomy and the Regional Policy indicators for the Just Transition Fund, resulting in a total of 17 direct result indicators which impact was evaluated by means of a Delphi experts survey.

Following the first Delphi expert survey, scores that were sensitively deviated from the mean were consulted again in a second expert survey, where consensus was reached for all direct result indicators.

The final scores obtained for the direct result indicators showed an advantage for the scenario involving an Eco-industrial park (with virtual power plant) + a green hydrogen plant. The other scenarios received similar scores and should therefore be considered as a complementary range of solutions for further analysis.

It should be noted that the greatest added value of this Deliverable is the methodology developed to assess scenarios for the use of end-of-life coal mines and coal-fired power plants, along with closely related neighbouring industries. The final results presented in this Deliverable, developed with the use of the above mentioned methodology, has been carried out in accordance with the knowledge and experience of the involved experts and are not site specific.

The developed methodology is an important tool for assessing the potential of specific decommissioned mining plants or power plants. Each of the parameters of the analysed system is of significant importance and may influence the final results of the study and, above all, the selection of the most optimal technology.

Nevertheless, it is envisaged that, according to the results of the evaluation of the direct result indicators presented in this Deliverable, preference should be given to the Eco-industrial Park (with virtual power plant) + green hydrogen plant, followed by the molten salt plant.

1 Introduction

Work Package 4 is to justify the selection of business model choices and their adaptation according to the expected transition process to update and re-adopt territorial just transition plans.

Specific objectives are:

1. To support the update and re-adoption of territorial just transition plans, show how these synergies can be used to develop new business models, define concrete prospects and transition plans from different implementation scenarios, and justify the business model choices.

2. To undergo an economic impact assessment to determine the economic diversification potential, the likely commercial viability, and the added value of the proposed business models.

3. To undergo a social impact assessment, analysing the expected job losses and requalification needs.

4. To undergo a territorial impact assessment to analyse the potential territorial impact of the business model proposals.

Within this work package, Task 4.3 *Specifying scenario outputs and result indicators*, comprises the activities to be carried out, based on Dephi surveys, for impact of 17 direct result indicators on 5 different business models of eco-industrial park (with virtual power plant).

The result achieved will be business models outputs and result indicators.

2 Business models outputs and result indicators

According to the aspects analysed within the justification approach: Green Deal policies, technical criteria, TRL, European taxonomy, synergistic potential, circular economy and sector coupling, the most appropriate and exciting business model choice to be selected are **Eco-industrial parks.**

They refer to an integrated alternative for sustainable energy generation technologies and circular economy contributions at these sites. The main objective of industrial parks is to reduce waste and pollution by promoting short-distance transport and optimising the parks' materials, resources, and energy flows.

Sustainable energy generation technologies comprise solar and wind energy production with energy storage and geothermal energy (from underground coal mines) to provide cooling/heating to the companies/industries participating in the Eco-industrial park.

Eco-industrial parks should be supported by pursuing financial privileges and other benefits to boost and diversify the economy of the area, attracting external investment: tax exemptions for businesses, access to preferential credits from National authorities, European Investment Bank, European Bank for Reconstruction and Development, EU; local business support institutions, and others.

Eco-industrial parks may be complemented with a **green hydrogen plant** installed in the former power plant according to their high TRL, provided that specific economic subventions are obtained to achieve balanced financial results. Other alternatives that should be considered according to the business model choices justification for actions and micro-actions within the former power plants are **molten salt plants**, **batteries** or **biofuels**.

Thus, the options to be analysed will be:

Nº	Option
1	Eco-industrial park (with virtual power plant) + green hydrogen plant
2	Eco-industrial park (with virtual power plant) + molten salt plants
3	Eco-industrial park (with virtual power plant) + batteries
4	Eco-industrial park (with virtual power plant) + biofuels production
5	Eco-industrial park (with virtual power plant) + biofuels combustion

Scenario outputs and result indicators were selected considering the targets set by the European Green Deal and related taxonomy and the Regional Policy indicators for the Just Transition Fund.

The study "Development of a system of common indicators for European Regional Development Fund and Cohesion Fund interventions after 2020" focuses on the eleven thematic objectives, as defined according to European Union (EU) Regulations 1300/2013, 1301/2013 and 1303/2013:

- TO 1 'Strengthening research, technological development and innovation',
- TO 2 'Enhancing access to, and use and quality of, information and communication technologies (ICT)',
- TO 3 'Enhancing the competitiveness of small and medium-sized enterprises (SMEs)',
- TO 4 'Supporting the shift towards a low-carbon economy in all sectors',
- TO 5 'Promoting climate change adaptation, risk prevention and management',
- TO 6 'Preserving and protecting the environment and promoting resource efficiency',
- TO 7 'Promoting sustainable transport and removing bottlenecks in key network infrastructures',
- TO 8 'Promoting sustainable and quality employment and supporting labour mobility',
- TO 9 'Promoting social inclusion, combating poverty and any discrimination',
- TO 10 'Investing in education, training and vocational training for skills and lifelong learning',
- TO 11 'Enhancing institutional capacity of public authorities and stakeholders and efficient public administration' and the corresponding Investment Priorities'.

These thematic objectives coincide with the initiatives included in the Green Deal.

In Table 2-1 the input survey for the Delphi expert analysis is shown.

Table 2-1. Scenario output and result indicators

		Eco-industrial park (with virtual power plant) +				
Nº	**Direct result indicators**	**Green H_2 plant**	**Molten salt plant**	**Batteries**	**Biofuels (production)**	**Biofuels (combustion)**
1	Full-Time Employment creation					
2	Full-Time new researchers					
3	Companies introducing process/product innovations					
4	Patent applications submitted to EPO					
5	Energy users connected to smart grids					
6	The capacity of renewable energy production installed and connected to the network					
7	Energy efficiency (support for the smart grid)					
8	Estimated low GHG emissions (tons of CO_2 equivalent) during the lifetime of the technology					
9	"Tons" of recycled waste (more waste, lower value)					
10	Space required to develop the option (more space, lower value)					
11	Improvement of quality of offered services within the eco-industrial park					
12	Benefits/return on investments (CAPEX and OPEX are considered)					
13	Potential to stimulate other business activities					
14	Energy security degree (independence)					
15	Reduction of environmental impact - LCA (higher impact, lower value)					
16	Environmental impact at the place of operation (higher impact, lower value)					
17	Increased competitiveness of the region					

The following scale was adopted for the evaluation of impact of indicators for scenarios:

1. LOW IMPACT – weight 1
2. MEDIUM-LOW IMPACT – weight 2
3. MEDIUM IMPACT – weight 3
4. MEDIUM-HIGH IMPACT – weight 4
5. HIGH IMPACT – weight 5

Two rounds of the DELPHI survey with experts were held:

1. First round on March 15, 2023.
2. Second (final) round on March 17, 2023.

The Delphi study involved researchers and experts from institutions:

1. Central Mining Institute with external experts from Polish Power Plants Association (GIG-TGPE).
2. Hulleras del Norte SA (HUNOSA).
3. VGB PowerTech e.V. and Technische Hochschule Georg Agricola University (VGB-THGA).
4. Universidad de Oviedo (UNIOVI).
5. Centre for Research and Technology – Hellas (CERTH).

3 First round Delphi survey – business models outputs & result indicators

Below are the results on scenario outputs and results direct indicators of first Delphi expert survey.

3.1 Full-Time Employment creation

The results for the indicator "Full Time Employment creation", from the first Delphi survey, are shown in Table 3-1 and Figure 3-1. The results that were consulted in the second Delphi survey (deviated from the average) are highlighted in yellow.

Table 3-1. Result of scenarios output for indicator "Full Time Employment creation" after first Delphi survey

Full-Time Employment increase	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	4	5	1	5	4
HUNOSA	3	3	1	5	4
VGB-THGA	3	3	2	4	4
UNIOVI	5	2	2	4	3
CERTH	4	4	2	4	2
Average	3,8	3,4	1,6	4,4	3,4

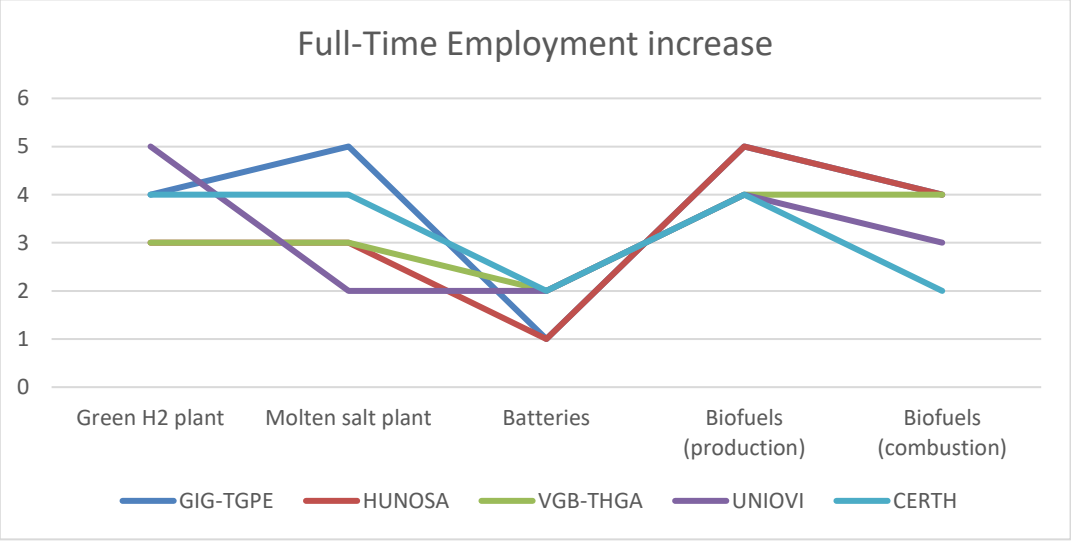

Figure 3-1. Graph of result of scenarios output for indicator "Full Time Employment creation" after first Delphi survey

3.2 Full-Time new researchers

The results for the indicator "Full-Time new researchers", from the first Delphi survey, are shown in Table 3-2 and Figure 3-2. The results that were consulted in the second Delphi survey (deviated from the average) are highlighted in yellow.

Table 3-2. Result of scenarios output for indicator "Full Time new researches" after first Delphi survey

Full-Time new researchers	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	5	2	1	4	3
HUNOSA	1	1	1	5	5
VGB-THGA	2	1	2	3	1
UNIOVI	3	2	1	2	1
CERTH	4	3	2	2	1
Average	3,0	1,8	1,4	3,2	2,2

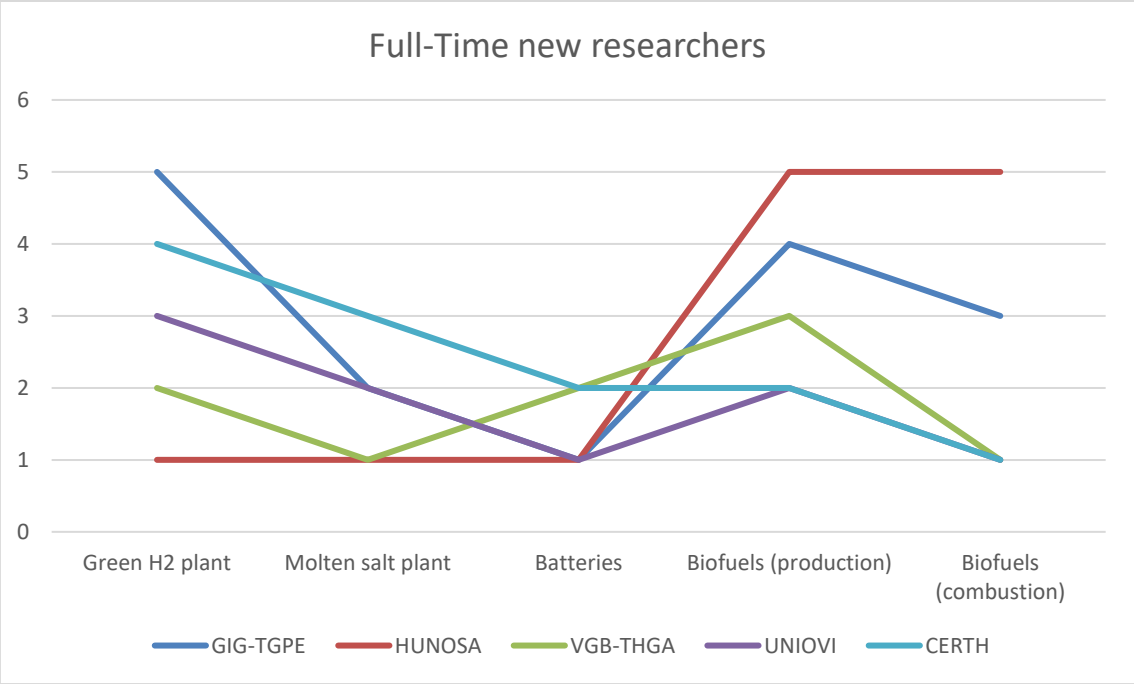

Figure 3-2. Graph of result of scenarios output for indicator "Full Time new researches" after first Delphi survey

3.3 Companies introducing process/product innovations

The results for the indicator "Companies introducing process/product innovations", from the first Delphi survey, are shown in Table 3-3 and Figure 3-3. The results that were consulted in the second Delphi survey (deviated from the average) are highlighted in yellow.

Table 3-3. Result of scenarios output for indicator "Companies introducing process/product innovations" after first Delphi survey

Companies introducing process/product innovations	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	4	1	2,5	4	3
HUNOSA	3	3	2	4	3
VGB-THGA	4	2	4	4	2
UNIOVI	5	1	1	2	1
CERTH	5	3	3	3	2
Average	4,2	2	2,5	3,4	2,2

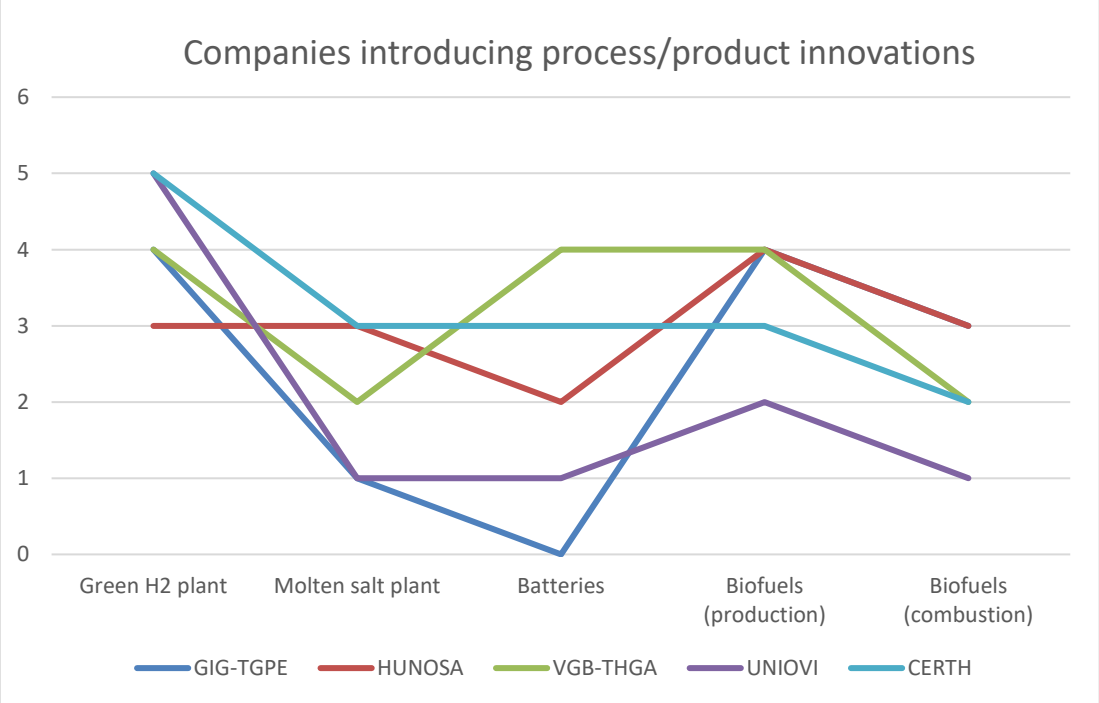

Figure 3-3. Graph of result of scenarios output for indicator "Companies introducing process/product innovations" after first Delphi survey

3.4 Patent applications submitted to EPO

The results for the indicator "Patent applications submitted to EPO", from the first Delphi survey, are shown in Table 3-4 and Figure 3-4. The results that were consulted in the second Delphi survey (deviated from the average) are highlighted in yellow.

Table 3-4. Result of scenarios output for indicator "Patent applications submitted to EPO" after first Delphi survey

Patent applications submitted to EPO	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	4	3	4	4	3
HUNOSA	2	2	1	3	2
VGB-THGA	3	2	3	4	1
UNIOVI	3	2	1	1	1
CERTH	3	3	2	2	2
Average	3	2,4	2,2	2,8	1,8

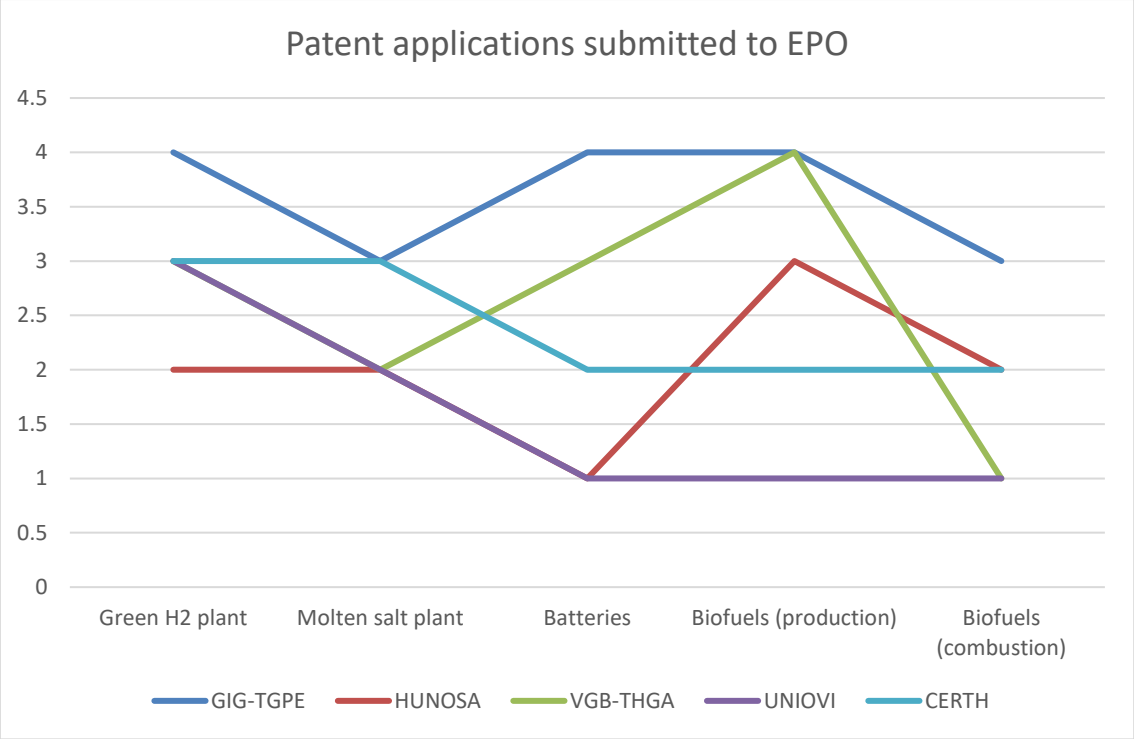

Figure 3-4. Graph of result of scenarios output for indicator "Patent applications submitted to EPO" after first Delphi survey

3.5 Energy users connected to smart grids

The results for the indicator "Energy users connected to smart grids", from the first Delphi survey, are shown in Table 3-5 and Figure 3-5. The results that were consulted in the second Delphi survey (deviated from the average) are highlighted in yellow.

Table 3-5. Result of scenarios output for indicator "Energy users connected to smart grid" after first Delphi survey

Energy users connected to smart grids	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	3	5	5	3	4
HUNOSA	5	5	5	1	3
VGB-THGA	1	1	3	1	1
UNIOVI	3	3	2	1	2
CERTH	4	3	3	2	3
Average	3,2	3,4	3,6	1,6	2,6

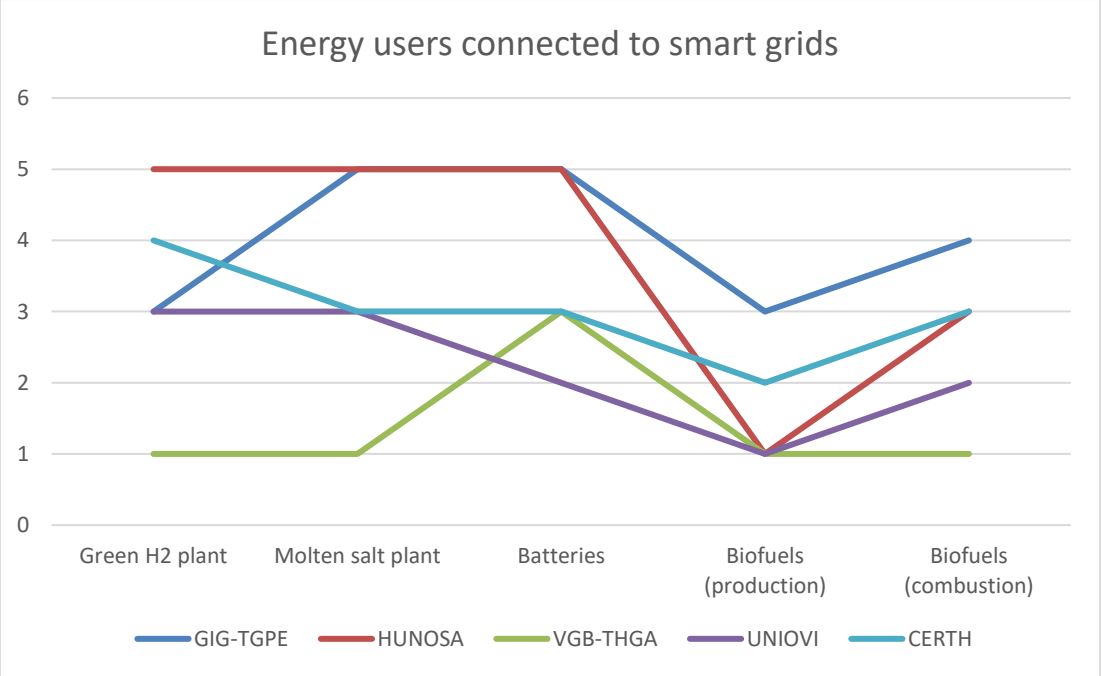

Figure 3-5. Graph of result of scenarios output for indicator "Energy users connected to smart grid" after first Delphi survey

3.6 Capacity of renewable energy production installed and connected to the network

The results for the indicator "Capacity of renewable energy production installed and connected to the network", from the first Delphi survey, are shown in Table 3-6 and Figure 3-6. The results that were consulted in the second Delphi survey (deviated from the average) are highlighted in yellow.

Table 3-6. Result of scenarios output for indicator "Capacity of renewable energy production installed and connected to the network" after first Delphi survey

Capacity of renewable energy production	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	5	5	4	5	4
HUNOSA	5	5	5	1	4
VGB-THGA	3	2	4	4	2
UNIOVI	1	3	2	1	3
CERTH	4	5	3	2	3
Average	3,6	4	3,6	2,6	3,2

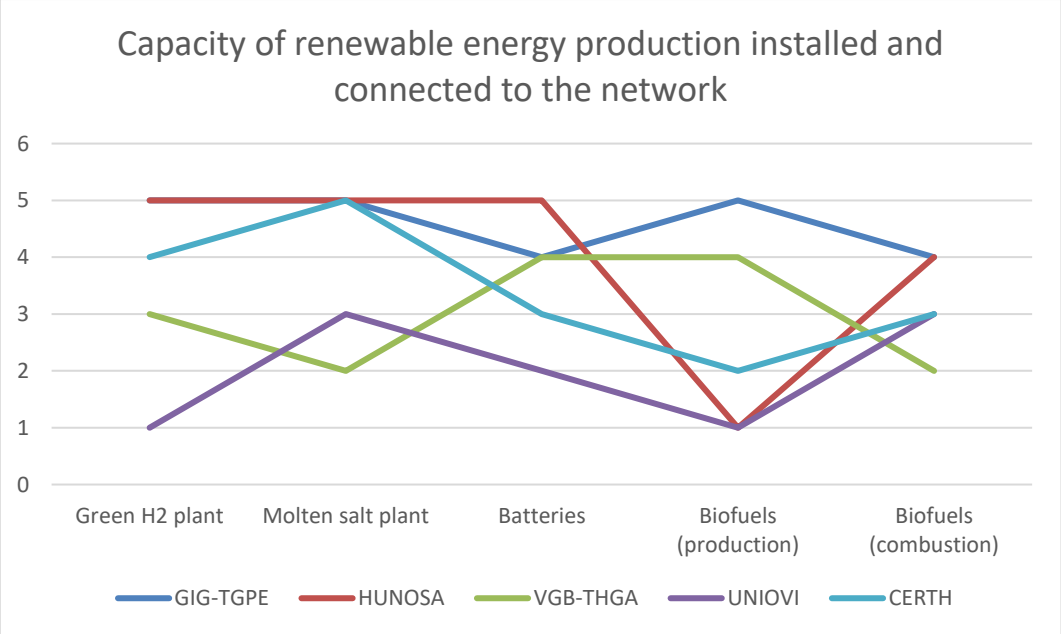

Figure 3-6. Graph of result of scenarios output for indicator "Capacity of renewable energy production installed and connected to the network" after first Delphi survey

3.7 Energy efficiency (support for the smart grid)

The results for the indicator "Energy efficiency (support for the smart grid)", from the first Delphi survey, are shown in Table 3-7 and Figure 3-7. The results that were consulted in the second Delphi survey (deviated from the average) are highlighted in yellow.

Table 3-7. Result of scenarios output for indicator "Energy efficiency (support for the smart grid)" after first Delphi survey

Energy efficiency (support for the smart grid)	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	1	4	5	3	3
HUNOSA	3	3	4	1	2
VGB-THGA	2	2	5	2	3
UNIOVI	1	4	3	1	5
CERTH	2	4	3	2	4
Average	1,8	3,4	4	1,8	3,4

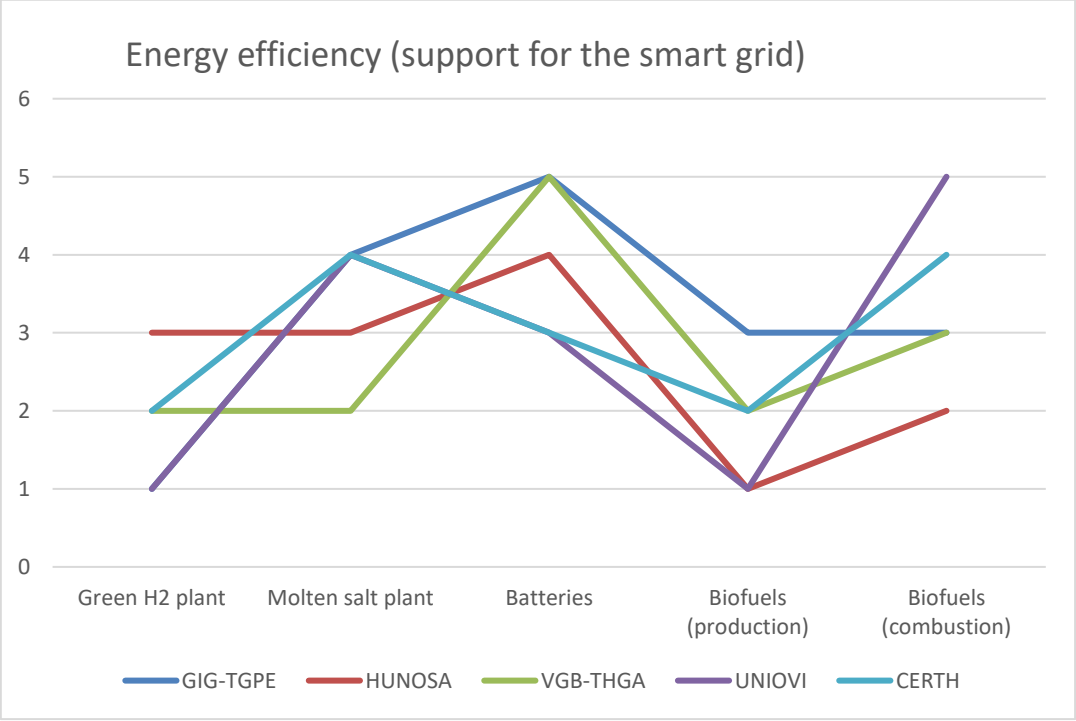

Figure 3-7. Graph of result of scenarios output for indicator "Energy efficiency (support for the smart grid)" after first Delphi survey

3.8 Estimated low GHG emissions (tons of CO_2 equivalent) during the lifetime of the technology

The results for the indicator "Estimated low GHG emissions (tons of CO_2 equivalent) during the lifetime of the technology", from the first Delphi survey, are shown in Table 3-8 and Figure 3-8. The results that were consulted in the second Delphi survey (deviated from the average) are highlighted in yellow.

Table 3-8. Result of scenarios output for indicator "Estimated low GHG emissions (tons of CO_2 equivalent) during the lifetime of the technology" after first Delphi survey

Estimated low GHG emissions (tons of CO_2 equivalent) during the lifetime of the technology	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	5	5	5	2	1
HUNOSA	4	4	4	3	3
VGB-THGA	3	4	3	2	1
UNIOVI	5	4	3	2	1
CERTH	5	4	3	2	2
Average	4,4	4,2	3,6	2,2	1,6

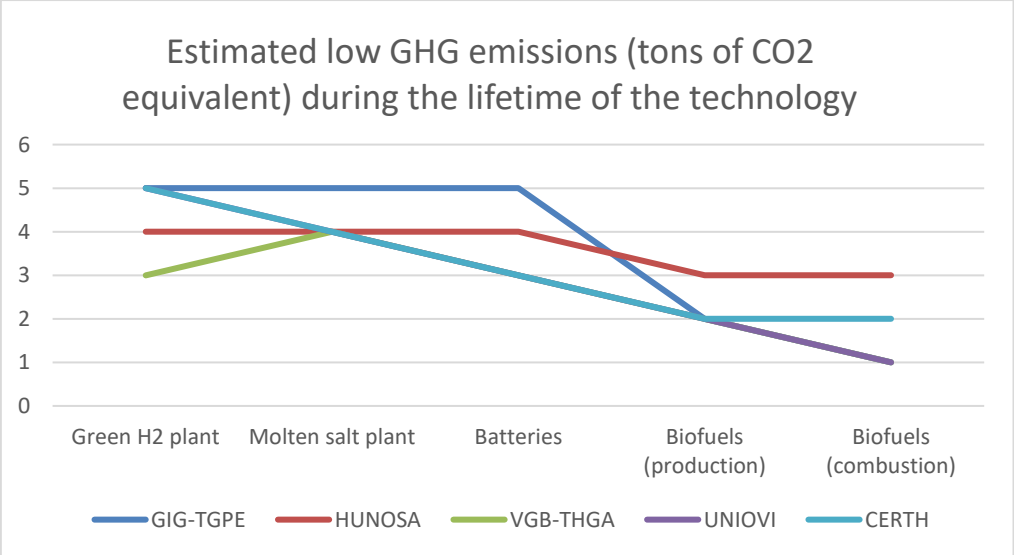

Figure 3-8. Graph of result of scenarios output for indicator "Estimated low GHG emissions (tons of CO_2 equivalent) during the lifetime of the technology" after first Delphi survey

3.9 "Tons" of recycled waste (more waste, lower value)

The results for the indicator "Tons of recycled waste (more waste, lower value)", from the first Delphi survey, are shown in Table 3-9 and Figure 3-9. The results that were consulted in the second Delphi survey (deviated from the average) are highlighted in yellow.

Table 3-9. Result of scenarios output for indicator "Tons of recycled waste (more waste, lower value" after first Delphi survey

"Tons" of recycled waste (more waste, lower value)	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	3	3	1	3	1
HUNOSA	5	3	1	2	1
VGB-THGA	1	1	1	1	1
UNIOVI	5	2	1	2	1
CERTH	4	4	1	3	2
Average	3,6	2,6	1	2,2	1,2

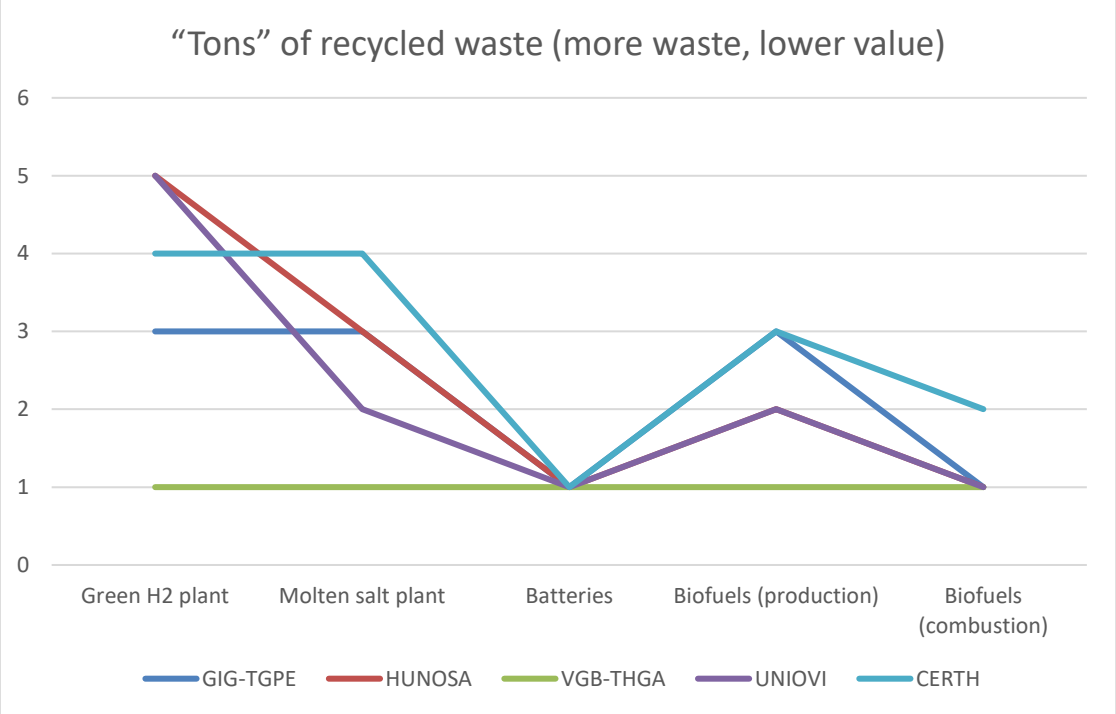

Figure 3-9. Graph of result of scenarios output for indicator "Tons of recycled waste (more waste, lower value" after first Delphi survey

3.10 Space required to develop the option (more space lower value)

The results for the indicator "Space required to develop the option (more space lower value)", from the first Delphi survey, are shown in Table 3-10 and Figure 3-10. The results that were consulted in the second Delphi survey (deviated from the average) are highlighted in yellow.

Table 3-10. Result of scenarios output for indicator "Space required to develop the option (more space lower value)" after first Delphi survey

Space required to develop the option (more space lower value)	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	2	3,5	5	1	1
HUNOSA	2	1	4	3	4
VGB-THGA	3	3	4	2	2
UNIOVI	2	5	4	2	1
CERTH	3	3	4	2	3
Average	2,4	3	4,2	2	2,2

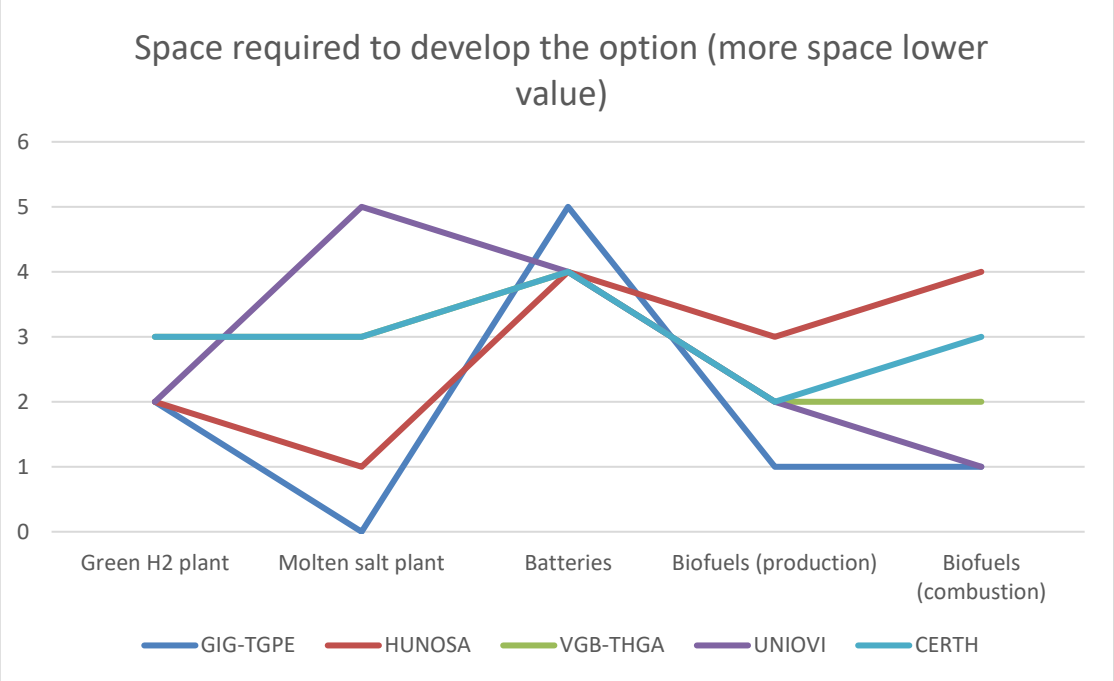

Figure 3-10. Graph of result of scenarios output for indicator "Space required to develop the option (more space lower value)" after first Delphi survey

3.11 Improvement of quality of offered services within the eco-industrial park

The results for the indicator "Improvement of quality of offered services within the eco-industrial park", from the first Delphi survey, are shown in Table 3-11 and Figure 3-11. The results that were consulted in the second Delphi survey (deviated from the average) are highlighted in yellow.

Table 3-11. Result of scenarios output for indicator "Improvement of quality of offered services within the eco-industrial park" after first Delphi survey

Improvement of quality of offered services within the eco-industrial park	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	3	4	5	4	4
HUNOSA	4	2	2	4	4
VGB-THGA	3	2	4	3	2
UNIOVI	5	3	2	1	4
CERTH	5	5	2	4	4
Average	4	3,2	3	3,2	3,6

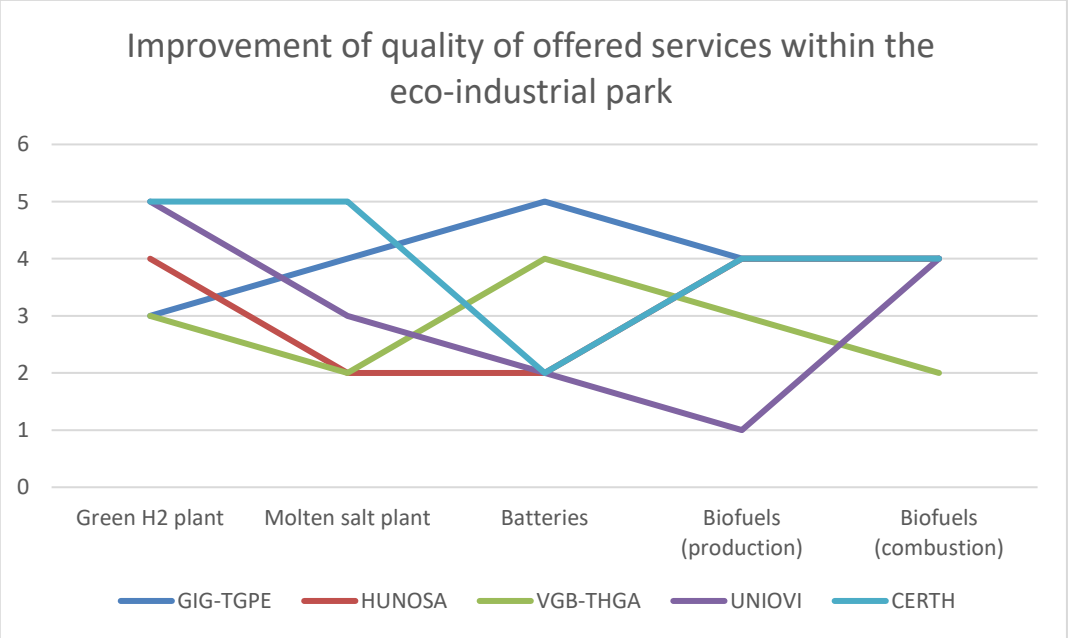

Figure 3-11. Graph of result of scenarios output for indicator "Improvement of quality of offered services within the eco-industrial park" after first Delphi survey

3.12 Benefits/return on investments (CAPEX and OPEX are considered)

The results for the indicator "Benefits/return on investments (CAPEX and OPEX are considered)", from the first Delphi survey, are shown in Table 3-12 and Figure 3-12. The results that were consulted in the second Delphi survey (deviated from the average) are highlighted in yellow.

Table 3-12. Result of scenarios output for indicator "Benefits/return on investments (CAPEX and OPEX are considered)" after first Delphi survey

Benefits/return on investments (CAPEX and OPEX are considered)	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	4	3	5	4	4
HUNOSA	2	3	3	3	5
VGB-THGA	3	2	4	3	3
UNIOVI	3	3	2	3	4
CERTH	4	3	2	3	3
Average	3,2	2,8	3,2	3,2	3,8

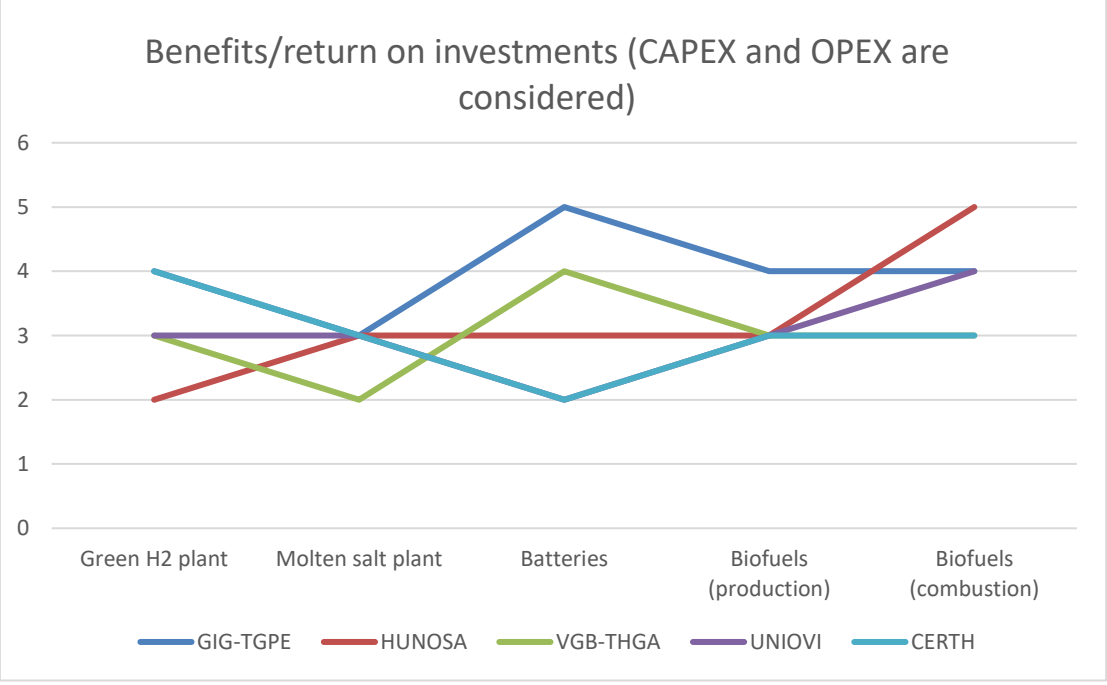

Figure 3-12. Graph of result of scenarios output for indicator "Benefits/return on investments (CAPEX and OPEX are considered)" after first Delphi survey

3.13 Potential to stimulate other business activities

The results for the indicator "Potential to stimulate other business activities", from the first Delphi survey, are shown in Table 3-13 and Figure 3-13. The results that were consulted in the second Delphi survey (deviated from the average) are highlighted in yellow.

Table 3-13. Result of scenarios output for indicator "Potential to stimulate other business activities" after first Delphi survey

Potential to stimulate other business activities	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	4,5	2,5	2	5	4
HUNOSA	5	2	2	5	4
VGB-THGA	5	2	5	3	2
UNIOVI	5	2	2	4	2
CERTH	4	4	3	3	3
Average	4,7	2,5	2,8	4	3

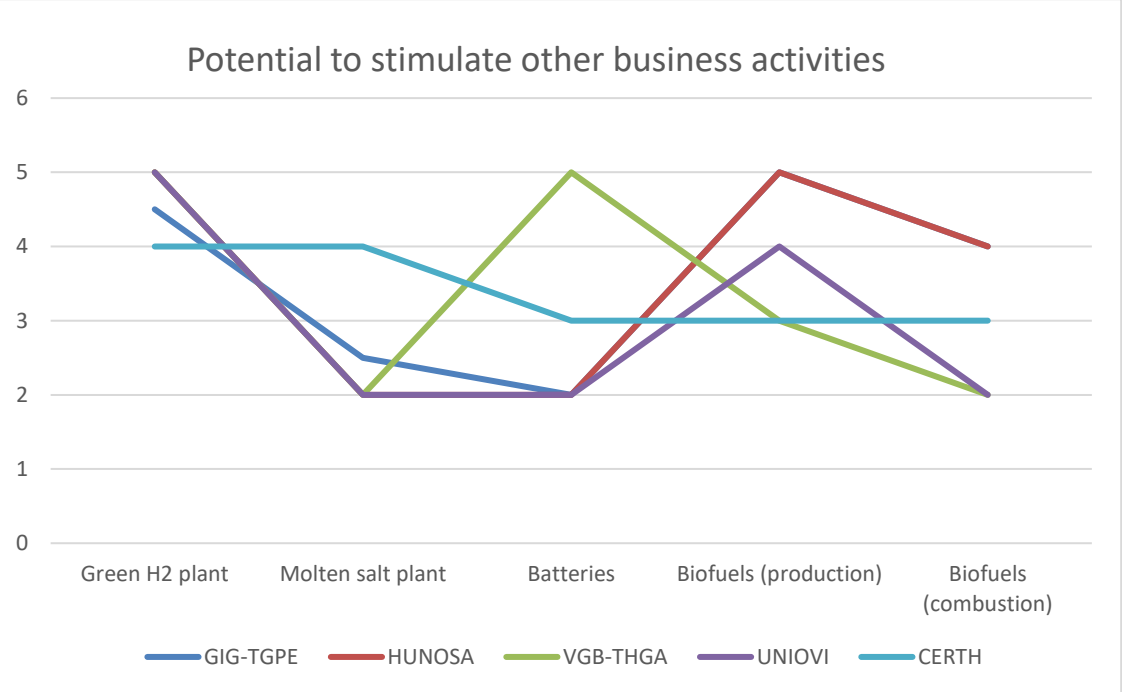

Figure 3-13. Graph of result of scenarios output for indicator "Potential to stimulate other business activities" after first Delphi survey

3.14 Energy security degree (independency)

The results for the indicator "Energy security degree (independency)", from the first Delphi survey, are shown in Table 3-14 and Figure 3-14. The results that were consulted in the second Delphi survey (deviated from the average) are highlighted in yellow.

Table 3-14. Result of scenarios output for indicator "Energy security degree (independency)" after first Delphi survey

Energy security degree (independency)	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	3	4	5	5	5
HUNOSA	5	4	5	5	4
VGB-THGA	4	3	4	2	3
UNIOVI	4	3	2	5	5
CERTH	4	4	2	4	5
Average	4	3,6	3,6	4,2	4,4

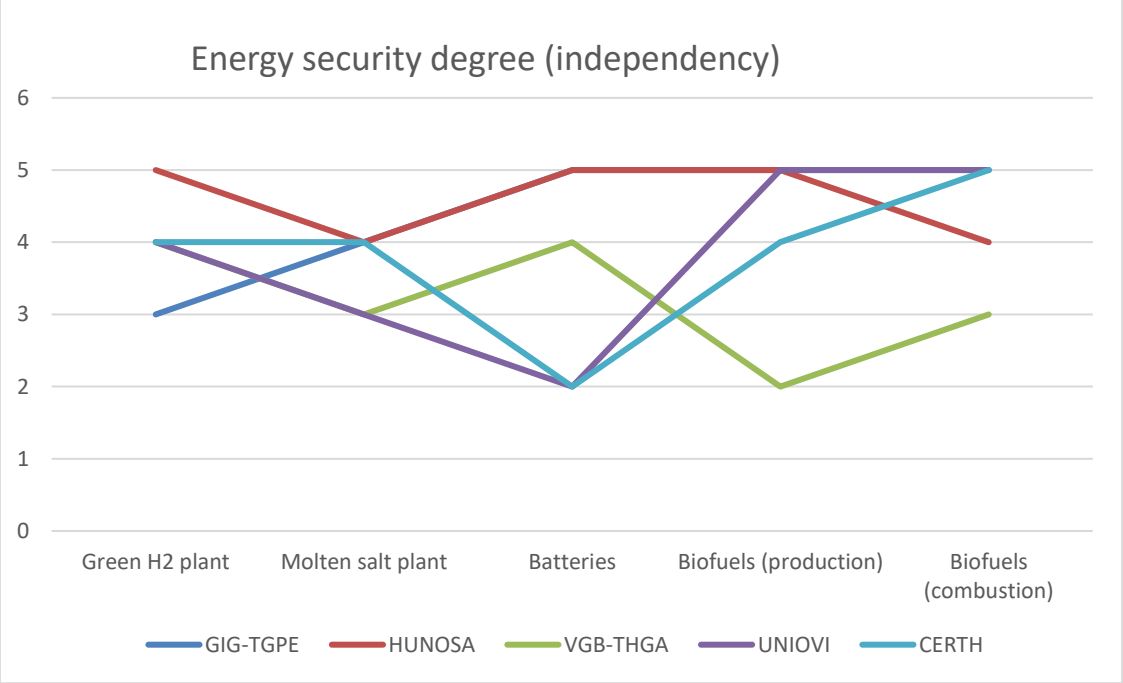

Figure 3-14. Graph of result of scenarios output for indicator "Energy security degree (independency)" after first Delphi survey

3.15 Reduction of environmental impact - LCA (higher impact, lower value)

The results for the indicator "Reduction of environmental impact - LCA (higher impact, lower value)", from the first Delphi survey, are shown in Table 3-15 and Figure 3-15. The results that were consulted in the second Delphi survey (deviated from the average) are highlighted in yellow.

Table 3-15. Result of scenarios output for indicator "Reduction of environmental impact - LCA (higher impact, lower value)" after first Delphi survey

Reduction of environmental impact - LCA (higher impact, lower value)	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	3,5	3	2	2	1
HUNOSA	5	4	1	2	1
VGB-THGA	5	5	4	3	2
UNIOVI	5	5	4	3	2
CERTH	3	3	3	2	3
Average	4,5	4,25	3	2,5	2

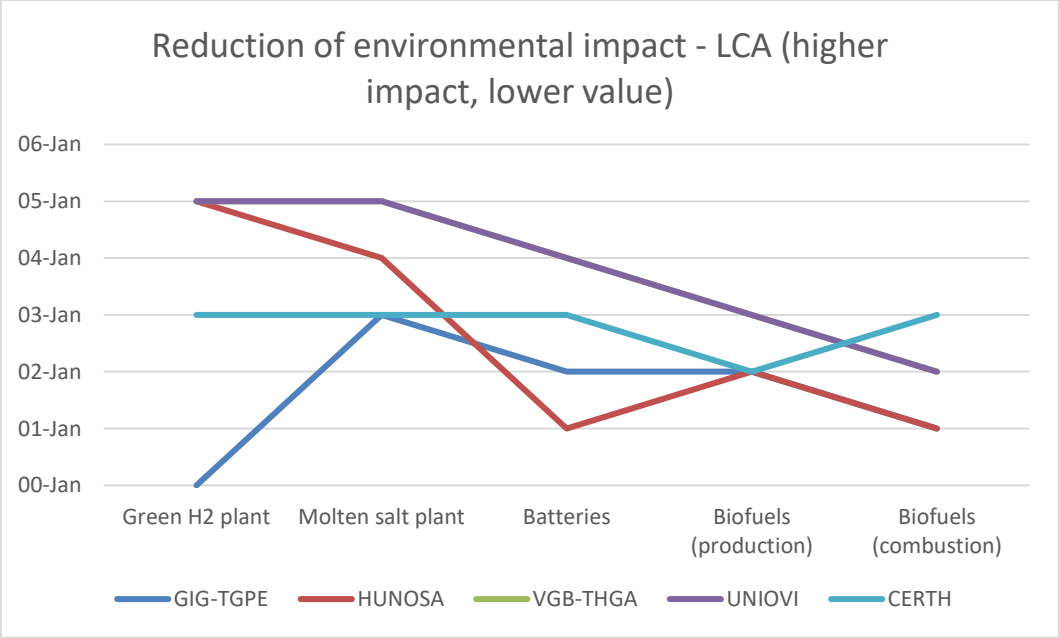

Figure 3-15. Graph of result of scenarios output for indicator "Reduction of environmental impact - LCA (higher impact, lower value)" after first Delphi survey

3.16 Environmental impact at the place of operation (higher impact, lower value)

The results for the indicator "Environmental impact at the place of operation (higher impact, lower value)", from the first Delphi survey, are shown in Table 3-16 and Figure 3-16. The results that were consulted in the second Delphi survey (deviated from the average) are highlighted in yellow.

Table 3-16. Result of scenarios output for indicator "Environmental impact at the place of operation (higher impact, lower value)" after first Delphi survey

Environmental impact at the place of operation (higher impact, lower value)	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	3	3	5	2	1
HUNOSA	4	2	3	2	1
VGB-THGA	5	5	5	4	2
UNIOVI	5	4	3	2	1
CERTH	4	4	4	3	2
Average	4,2	3,6	4	2,6	1,4

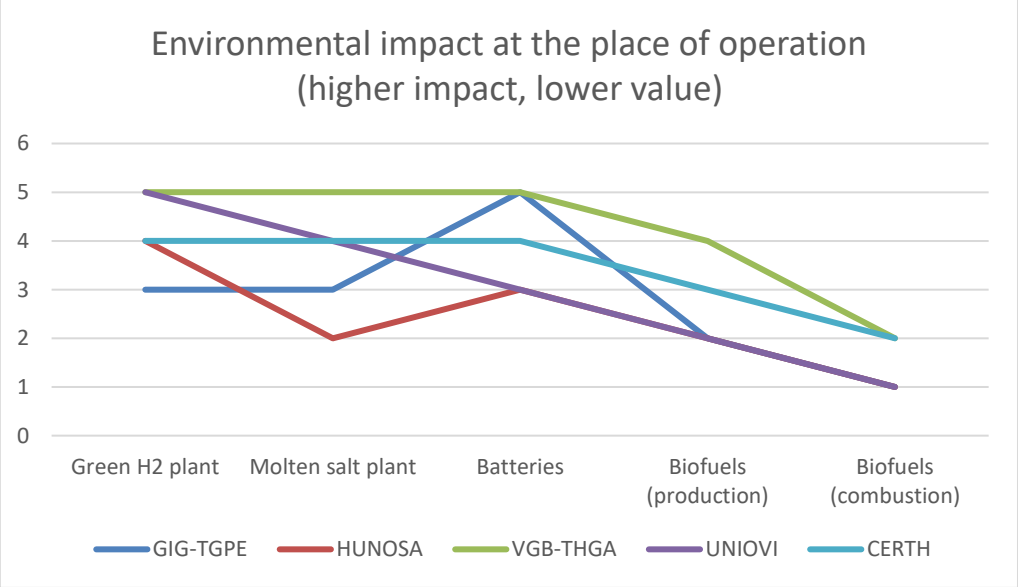

Figure 3-16. Graph of result of scenarios output for indicator "Environmental impact at the place of operation (higher impact, lower value)" after first Delphi survey

3.17 Increased competitiveness of the region

The results for the indicator "Increased competitiveness of the region", from the first Delphi survey, are shown in Table 3-17 and Figure 3-17. The results that were consulted in the second Delphi survey (deviated from the average) are highlighted in yellow.

Table 3-17. Result of scenarios output for indicator "Increased competitiveness of the region" after first Delphi survey

Increased competitiveness of the region	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	4	2	2	5	4
HUNOSA	5	2	2	5	4
VGB-THGA	4	3	4	4	3
UNIOVI	5	3	2	4	5
CERTH	4	4	3	4	4
Average	4,4	2,8	2,6	4,4	4

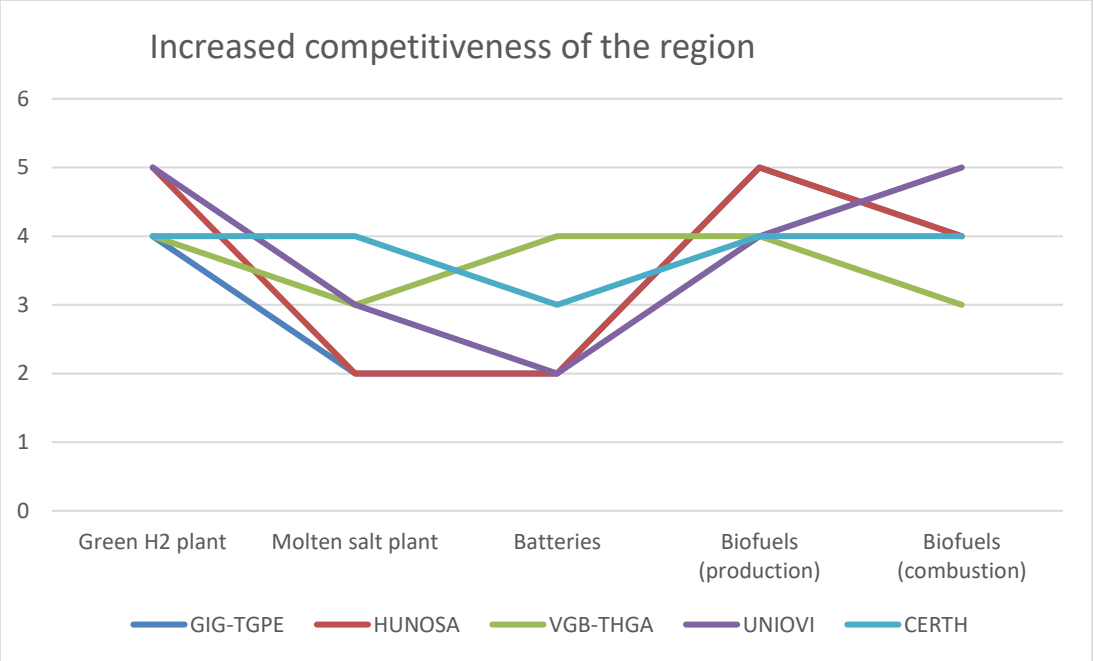

Figure 3-17. Graph of result of scenarios output for indicator "Increased competitiveness of the region" after first Delphi survey

4 Second round Delphi survey - business models outputs and result indicators

Outputs and results indicators - consensus after second Delphi surveys the March 17, 2023 meeting – are described below.

4.1 Full-Time Employment creation

After discussion for molten salt plant business model GIG-TGPE changed the value of the indicator “Full-Time Employment creation” from 5 (high) to 4 (medium-high).

After discussion for molten salt plant business model UNIOVI remained at its indicator “Full-Time Employment creation” value of 2 (medium-low) - action will not result in a significant increase in full-time employment.

After discussion for biofuels (combustion) business model CERTH changed the value of the indicator “Full-Time Employment creation” from 2 (medium-low) to 3 (medium) - new plant results in more employees.

4.2 Full-Time new researchers

After discussion for green H_2 plant business model GIG-TGPE changed the value of the indicator “Full-Time new researchers” from 5 (high) to 4 (medium-high).

After discussion for green H_2 plant business model HUNOSA changed the value of the indicator “Full-Time new researchers” from 1 (low) to 2 (medium-low) - no need to create new jobs for new scientists/specialists.

After discussion for biofuels (production) business model HUNOSA changed the value of the indicator “Full-Time new researchers” from 5 (high) to 4 (medium-high).

After discussion for biofuels (combustion) business model HUNOSA changed the value of the indicator “Full-Time new researchers” from 5 (high) to 4 (medium-high).

4.3 Companies introducing process/product innovations

After discussion for batteries business model VGBE-THGA remained at its indicator “Companies introducing process/product innovations” value of 4 (medium-high) - action will have a high potential, recycling of batteries will be important (“second hand”).

After discussion for batteries business model UNIOVI remained at its indicator “Companies introducing process/product innovations” value of 1 (low) - action comparison with the hydrogen plant.

After discussion for biofuels (production) business model UNIOVI remained at its indicator “Companies introducing process/product innovations” value of 2 (medium-low) - action comparison with the hydrogen plant.

After discussion for biofuels (production) business model UNIOVI changed the value of the indicator “Companies introducing process/product innovations” from 1 (low) to 2 (medium-low) - action comparison with the hydrogen plant.

4.4 Patent applications submitted to EPO

After discussion for batteries model business GIG-TGPE changed the value of the indicator “Patent applications submitted to EPO” from 4 (medium-high) to 3 (medium).

After discussion for batteries model business UNIOVI changed the value of the indicator “Patent applications submitted to EPO” from 1 (low) to 2 (medium-low).

After discussion for biofuels (production) model business UNIOVI changed the value of the indicator “Patent applications submitted to EPO” from 1 (low) to 2 (medium-low).

4.5 Energy users connected to smart grids

After discussion for batteries model business GIG-TGPE changed the value of the indicator “Energy users connected to smart grids” from 4 (medium-high) to 3 (medium).

After discussion for green H_2 plant business model UNIOVI remained at its indicator “Energy users connected to smart grids” value of 5 (high).

After discussion for green H_2 plant model business VGB-THGA changed the value of the indicator “Energy users connected to smart grids” from 1 (low) to 3 (medium) - will not significantly affect capacity, depends on what we expect (energy storage, powering public transportation).

After discussion for molten salt plant model business VGB-THGA changed the value of the indicator “Energy users connected to smart grids” from 1 (low) to 3 (medium) - will not significantly affect capacity, depends on what we expect (energy storage, powering public transportation).

After discussion for batteries model business UNIOVI changed the value of the indicator “Energy users connected to smart grids” from 2 (medium-low) to 3 (medium).

4.6 Capacity of renewable energy production installed and connected to the network

After discussion for green H2 plant business model UNIOVI remained at its indicator "Capacity of renewable energy production installed and connected to the network" value of 1 (low).

After discussion for molten salt plant model business VGB-THGA changed the value of the indicator "Capacity of renewable energy production installed and connected to the network" from 2 (medium-low) to 3 (medium).

After discussion for batteries business model UNIOVI remained at its indicator "Capacity of renewable energy production installed and connected to the network" value of 2 (medium-low)

After discussion for biofuels (production) model business GIG-TGPE changed the value of the indicator "Capacity of renewable energy production installed and connected to the network" from 5 (high) to 3 (medium).

After discussion for biofuels (combustion) model business VGB-THGA changed the value of the indicator "Capacity of renewable energy production installed and connected to the network" from 2 (medium-low) to 3 (medium).

4.7 Energy efficiency (support for the smart grid)

After discussion for green H2 plant business model HUNOSA remained at its indicator "Energy efficiency (support for the smart grid)" value of 3 (medium).

After discussion for molten salt plant model business VGB-THGA changed the value of the indicator "Energy efficiency (support for the smart grid)" from 2 (medium-low) to 3 (medium).

After discussion for biofuels (combustion) business model UNIOVI remained at its indicator "Energy efficiency (support for the smart grid)" value of 5 (high) - production of a large amount of energy.

4.8 Estimated low GHG emissions (tons of CO_2 equivalent) during the lifetime of the technology

After discussion for batteries business model GIG-TGPE remained at its indicator "Estimated low GHG emissions (tons of CO_2 equivalent) during the lifetime of the technology" value of 5 (high) – high GHG emissions for batteries only during their production.

After discussion for green H_2 plant model business VGB-THGA changed the value of the indicator "Estimated low GHG emissions (tons of CO_2 equivalent) during the lifetime of the technology" from 3 (medium) to 4 (medium-high).

4.9 "Tons" of recycled waste (more waste, lower value)

After discussion for green H_2 plant model business VGB-THGA changed the value of the indicator "Tons of recycled waste (more waste, lower value)" from 1 (low) to 3 (medium) - waste to be recycled are generated.

After discussion for molten salt plant model business VGB-THGA changed the value of the indicator "Tons of recycled waste (more waste, lower value)" from 1 (low) to 3 (medium) - waste to be recycled are generated.

After discussion for biofuels (production) model business VGB-THGA changed the value of the indicator "Tons of recycled waste (more waste, lower value)" from 1 (low) to 3 (medium) - waste to be recycled are generated.

4.10 Space required to develop the option (more space lower value)

After discussion for molten salt plant model business HUNOSA changed the value of the indicator "Space required to develop the option (more space lower value)" from 1 (low) to 2,5 (between medium-low, and medium).

After discussion for molten salt plant model business UNIOVI changed the value of the indicator "Space required to develop the option (more space lower value)" from 5 (high) 4 (medium-high) - space is needed for this business model, but not much more than for others (e.g., batteries)

After discussion for biofuels (production) model business GIG-TGPE changed the value of the indicator "Space required to develop the option (more space lower value)" from 1 (low) to 2 (medium-low) – space is required for biofuels production.

After discussion for biofuels (combustion) model business GIG-TGPE changed the value of the indicator "Space required to develop the option (more space lower value)" from 1 (low) to 2 (medium-low) – space is required for biofuels combustion.

After discussion for biofuels (combustion) model business HUNOSA changed the value of the indicator "Space required to develop the option (more space lower value)" from 4 (medium-high) to 3 (medium) – it is not really big technology in aspect of space needed.

4.11 Improvement of quality of offered services within the eco-industrial park

After discussion for molten salt plant business model CERTH changed the value of the indicator "Improvement of quality of offered services within the eco-industrial park" from 5 (high) to 4 (medium-high).

After discussion for batteries business model GIG-TGPE changed the value of the indicator "Improvement of quality of offered services within the eco-industrial park" from 5 (high) to 4 (medium-high).

After discussion for biofuels (production) business model UNIOVI changed the value of the indicator "Improvement of quality of offered services within the eco-industrial park" from 1 (low) to 2 (medium-low).

After discussion for biofuels (combustion) business model GIG-TGPE changed the value of the indicator "Improvement of quality of offered services within the eco-industrial park" from 2 (medium-low) to 3 (medium).

4.12 Benefits/return on investments (CAPEX and OPEX are considered)

After discussion for green H_2 plant business model HUNOSA remained at its indicator "Benefits/return on investments (CAPEX and OPEX are considered)" value of 2 (medium-low) – not a high benefits/return on investments from their point of view.

After discussion for batteries business model GIG-TGPE changed the value of the indicator "Benefits/return on investments (CAPEX and OPEX are considered)" from 5 (high) to 4 (medium-high).

After discussion for biofuels (combustion) business model GIG-TGPE changed the value of the indicator "Benefits/return on investments (CAPEX and OPEX are considered)" from 5 (high) to 4,5 (between high, and medium-high).

4.13 Potential to stimulate other business activities

After discussion for molten salt plant business model GIG-TGPE changed the value of the indicator "Benefits/return on investments (CAPEX and OPEX are considered)" from 4 (medium-high) to 4 (medium).

After discussion for batteries business model HUNOSA remained at its indicator "Potential to stimulate other business activities" value of 5 (high) – increasing the other activities.

4.14 Energy security degree (independency)

After discussion for green H2 plant business model HUNOSA remained at its indicator "Energy security degree (independency)" value of 5 (high) – storage solution, important role for energy security.

After discussion for batteries business model UNIOVI changed the value of the indicator "Energy security degree (independency)" from 2 (medium-low) to 3 (medium).

After discussion for batteries business model CERTH changed the value of the indicator "Energy security degree (independency)" from 2 (medium-low) to 3 (medium).

After discussion for biofuels (production) business model VGB-THGA changed the value of the indicator "Energy security degree (independency)" from 2 (medium-low) to 3 (medium).

After discussion for biofuels (combustion) business model VGB-THGA changed the value of the indicator "Energy security degree (independency)" from 3 (medium) to 4 (medium-high).

4.15 Reduction of environmental impact - LCA (higher impact, lower value)

After discussion for green H_2 plant business model CERTH changed the value of the indicator "Reduction of environmental impact - LCA (higher impact, lower value)" from 3 (medium) to 4 (medium-high) - there is not enough information on this variant.

After discussion for batteries business model HUNOSA changed the value of the indicator "Reduction of environmental impact - LCA (higher impact, lower value)" from 1 (low) to 2 (medium-low) - In this aspect, the components of the battery are important.

4.16 Environmental impact at the place of operation (higher impact, lower value)

After discussion for molten salt plant business model UNIOVI changed the value of the indicator "Environmental impact at the place of operation (higher impact, lower value)" from 2 (medium-low) to 3 (medium).

After discussion for biofuels (production) business model UNIOVI changed the value of the indicator "Environmental impact at the place of operation (higher impact, lower value)" from 4 (medium-high) to 3 (medium) – negative impact of biofuels production at the place of operations.

4.17 Increased competitiveness of the region

After discussion for batteries business model VGB-THGA changed the value of the indicator “Increased competitiveness of the region” from 4 (medium-high) to 3 (medium) – not a high influence for increased competitiveness of the region.

5 Final results – after second Delphi survey

Below are the results obtained from two stages of Delphi expert surveys.

5.1 Full-Time Employment creation

The final results for the indicator "Full Time Employment creation" (after second Delphi survey) are shown in Table 5-1 and Figure 5-1. The indicator "Full Time Employment creation" is most relevant for the Eco-industrial park (with virtual power plant) combined with biofuels (production), or green H_2 plant, or biofuels (combustion).

Table 5-1. Result of scenarios output for indicator "Full Time Employment creation" final after second Delphi survey

Full-Time Employment creation	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	4	4	1	5	4
HUNOSA	3	3	1	5	4
VGB-THGA	3	3	2	4	4
UNIOVI	5	2	2	4	3
CERTH	4	4	2	4	3
Average	3,8	3,2	1,6	4,4	3,6

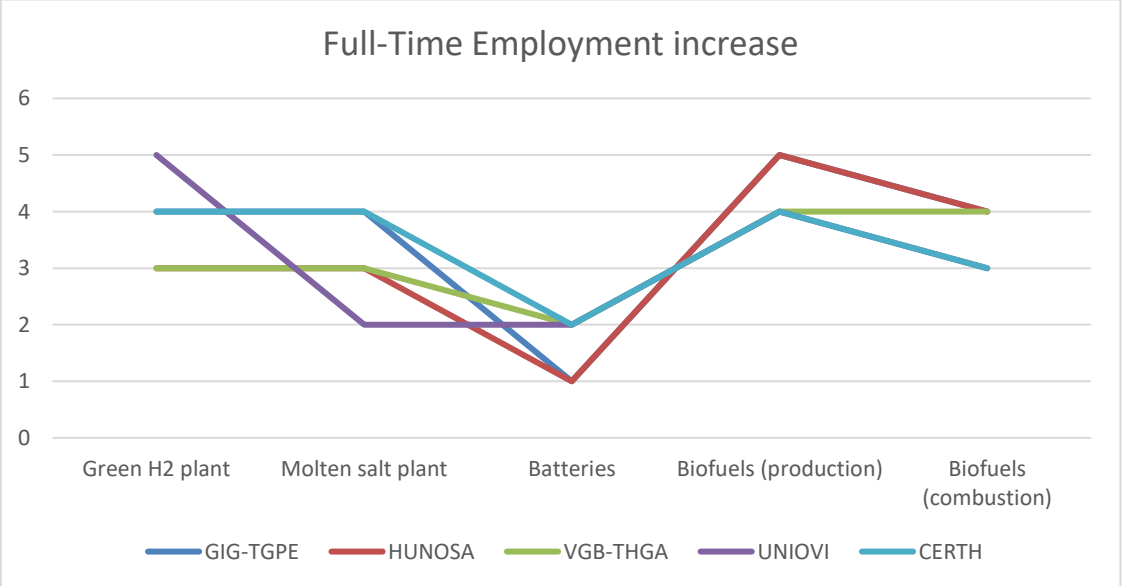

Figure 5-1. Graph of result of scenarios output for indicator "Full Time Employment creation" final after second Delphi survey

5.2 Full-Time new researchers

The final results for the indicator "Full-Time new researchers" (after second Delphi survey) are shown in Table 5-2 and Figure 5-2.

The indicator "Full-Time new researchers" is most relevant for the Eco-industrial park (with virtual power plant) combined with biofuels (production), or green H_2 plant.

Table 5-2. Result of scenarios output for indicator "Full Time new researches" final after second Delphi survey

Full-Time new researchers	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	4	2	1	4	3
HUNOSA	2	1	1	4	4
VGB-THGA	2	1	2	3	1
UNIOVI	3	2	1	2	1
CERTH	4	3	2	2	1
Average	3,0	1,8	1,4	3,0	2,0

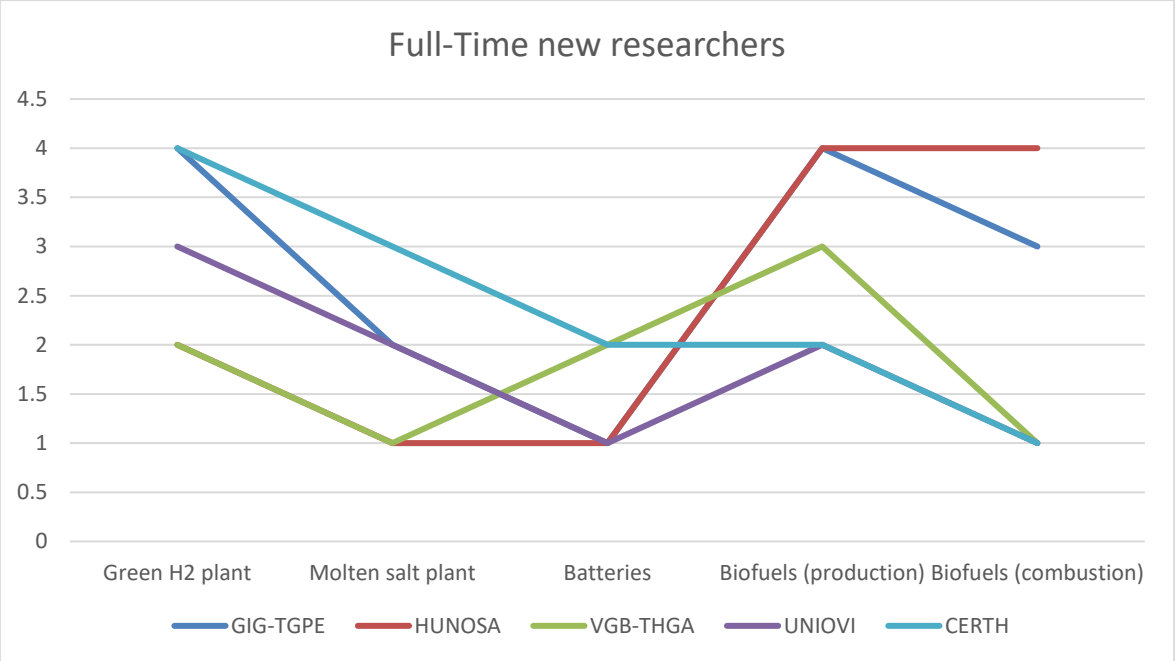

Figure 5-2. Result of scenarios output for indicator "Companies introducing process/product innovations" final after second Delphi survey

5.3 Companies introducing process/product innovations

The final results for the indicator "Companies introducing process/product innovations" (after second Delphi survey) are shown in Table 5-3 and Figure 5.3.

The indicator "Companies introducing process/product innovations" is most relevant for the Eco-industrial park (with virtual power plant) combined with green H_2 plant or biofuels (production).

Table 5-3. Result of scenarios output for indicator "Companies introducing process/product innovations" final after second Delphi survey

Companies introducing process/product innovations	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	4	1	2,5	4	3
HUNOSA	3	3	2	4	3
VGBE-THGA	4	2	4	4	2
UNIOVI	5	1	1	2	2
CERTH	5	3	3	3	2
Average	4,2	2	2,5	3,4	2,4

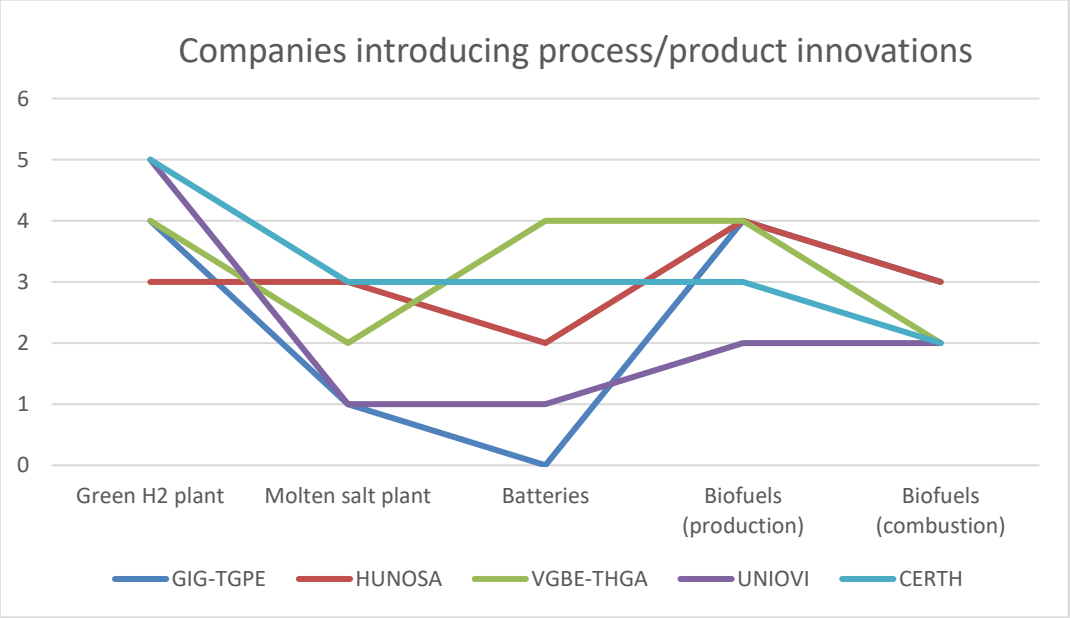

Figure 5-3. Graph of result of scenarios output for indicator "Companies introducing process/product innovations" final after second Delphi survey

5.4 Patent applications submitted to EPO

The final results for the indicator "Patent applications submitted to EPO" (after second Delphi survey) are shown in Table 5-4 and Figure 5-4.

The indicator "Patent applications submitted to EPO" is most relevant for the Eco-industrial park (with virtual power plant) combined with green H_2 plant or biofuels (production).

Table 5-4. Result of scenarios output for indicator "Patent applications submitted to EPO" final after second Delphi survey

Patent applications submitted to EPO	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	4	3	3	4	3
HUNOSA	2	2	1	3	2
VGBE-THGA	3	2	3	4	1
UNIOVI	3	2	2	2	1
CERTH	3	3	2	2	2
Average	3	2,4	2,2	3	1,8

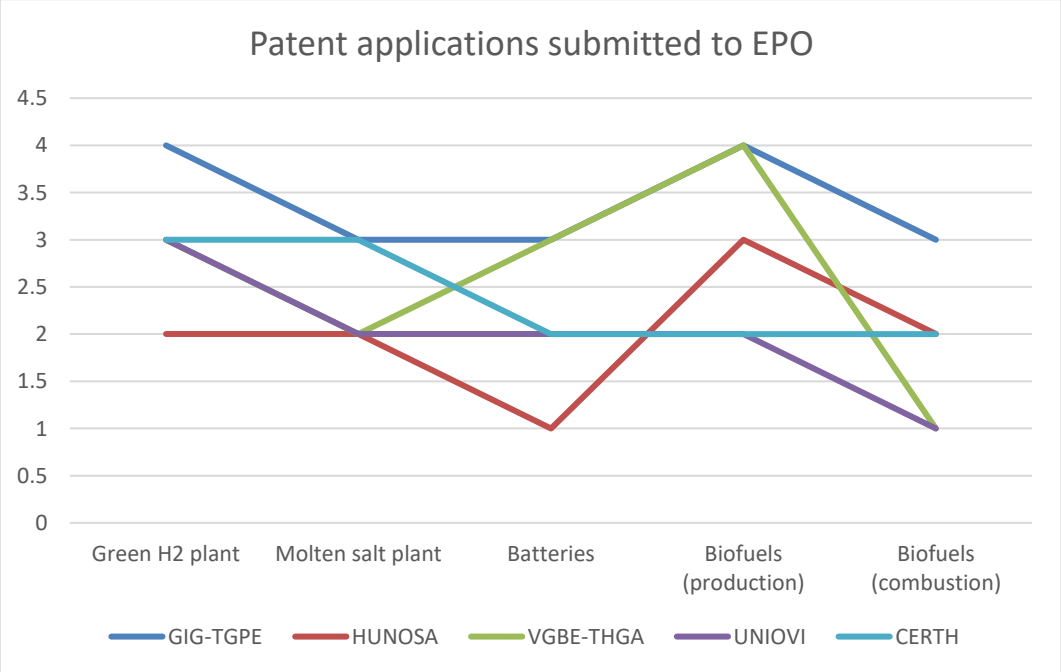

Figure 5-4. Graph of result of scenarios output for indicator "Patent applications submitted to EPO" final after second Delphi survey

5.5 Energy users connected to smart grids

The final results for the indicator "Energy users connected to smart grids" (after second Delphi survey) are shown in Table 5-5 and Figure 5-5.

The indicator "Patent applications submitted to EPO" is most relevant for the Eco-industrial park (with virtual power plant) combined with molten salt plant, or batteries, or green H_2 plant.

Table 5-5. Result of scenarios output for indicator "Energy users connected to smart grid" final after second Delphi survey

Energy users connected to smart grids	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	3	5	5	3	3
HUNOSA	5	5	5	1	3
VGB-THGA	3	3	3	1	1
UNIOVI	3	3	3	1	2
CERTH	4	3	3	2	3
Average	3,6	3,8	3,8	1,6	2,4

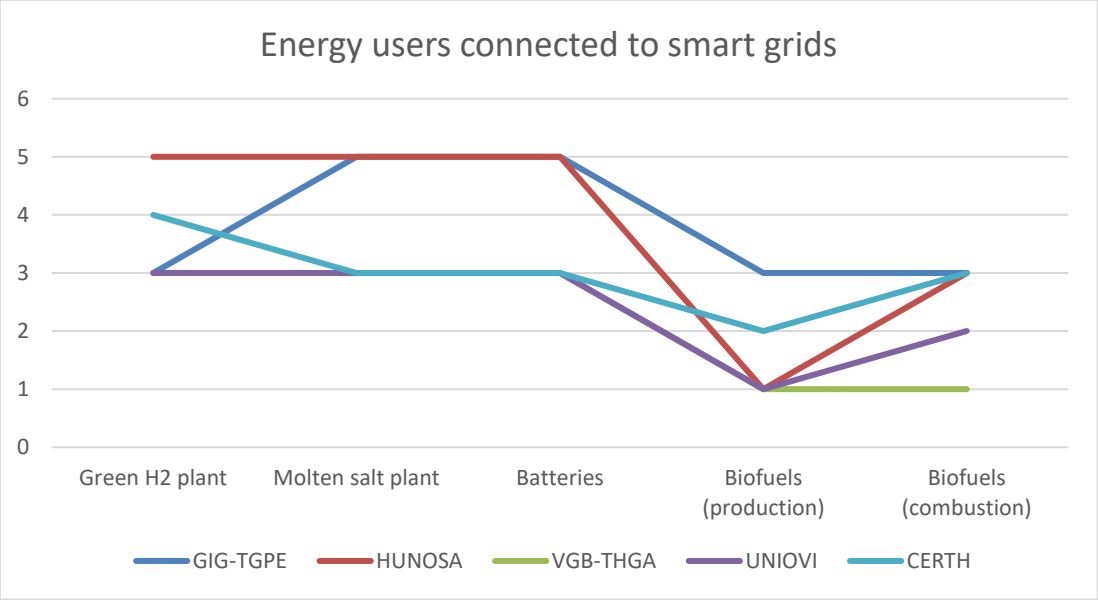

Figure 5-5. Graph of result of scenarios output for indicator "Energy users connected to smart grid" final after second Delphi survey

5.6 Capacity of renewable energy production installed and connected to the network

The final results for the indicator "Capacity of renewable energy production installed and connected to the network" (after second Delphi survey) are shown in Table 5-6 and Figure 5-6. The indicator "Capacity of renewable energy production installed and connected to the network" is most relevant for the Eco-industrial park (with virtual power plant) combined with molten salt plant, or batteries, or green H_2 plant.

Table 5-6. Result of scenarios output for indicator "Capacity of renewable energy production installed and connected to the network" final after second Delphi survey

Capacity of renewable energy production	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	5	5	4	3	4
HUNOSA	5	5	5	1	4
VGBE-THGA	3	3	4	4	3
UNIOVI	1	3	2	1	3
CERTH	4	5	3	2	3
Average	3,6	4,2	3,6	2,2	3,4

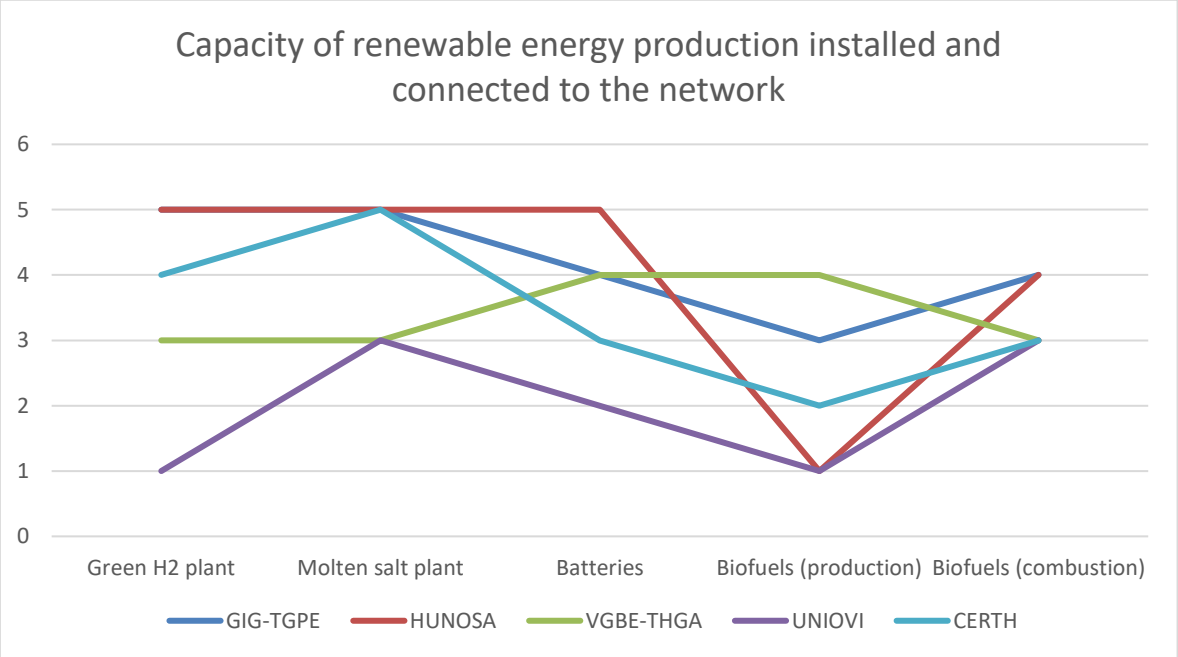

Figure 5-6. Graph of result of scenarios output for indicator "Capacity of renewable energy production installed and connected to the network" final after second Delphi survey

5.7 Energy efficiency (support for the smart grid)

The final results for the indicator "Energy efficiency (support for the smart grid)" (after second Delphi survey) are shown in Table 5-7 and Figure 5-7.

The indicator "Energy efficiency (support for the smart grid)" is most relevant for the Eco-industrial park (with virtual power plant) combined with molten salt plant, or biofuels (combustion).

Table 5-7. Result of scenarios output for indicator "Energy efficiency (support for the smart grid)" final after second Delphi survey

Energy efficiency (support for the smart grid)	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	1	4	5	3	3
HUNOSA	3	3	4	1	2
VGBE-THGA	2	3	5	2	3
UNIOVI	1	4	3	1	5
CERTH	2	4	3	2	4
Average	1,8	3,6	4	1,8	3,4

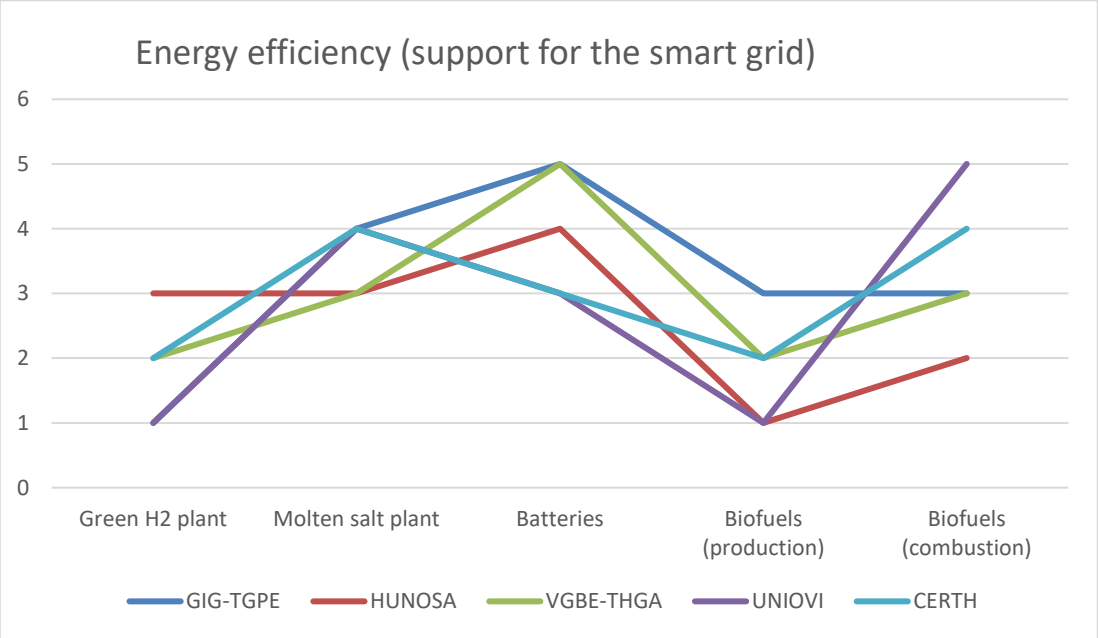

Figure 5-7. Graph of result of scenarios output for indicator "Energy efficiency (support for the smart grid)" final after second Delphi survey

5.8 Estimated low GHG emissions (tons of CO_2 equivalent) during the lifetime of the technology

The final results for the indicator "Estimated low GHG emissions (tons of CO_2 equivalent) during the lifetime of the technology" (after second Delphi survey) are shown in Table 5-8 and Figure 5-8.

The indicator "Estimated low GHG emissions (tons of CO_2 equivalent) during the lifetime of the technology" is most relevant for the Eco-industrial park (with virtual power plant) combined with green H_2 plant, or molten salt plant.

Table 5-8. Result of scenarios output for indicator "Estimated low GHG emissions (tons of CO_2 equivalent) during the lifetime of the technology" final after second Delphi survey

Estimated low GHG emissions (tons of CO_2 equivalent)	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	5	5	5	2	1
HUNOSA	4	4	4	3	3
VGBE-THGA	4	4	3	2	1
UNIOVI	5	4	3	2	1
CERTH	5	4	3	2	2
Average	4,6	4,2	3,6	2,2	1,6

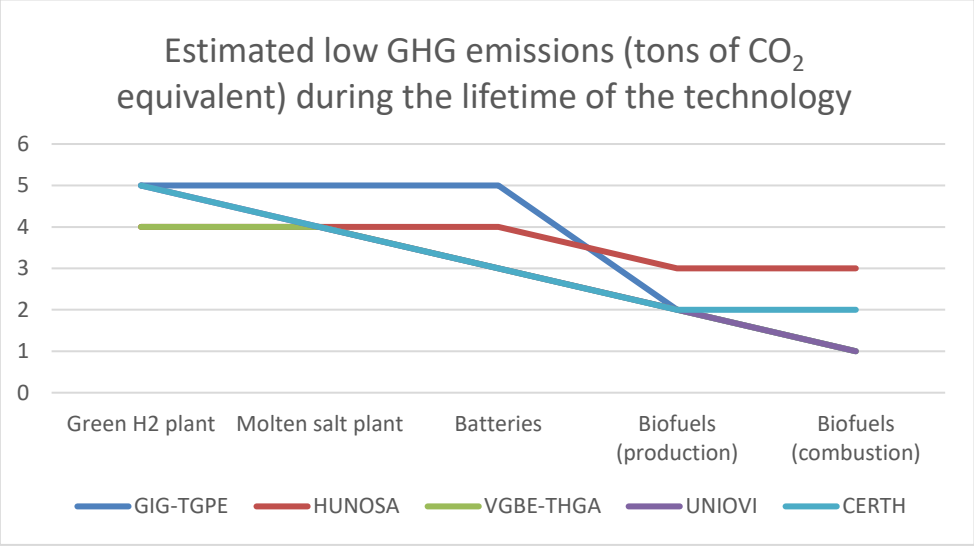

Figure 5-8. Graph of result of scenarios output for indicator "Estimated low GHG emissions (tons of CO_2 equivalent) during technology lifetime" final after second Delphi survey

5.9 "Tons" of recycled waste (more waste, lower value)

The final results for the indicator "Tons of recycled waste (more waste, lower value" (after second Delphi survey) are shown in Table 5-9 and Figure 5-9. The indicator "Tons of recycled waste (more waste, lower value" is most relevant for the Eco-industrial park (with virtual power plant) combined with green H2 plant, or molten salt plant.

Table 5-9. Result of scenarios output for indicator "Tons of recycled waste (more waste, lower value" final after second Delphi survey

"Tons" of recycled waste (more waste, lower value)	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	3	3	1	3	1
HUNOSA	5	3	1	2	1
VGBE-THGA	3	3	1	3	1
UNIOVI	5	2	1	2	1
CERTH	4	4	1	3	2
Average	4	3	1	2,6	1,2

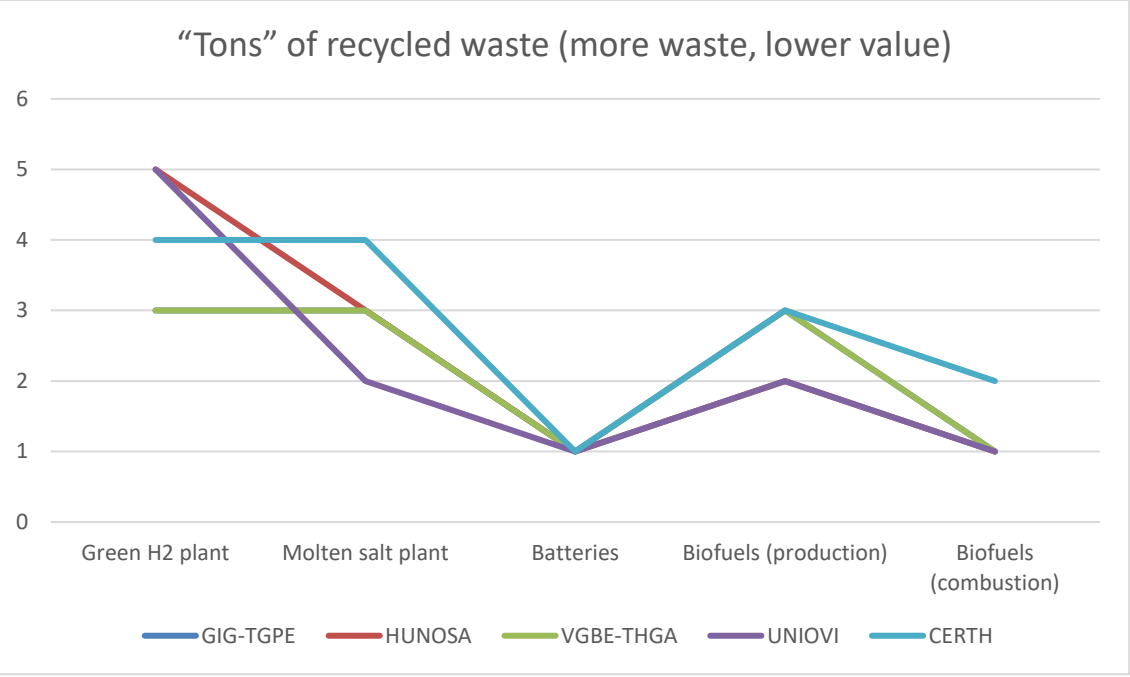

Figure 5-9. Graph of result of scenarios output for indicator "Tons of recycled waste (more waste, lower value" final after second Delphi survey

5.10 Space required to develop the option (more space lower value)

The final results for the indicator "Space required to develop the option (more space lower value)" (after second Delphi survey) are shown in Table 5-10 and Figure 5-10.

The indicator "Space required to develop the option (more space lower value)" is most relevant for the Eco-industrial park (with virtual power plant) combined with batteries.

Table 5-10. Result of scenarios output for indicator "Space required to develop the option (more space lower value)" final after second Delphi survey

Space required to develop the option	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	2	3,5	5	2	2
HUNOSA	2	2,5	4	3	3
VGB-THGA	3	3	4	2	2
UNIOVI	2	4	4	2	1
CERTH	3	3	4	2	3
Average	2,4	3,125	4,2	2,2	2,2

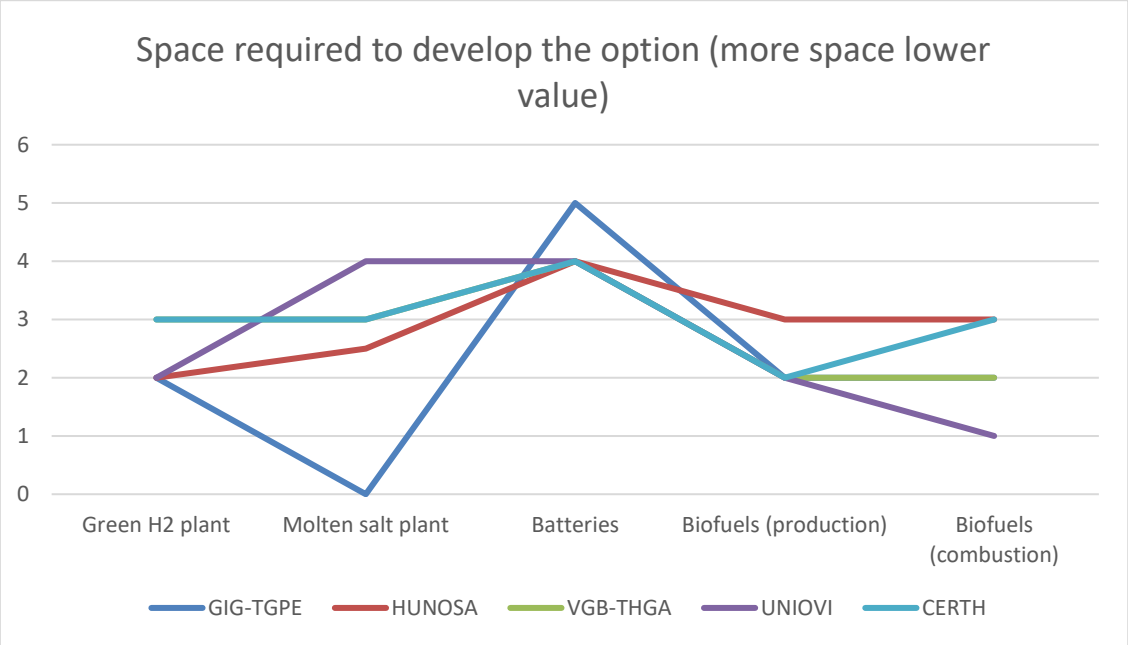

Figure 5-10. Graph of result of scenarios output for indicator "Space required to develop the option (more space lower value)" final after second Delphi survey

5.11 Improvement of quality of offered services within the eco-industrial park

The final results for the indicator "Improvement of quality of offered services within the eco-industrial park" (after second Delphi survey) are shown in Table 5-11 and Figure 5-11. The indicator "Improvement of quality of offered services within the eco-industrial park" is most relevant for the Eco-industrial park (with virtual power plant) combined with green H_2 plant, or biofuels – combustion & production.

Table 5-11. Result of scenarios output for indicator "Improvement of quality of offered services within the eco-industrial park" final after second Delphi survey

Improvement of quality of offered services	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	3	4	4	4	4
HUNOSA	4	2	2	4	4
VGBE-THGA	3	2	4	3	3
UNIOVI	5	3	2	2	4
CERTH	5	4	2	4	4
Average	4	3	2,8	3,4	3,8

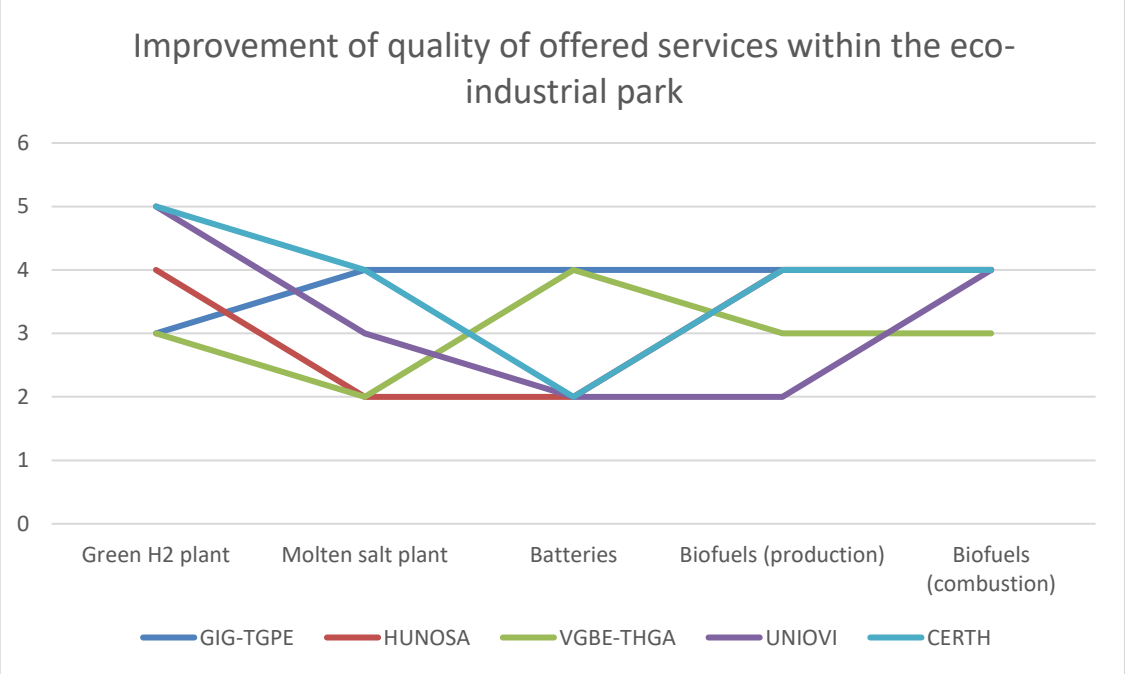

Figure 5-11. Graph of result of scenarios output for indicator "Improvement of quality of offered services within the eco-industrial park" final after second Delphi survey

5.12 Benefits/return on investments (CAPEX and OPEX are considered)

The final results for the indicator "Benefits/return on investments (CAPEX and OPEX are considered)" (after second Delphi survey) are shown in Table 5-12 and Figure 5-12.

The indicator "Benefits/return on investments (CAPEX and OPEX are considered)" is most relevant for the Eco-industrial park (with virtual power plant) combined with biofuels (combustion), or biofuels (production), or green H_2 plant.

Table 5-12. Result of scenarios output for indicator "Benefits/return on investments (CAPEX and OPEX are considered)" final after second Delphi survey

Benefits/return on investments (CAPEX and OPEX are considered)	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	4	3	4	4	4
HUNOSA	2	3	3	3	4,5
VGB-THGA	3	2	4	3	3
UNIOVI	3	3	2	3	4
CERTH	4	3	2	3	3
Average	3,2	2,8	3	3,2	3,7

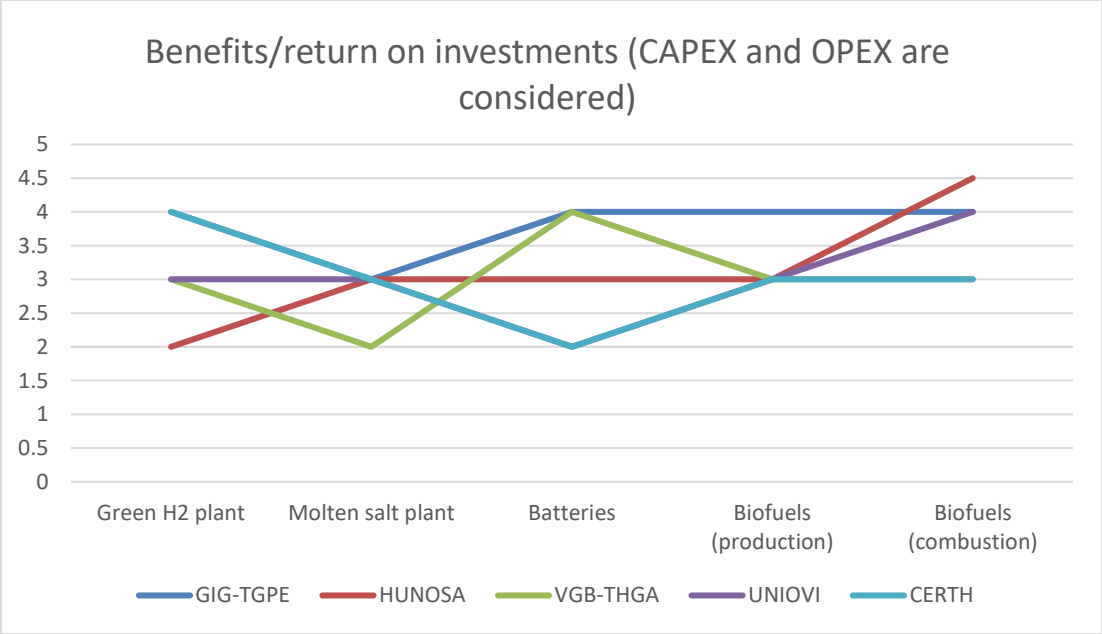

Figure 5-12. Graph of result of scenarios output for indicator "Benefits/return on investments (CAPEX and OPEX are considered)" final after second Delphi survey

5.13 Potential to stimulate other business activities

The final results for the indicator "Potential to stimulate other business activities" (after second Delphi survey) are shown in Table 5-13 and Figure 5-13. The indicator "Potential to stimulate other business activities" is most relevant for the Eco-industrial park (with virtual power plant) combined with green H_2 plant, or biofuels production.

Table 5-13. Result of scenarios output for indicator "Potential to stimulate other business activities" final after second Delphi survey

Potential to stimulate other business activities	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	4,5	2,5	2	5	4
HUNOSA	5	2	2	5	4
VGBE-THGA	5	2	5	3	2
UNIOVI	5	2	2	4	2
CERTH	4	3	3	3	3
Average	4,7	2,3	2,8	4	3

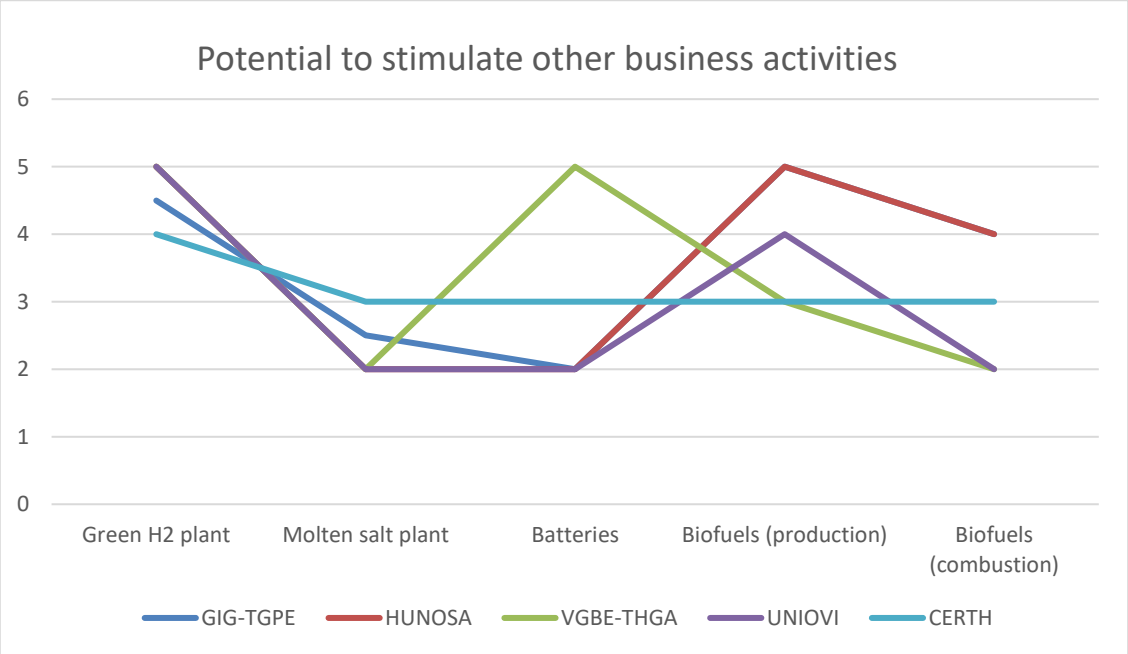

Figure 5-13. Graph of result of scenarios output for indicator "Potential to stimulate other business activities" final after second Delphi survey

5.14 Energy security degree (independency)

The final results for the indicator "Energy security degree (independency)" (after second Delphi survey) are shown in Table 5-14 and Figure 5-14. The indicator "Potential to stimulate other business activities" is most relevant for the Eco-industrial park (with virtual power plant) combined with biofuels combustion and production.

Table 5-14. Result of scenarios output for indicator "Energy security degree (independency)" final after second Delphi survey

Energy security degree (independency)	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	3	4	5	5	5
HUNOSA	5	4	5	5	4
VGBE-THGA	4	3	4	3	4
UNIOVI	4	3	3	5	5
CERTH	4	4	3	4	5
Average	4	3,6	4	4,4	4,6

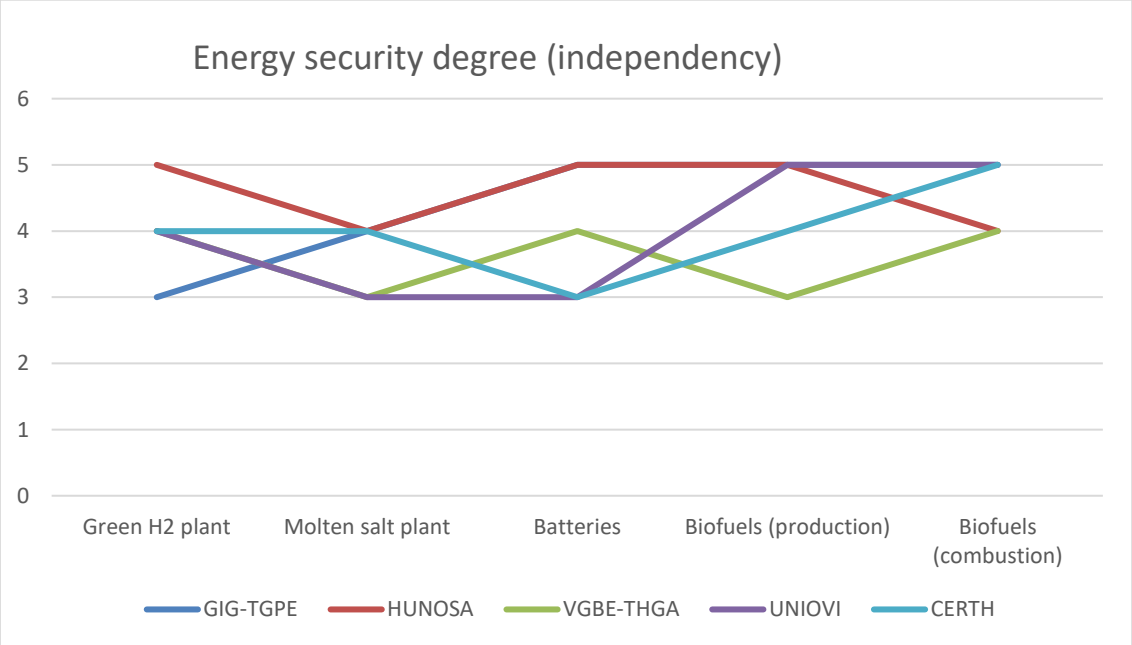

Figure 5-14. Graph of result of scenarios output for indicator "Energy security degree (independency)" final after second Delphi survey

5.15 Reduction of environmental impact - LCA (higher impact, lower value)

The final results for the indicator "Reduction of environmental impact - LCA (higher impact, lower value)" (after second Delphi survey) are shown in Table 5-15 and Figure 5-15. The indicator "Reduction of environmental impact - LCA (higher impact, lower value)" is most relevant for the Eco-industrial park (with virtual power plant) combined with green H_2 plant, or molten salt plant.

Table 5-15. Result of scenarios output for indicator "Reduction of environmental impact - LCA (higher impact, lower value)" final after second Delphi survey

Reduction of environmental impact - LCA	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	3,5	3	2	2	1
HUNOSA	5	4	2	2	1
VGB-THGA	5	5	4	3	2
UNIOVI	5	5	4	3	2
CERTH	4	3	3	2	3
Average	4,75	4,25	3,25	2,5	2

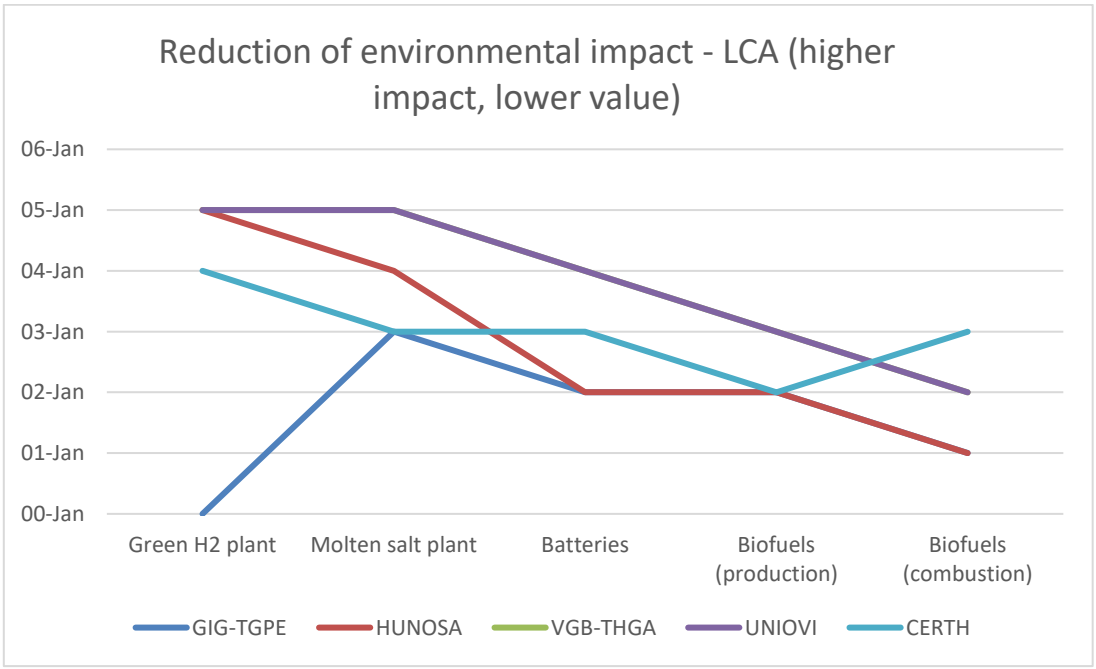

Figure 5-15. Graph of result of scenarios output for indicator "Reduction of environmental impact - LCA (higher impact, lower value)" final after second Delphi survey

5.16 Environmental impact at the place of operation (higher impact, lower value)

The final results for the indicator "Environmental impact at the place of operation (higher impact, lower value)" (after second Delphi survey) are shown in Table 5-16 and Figure 5-16. The indicator "Environmental impact at the place of operation (higher impact, lower value)" is most relevant for the Eco-industrial park (with virtual power plant) combined with green H_2 plant, or batteries, or molten salt plant.

Table 5-16. Result of scenarios output for indicator "Environmental impact at the place of operation (higher impact, lower value)" final after second Delphi survey

Environmental impact at the place of operation	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	3	3	5	2	1
HUNOSA	4	3	3	2	1
VGBE-THGA	5	5	5	3	2
UNIOVI	5	4	3	2	1
CERTH	4	4	4	3	2
Average	4,2	3,8	4	2,4	1,4

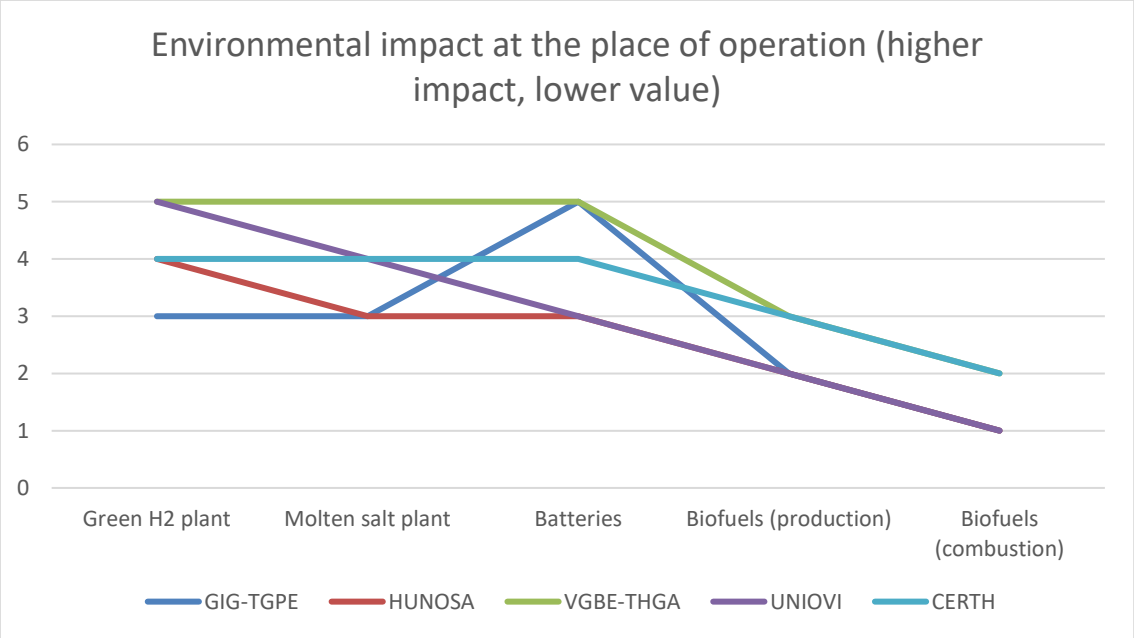

Figure 5-16. Graph of result of scenarios output for indicator "Environmental impact at the place of operation (higher impact, lower value)" final after second Delphi survey

5.17 Increased competitiveness of the region

The final results for the indicator "Increased competitiveness of the region" (after second Delphi survey) are shown in Table 5-16 and Figure 5-16. The indicator "Increased competitiveness of the region" is most relevant for the Eco-industrial park (with virtual power plant) combined with green H_2 plant, or biofuels (production).

Table 5-17. Result of scenarios output for indicator "Increased competitiveness of the region" final after second Delphi survey

Increased competitiveness of the region	Green H_2 plant	Molten salt plant	Batteries	Biofuels (production)	Biofuels (combustion)
GIG-TGPE	4	2	2	5	4
HUNOSA	5	2	2	5	4
VGBE-THGA	4	3	3	4	3
UNIOVI	5	3	2	4	5
CERTH	4	4	3	4	4
Average	4,4	2,8	2,4	4,4	4

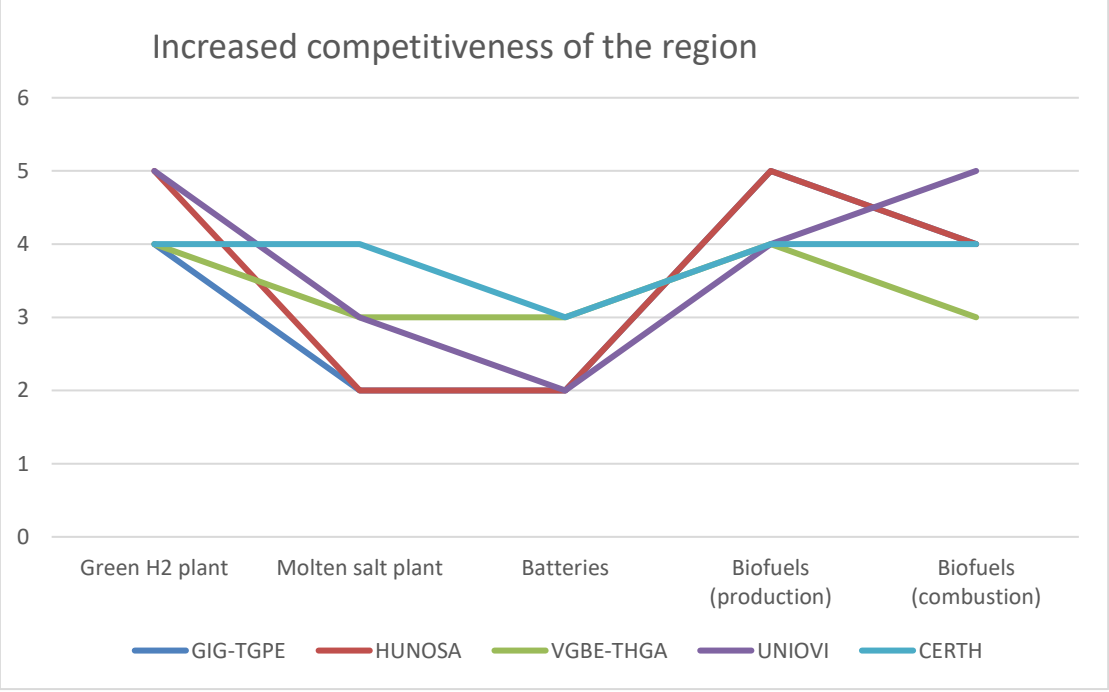

Figure 5-17. Graph of result of scenarios output for indicator "Increased competitiveness of the region" final after second Delphi survey

6 Conclusions and lessons learnt

Considering 17 direct result indicators derived from the targets set by the European Green Deal and related taxonomy and the Regional Policy indicators for the Just Transition Fund, a research for five business models was conducted by means of a Delphi study: (1) Eco-industrial park (with virtual power plant) + green H_2 plant; (2) Eco-industrial park (with virtual power plant) + molten salt plant; (3) Eco-industrial park (with virtual power plant) + batteries; (4) Eco-industrial park (with virtual power plant) + biofuels (production); (5) Eco-industrial park (with virtual power plant) + biofuels (combustion).

The final results are summarized in Table A-1 and Figures A-1 to A-5, presented in the Annex. Taking into account all 17 direct result indicators, the business model that received the highest score is the eco-industrial park (with virtual power plant) and a green H_2 plant.

The greatest added value of this deliverable is the methodology developed to assess scenarios for the use of end-of-life coal mines and coal-fired power plants, along with closely related neighbouring industries. The final results presented in this Deliverable, developed with the use of the above mentioned methodology, has been carried out in accordance with the knowledge and experience of the involved experts and are not site specific. The developed methodology is an important tool for assessing the potential of specific decommissioned mining plants or power plants. Each of the parameters of the analysed system is of significant importance and may influence the final results of the study and, above all, the selection of the most optimal technology.

The lessons relevant to the Project from this deliverable can be summarised as follows:

1. While considering a portfolio of solutions (business models), and although the results obtained are different for individual technologies, none of them should be rejected. The site specific requirements may differ due to the "weighting" of technology for individual locations.

2. To select the scenario outputs and result indicators, the targets set by the European Green Deal and related taxonomy and the Regional Policy indicators for the Just Transition Fund were considered, together with the eleven thematic objectives defined according to European Union (EU) Regulations 1300/2013, 1301/2013 and 1303/2013.

3. The study “"Development of a system of common indicators for European Regional Development Fund and Cohesion Fund interventions after 2020” that was also focused on the eleven thematic objectives was of a big help to achieve the goals of this task.

4. It was necessary to undergo two rounds of the DELPHI survey with experts due to the fact that some results were sensitively deviated from the average. The second experts survey facilitates a consensus agreement for all the direct result indicators.

7 Glossary

AEL – Associated emissions levels

APV – Agrophotovoltaics

BAT – Best available technique

CCGT – Combine-Cycle Gas Turbine

CAES – Compressed Air Energy Storage

CSP – Concentrated Solar Power

DNSH – Do no significant harm

EPA – United States Environmental Protection Agency

ES – Ecosystem Services

EU – European Union

GHG – Greenhouse gas

GTP – Geothermal Technologies Programme

I&C – Instrumentation and control

ILUC – Indirect land use change

IT – Information Technology

MICMAC – Software tool for structural analysis developed by the Institut d'Innovation Informatique pour l'Entreprise 3IE

MORPHOL – Software tool for morphological analysis developed by the Institut d'Innovation Informatique pour l'Entreprise 3IE

MSP – Malten Salt Plant

NASA – National Aeronautics and Space Administration

NPV – Net Present Value

PHS – Pumped Hydroelectric Storage

PCBs – Polychlorinated Biphenyls

PV – Photovoltaic

R&D – Research and Development

RE – Renewable Energy

RE H&C – Renewable Heating and Cooling

RFCS – Research Fund for Coal and Steel

RTE – Roundtrip efficiency

SMR – Small Modular Reactors

TRL – Technology Readiness Level

UNIOVI – University of Oviedo

UPHS – Unconventional Pumped Hydro Storage

VPP – Virtual Power Plant

References

Agrawal, N.M. (2019). Modelling Deming's quality principles to improve performance using interpretive structural modelling and MICMAC analysis. International Journal of Quality & Reliability Management 36(7), 1159-1180. https://doi.org/10.1108/IJQRM-07-2018-0204

Balouli, H.E. & Chine, L. (2019). Morphological analysis of agricultural entrepreneurship in Algeria using Morphol method. Roa Iktissadia Review, vol. 09(01), 113-120.

Bauer, T., Odenthal, Ch. & Bonk, A. (2021). Molten Salt Storage for Power Generation. Chemie Ingenieur Technik 93(4), 534-546. https://doi.org/10.1002/cite.202000137

Bielecki, A., Ernst, S., Skrodzka, W., & Wojnick, I. (2019). Concentrated Solar Power Plants with Molten Salt Storage: Economic Aspects and Perspectives in the European Union. International Journal of Photoenergy, vol. 2019, Article ID 8796814, 10 pages. https://doi.org/10.1155/2019/8796814

Dhir, S., & Dhir, S. (2020). Modelling of strategic thinking enablers: a modified total interpretive structural modelling (TISM) and MICMAC approach. International Journal of System Assurance Engineering and Management 11(1), 175-188. https://doi.org/10.1007/s13198-019-00937-z

Duperrin, J. & Godet, M. (1975). SMIC 74—A method for constructing and ranking scenarios. Futures 7, 302–312.

European Commission (2017). Technology readiness level: guidance principles for renewable energy technologies: final report. Brussels: Publications Office. Directorate-General for Research and Innovation, Strazza, C., Olivieri, N., De Rose, A., et al. https://data.europa.eu/doi/10.2777/577767

European Parliament (2018). Sector coupling: how can it be enhanced in the EU to foster grid stability and decarbonise? Directorate-General for Internal Policies of the Union, Rademaekers, K., Van Nuffel, L., Gorenstein Dedecca, J., et al. https://data.europa.eu/doi/10.2861/63462

European Union (2018). Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council. Brussels: Official

Journal of the European Union L 328/1, 21.12.2018. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R1999&from=EN

European Union (2020). Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088. Brussels: Official Journal of the European Union L 198/13, 22.6.2020. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020R0852&from=EN

European Union (2021). Commission Delegated Regulation (EU) 2021/2139 of 4 June 2021 supplementing Regulation (EU) 2020/852 of the European Parliament and of the Council by establishing the technical screening criteria for determining the conditions under which an economic activity qualifies as contributing substantially to climate change mitigation or climate change adaptation and for determining whether that economic activity causes no significant harm to any of the other environmental objectives. Official Journal of the European Union L 442/1, 9.12.2021. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R2139&from=EN

European Union (2022). Commission Delegated Regulation (EU) 2022/1214 of 9 March 2022 amending Delegated Regulation (EU) 2021/2139 as regards economic activities in certain energy sectors and Delegated Regulation (EU) 2021/2178 as regards specific public disclosures for those economic activities. Official Journal of the European Union L 188/1, 15.7.2022
https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022R1214&from=EN

Geyer, M. (2022). What is long-duration energy storage and why is it important? In World Bank Technical Workshop: Replacing coal with renewables in Poland: the role of different storage technologies and the implications for jobs. Long Duration Energy Storage Council. http://www.ldescouncil.com/

Godet, M. (2001). Manuel de propective stratégique. Dunod: Paris.

Godet, M., & Durance, P. (2011). Strategic Foresight for Corporate and Regional Development. UNESCO – Dunod: Paris.

Johnson, S. et al. (2019). Selecting Favorable Energy Storage Technologies for Nuclear Power. In: Storage and Hybridisation of Nuclear Energy. 119-175. Academic Press. https://doi.org/10.1016/B978-0-12-813975-2.00005-3

Krzemień, A., Sánchez, A.S., Fernández, P.R., Zimmermann, K., & González Coto, F. (2016). Towards sustainability in underground coal mine closure contexts: A methodology proposal for environmental risk management. Journal of Cleaner Production, 139, 1044–1056. https://doi.org/10.1016/j.jclepro.2016.08.149

Liu, Z., & Fan, J. (2014). Technology readiness assessment of Small Modular Reactor (SMR) designs. Progress in Nuclear Energy 70, 20-28. https://doi.org/10.1016/j.pnucene.2013.07.005

Martín Gómez, A. M., Aguayo González, F., & Marcos Bárcena, M. (2018). Smart eco-industrial parks: A circular economy implementation based on industrial metabolism. Resources, Conservation and Recycling, 135(September 2017), 58–69. https://doi.org/10.1016/j.resconrec.2017.08.007

Pacific Northwest National Laboratory (2022). Energy Storage Cost and Performance Database. URL: https://www.pnnl.gov/ESGC-cost-performance (accessed 25 November 2022).

Ponciroli, R., Wang, H., Vilim, R.B., Frick, K., Rabiti, C. (2021). Development of Energy Storage: Cost models. IES Simulation Ecosystem Control System Development. Nuclear Science and Engineering Division, Argonne National Laboratory & Reactor Systems Design & Analysis Division, Idaho National Laboratory. ANL/NSE-21/13. https://publications.anl.gov/anlpubs/2021/04/167188.pdf

Roper, R., Harkema, M., Sabharwall, P., Riddle, C., Chisholm, B, Day, B., & Marotta, P. (2022). Molten salt for advanced energy applications: A review. Annals of Nuclear Energy, 169, 108924, https://doi.org/10.1016/j.anucene.2021.108924

Turchi, C. S., Heath, G. A. (2013). Molten Salt Power Tower Cost Model for the System Advisor Model (SAM). National Renewable Energy Lab. (NREL), Golden, CO (United States). NREL/TP-5500-57625. https://doi.org/0.2172/1067902

United States Environmental Protection Agency (EPA) (2022). National Recycling Strategy. Circular Economy Basics. https://www.epa.gov/recyclingstrategy/what-circular-economy

Villacorta, P.J.; Masegosa, A.D.; Castellanos, D. & Lamata, M.T. (2012). A Linguistic Approach to Structural Analysis in Prospective Studies. In International Conference on Information Processing and Management of Uncertainty in Knowledge-Based Systems; Springer: Berlin/Heidelberg, Germany, 150–159.

Wei, Z., Xu, D., Wang, Z., & Song, G. (2017). Coal Mine Based Circular Economy Park: A Case Study. Geo-Resources Environment and Engineering, 2(September). https://doi.org/10.15273/gree.2017.02.00

World Bank (2018). Managing Coal Mine Closure: Achieving a Just Transition for All. Washington: Working paper 130659. Stanley, M., Strongman, J., Perks, R.B., Nguyen, H.B.T., Cunningham, W., Schmillen, A.D. & Mccormick, M.S.

https://documents1.worldbank.org/curated/en/484541544643269894/pdf/130659-REVISED-PUBLIC-Managing-Coal-Mine-Closure-Achieving-a-Just-Transition-for-All-November-2018-final.pdf

Zhao, H., Guo, S., & Zhao, H. (2018). Comprehensive benefit evaluation of eco-industrial parks by employing the best-worst method based on circular economy and sustainability. Environment, Development and Sustainability, 20(3), 1229–1253. https://doi.org/10.1007/s10668-017-9936-6

Annex

Table A-1. Summary of results

		Eco-industrial park (with virtual power plant) +				
Nº	**Direct result indicators**	**Green H_2 plant**	**Molten salt plant**	**Batteries**	**Biofuels (production)**	**Biofuels (combustion)**
1	Full-Time Employment creation	3,8	3,2	1,6	4,4	3,6
2	Full-Time new researchers	3	1,8	1,4	3	2
3	Companies introducing process/product innovations	4,2	2	2,5	3,4	2,4
4	Patent applications submitted to EPO	3	2,4	2,2	3	1,8
5	Energy users connected to smart grids	3,6	3,8	3,8	1,6	2,4
6	The capacity of renewable energy production installed and connected to the network	3,6	4,2	3,6	2,2	3,4
7	Energy efficiency (support for the smart grid)	1,8	3,6	4	1,8	3,4
8	Estimated low GHG emissions (tons of CO_2 equivalent) during the lifetime of the technology	4,6	4,2	3,6	2,2	1,6
9	"Tons" of recycled waste (more waste produced, lower value)	4	3	1	2,6	1,2
10	Space required to develop the option (more space, lower value)	2,4	3,125	4,2	2,2	2,2
11	Improvement of quality of offered services within the eco-industrial park	4	3	2,8	3,4	3,8
12	Benefits/return on investments (CAPEX and OPEX are considered)	3,2	2,8	3	3,2	3,7
13	Potential to stimulate other business activities	4,7	2,3	2,8	4	3
14	Energy security degree (independence)	4	3,6	4	4,4	4,6
15	Reduction of environmental impact - LCA (higher impact produced, lower value)	4,75	4,25	3,25	2,5	2
16	Environmental impact at the place of operation (higher impact, lower value)	4,2	3,8	4	2,4	1,4
17	Increased competitiveness of the region	4,4	2,8	2,4	4,4	4
	SUM	**63,25**	**53,875**	**50,15**	**50,7**	**46,5**

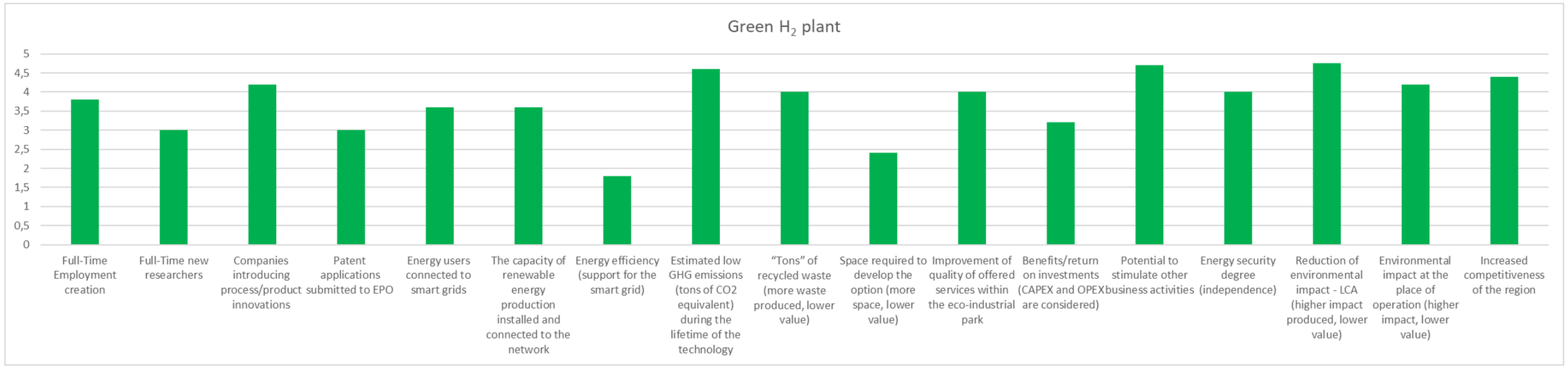

Figure A-1. Summary of results for eco-industrial park (with virtual power plant) + green H_2 plant

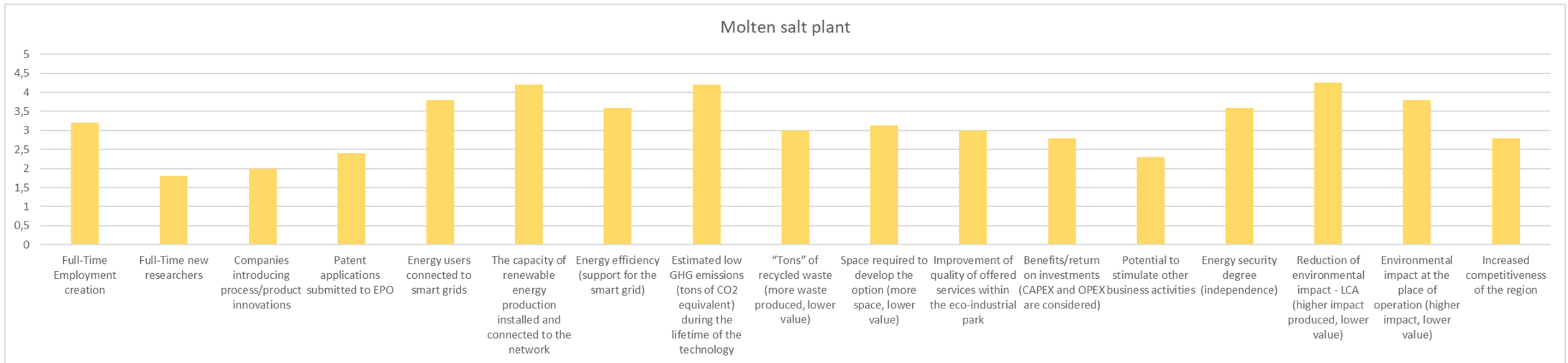

Figure A-2. Summary of results for eco-industrial park (with virtual power plant) + molten salt plant

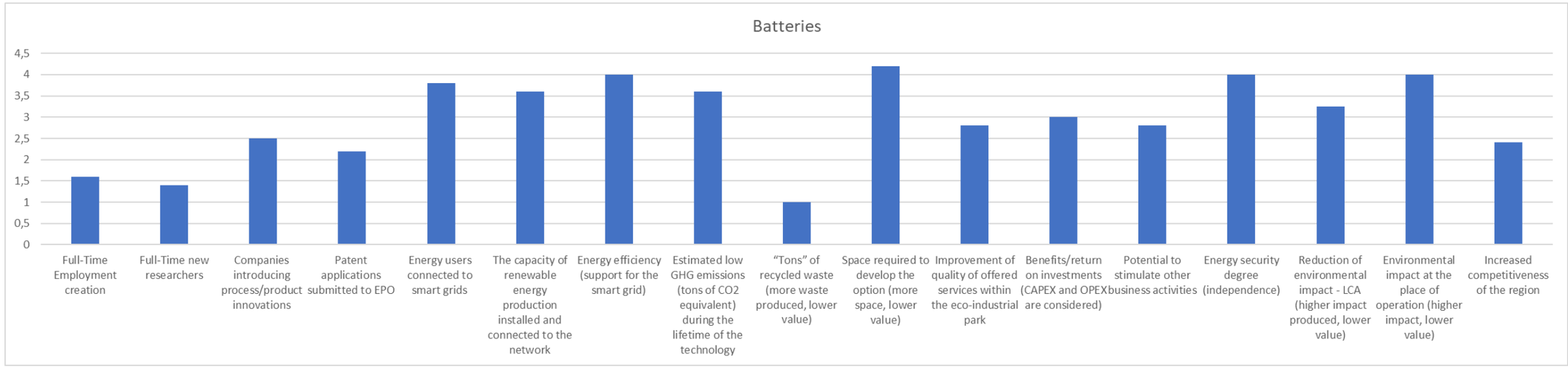

Figure A-3. Summary of results for eco-industrial park (with virtual power plant) + batteries

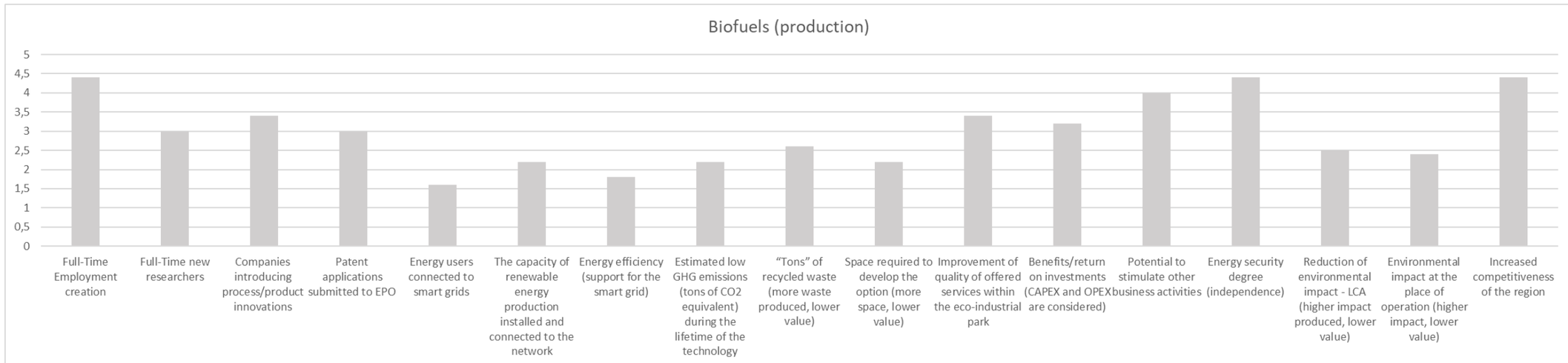

Figure A-4. Summary of results for eco-industrial park (with virtual power plant) + biofuels (production)

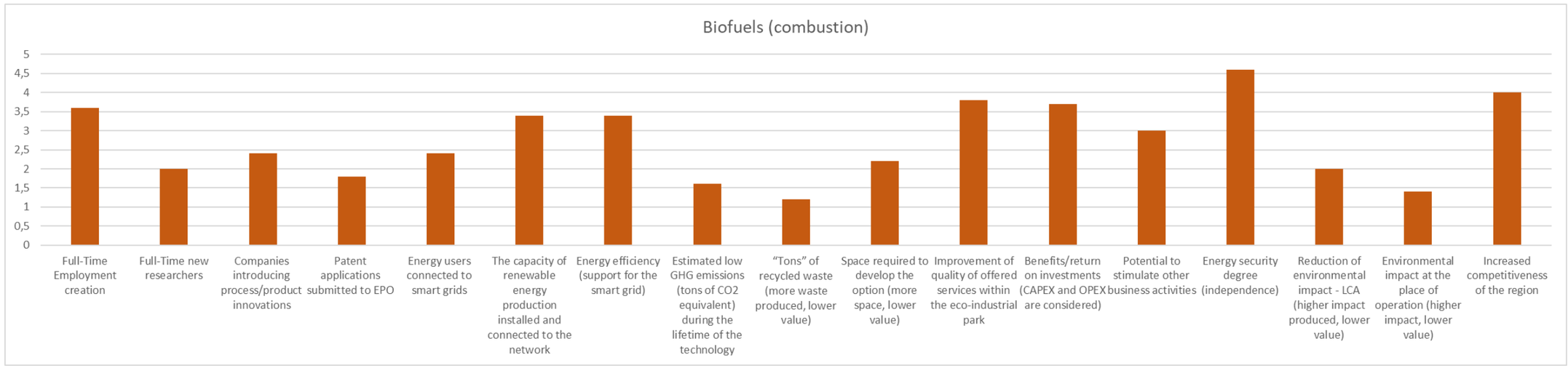

Figure A-5. Summary of results for eco-industrial park (with virtual power plant) + biofuels (combustion)