METASAT UK: A START-UP IN SPACE LCA

ESA Clean Space Industrial Days 2022

European Space Research & Technology Centre (ESTEC)

Noordwijk, Netherlands

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!!! although we do a lot of work in all aspects of space sustainability, the focus of this presentation will be solely space LCA !!!

Brief overview of company

The space LCA specialists!

- An aerospace company founded in December 2020 in response to the growing interest in space sustainability.
- Our goal is to empower the space sector innovate towards a more sustainable future.
- The company provides SMEs with consultancy-based services on space sustainability and develops space technologies with the concept of sustainable development at their core.
- In particular, Metasat UK Ltd aims to lessen the environmental footprint of their customer's products, processes and services through life cycle assessment (LCA) / ecodesign and develop a variety of space technologies for (and in collaboration with) its clients, designed to aid in boosting sustainable development.
- Such technologies include (but are not limited to) space debris detection technologies and solar power satellites. Additionally, the company also intends to use space data to boost sustainable development and contribute towards the attainment of the Sustainable Development Goals (SDGs).
- Collaborators: University of Strathclyde, TU Munich, and SPACE Canada
- Metasat UK is sustainably developing space systems and offering eco-tech!
- We’re on Facebook, Twitter, Instagram and LinkedIn – follow us!

@metasatuk

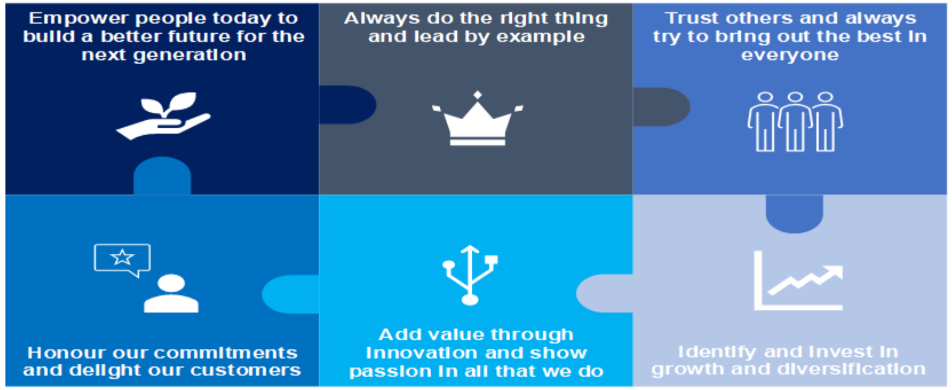
Core values and structure

Core business focus and values

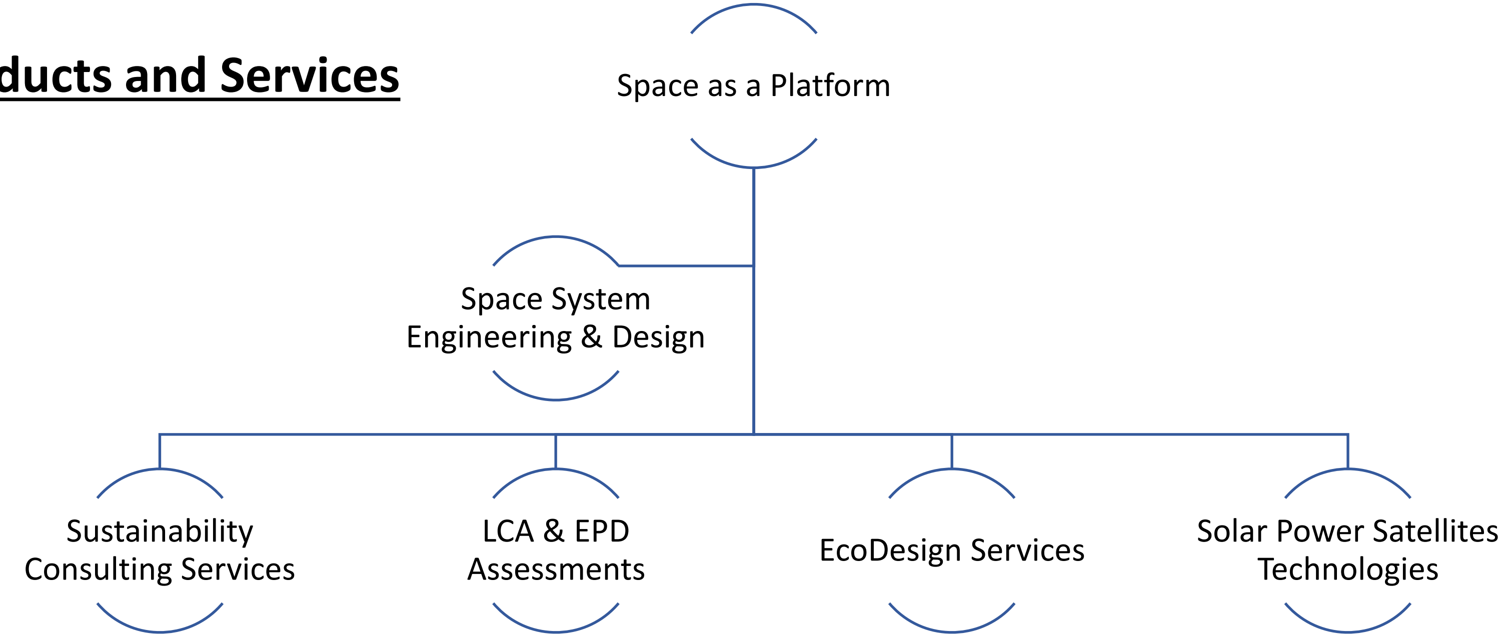
Core business focus

1. Using space as **a platform** to directly or indirectly address global problems.
2. Viewing space as **a natural resource** for preservation, exploitation and exploration.
3. Addressing the **impacts of space activities** to the terrestrial and space environment.

Core business values



Products and Services



What have we achieved in our first two years?

Successes and challenges

- Presented at Energy Innovation Summit 2022 and Space Suppliers Summit 2022.
- Participated in the European Commission Workshop to define a common framework for European Footprint studies of European space activities.
- ESA-EISC Space for Sustainability Award 2021.
- Metasat UK and the University of Strathclyde, “Life Cycle Assessment of the UK Space Energy Initiative Technology Roadmap.” Technical Report, 2022.
- Metasat UK, “SEI Space Based Solar Power Rectenna Siting – Environmental Impact Assessment Scoping Report.” Technical Report, 2021.
- Andrew Ross Wilson, Sara Morales Serrano, Keith Baker, Haroon B Oqab, George B Dietrich, Massimiliano Vasile, Tiago Soares, and Luisa Innocenti. “From Life Cycle Assessment of Space Systems to Environmental Communication and Reporting.” 72nd International Astronautical Congress (IAC 2021).
- Andrew Ross Wilson, Massimiliano Vasile, Haroon B Oqab, and George B Dietrich. “A Process-Based Life Cycle Sustainability Assessment of the Space-Based Solar Power Concept.” 71st International Astronautical Congress (IAC2020).

Our team

We're always looking to grow our team, if you are interested, talk to us!

Management

Dr Andrew Wilson
Managing Director

Haroon Oqab
Director

George Dietrich
Director

Lesley Macpherson
HR

Technical Developers

Morgan Bastarache

Daryl Yuen

Interns

Andrea Macchia

Alessia Pregrasso

Max Gill

What have we achieved in our first two years?

Key space environmental work outputs

- Environmental Impact Assessment Scoping report for a rectenna on behalf of the UK Space Energy Initiative (SEI).
- Life Cycle Assessment report for the UK Space Energy Initiative (SEI) technology roadmap.
- Full papers on both reports will be presented as part of the 'BIS Reinventing Space Conference'.

Our focus for the purpose of this talk


SPACE BASED SOLAR POWER RECTENNA SITING

(BEATRICE OFFSHORE WINDFARM)

EIA: SCOPING REPORT

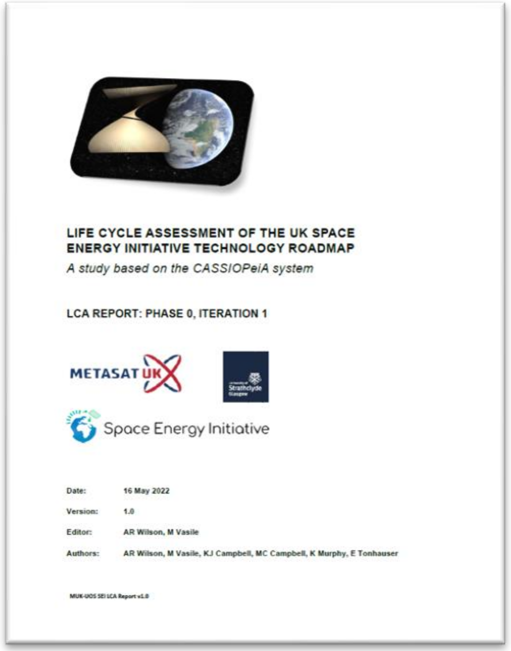
METASAT UK

Date: 23 August 2021

Version: 1.0

Editor: AR Wilson

Authors: AR Wilson, KJ Campbell, MC Campbell, K Murphy, E Tonhauser


LIFE CYCLE ASSESSMENT OF THE UK SPACE ENERGY INITIATIVE TECHNOLOGY ROADMAP

A study based on the CASSIOPeiA system

LCA REPORT: PHASE 0, ITERATION 1

METASAT UK

Space Energy Initiative

Date: 16 May 2022

Version: 1.0

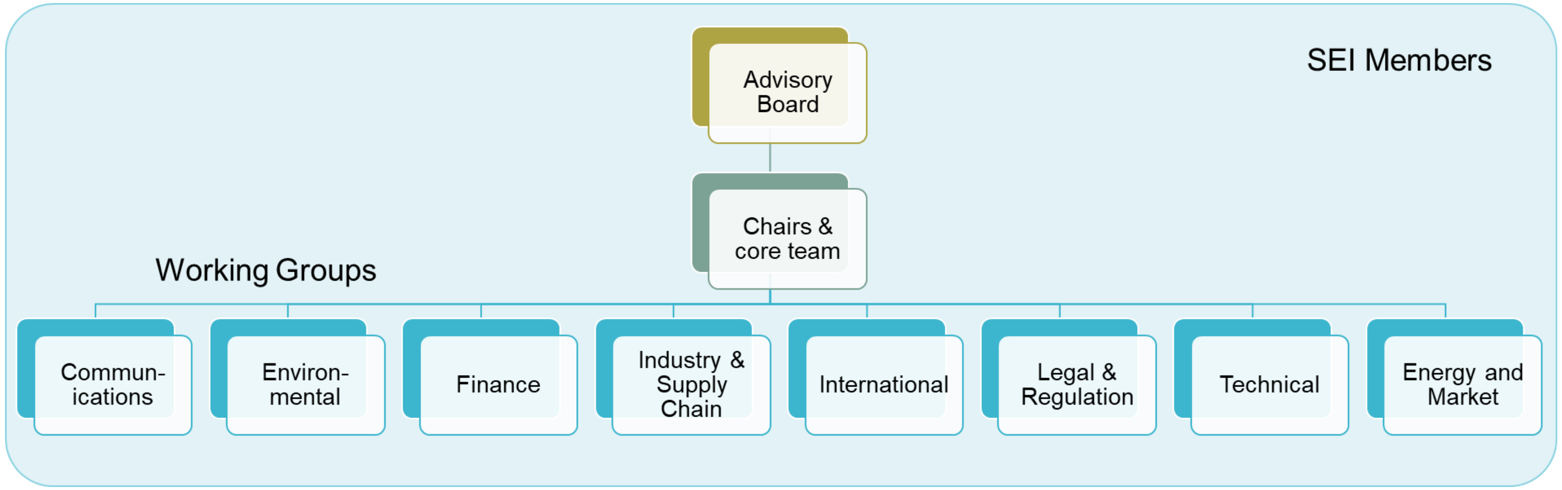
Editor: AR Wilson, M Vasile

Authors: AR Wilson, M Vasile, KJ Campbell, MC Campbell, K Murphy, E Tonhauser

MUK-UOS SEI LCA Report v1.0

Case Study

The UK Space Energy Initiative (SEI)



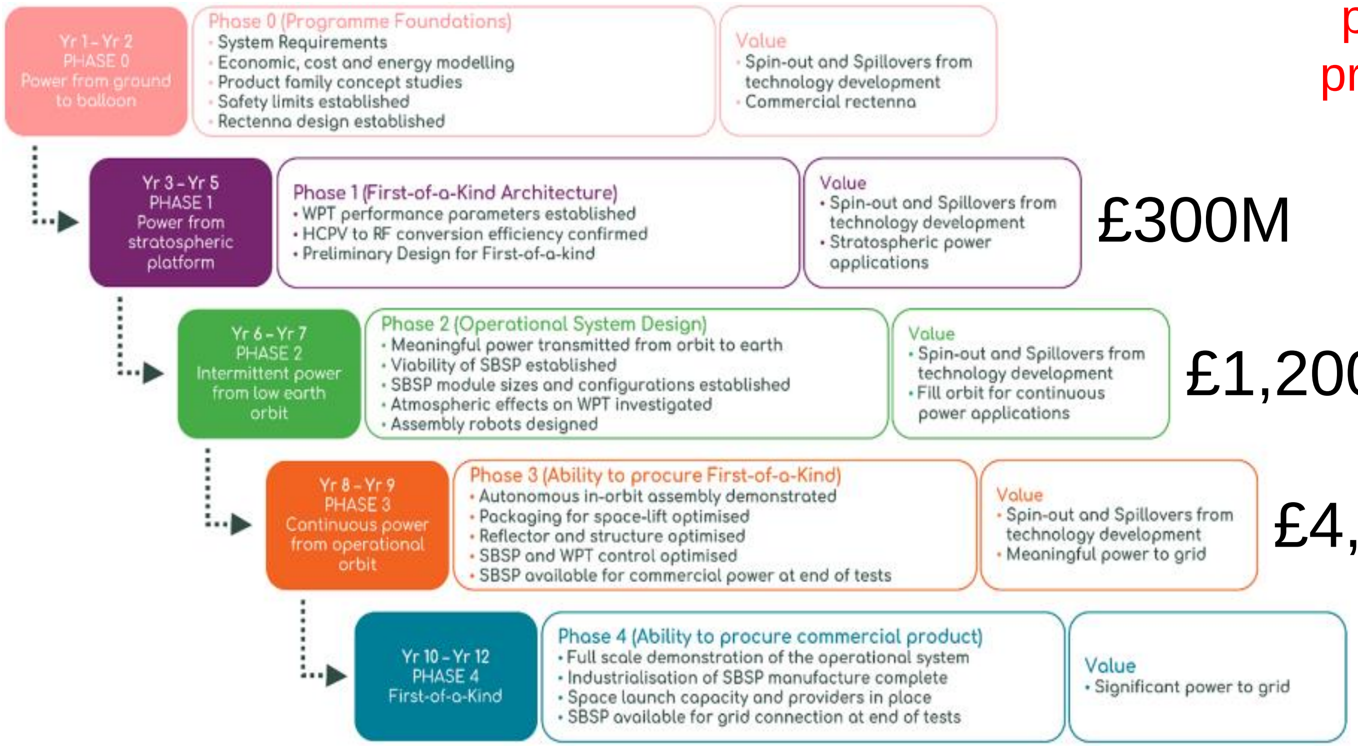
Build support with policy makers & public
Develop investable, integrated plan
Secure public / private funding
International outreach to partners
Build capability and deliver value

Case Study

The UK SEI Technology Roadmap

- 12 year development programme
- First 2GW system operational by 2035
- Delivering 30GW by 2050.
- Strong economic benefits and spin-off

Increasing proportion of private finance



£300M

£1,200M

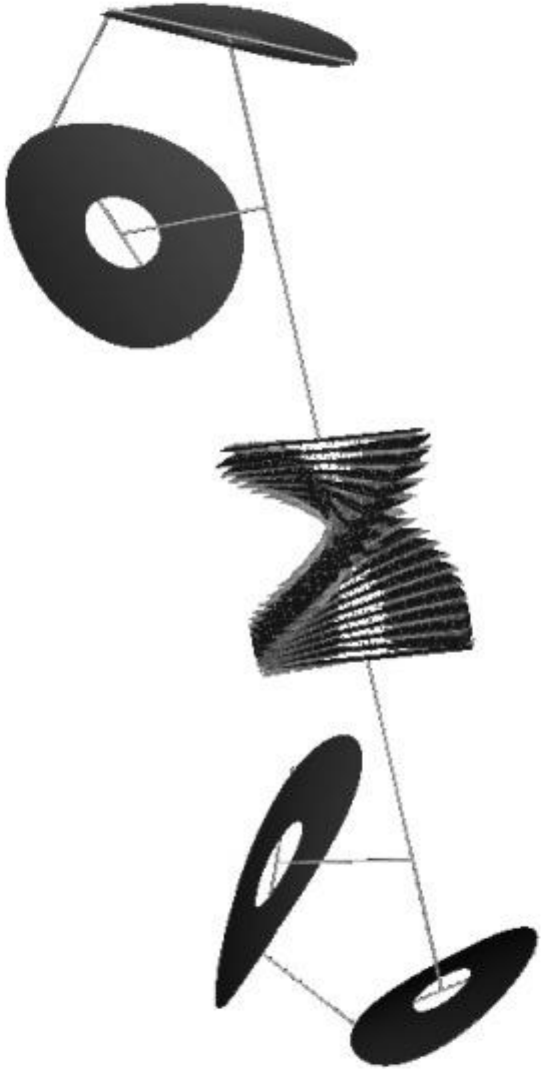
£4,000M

£10,500M

Case Study

LCA of the UK SEI Technology Roadmap

- To provide the UK SEI with updated information on the life cycle environmental impacts of their technology roadmap.
- Based on the CASSIOPeiA solar power satellite (SPS) system.
- The information covers the time period from 2022 to 2080 and is relevant for:
  - five stratospheric SPS prototypes,
  - five low Earth orbit (LEO) SPS prototypes, and
  - twenty-five full-scale 2 GW CASSIOPeiA systems.
- Each CASSIOPeiA system has been modelled on the assumption that it will operate at 2.45 gigahertz (GHz) with 4-sun CPV variant in geostationary Earth orbit (GEO) for an average lifetime of thirty years.



Case Study

Data collection

- Primary data was collected from the SEI Technical Working Group and is considered to be representative of the current SEI technology roadmap.
- This information was collected via a Microsoft Excel Spreadsheet titled ‘SEI LCA 1.0’ and transposed into the SSSD.
- Whilst the majority of the collected data was considered to be robust and of a sufficiently high data quality, the manufacturing & production of the rectenna was mainly based on well-judged estimations and data extrapolations.
- Data collection covers system boundary on next slide.
- FU: “The SEI technology roadmap in fulfilment of its requirements”.

Case Study

	Space Segment	Launch Segment	Ground Segment	Infrastructures
Phase A+B: Feasibility and Preliminary Definition				
	Office work and travelling Qualification and testing			
Phase C+D: Detailed Definition and Qualification & Production				
	Office work and travelling Production of SPS systems and prototypes Qualification, testing & verification Assembly & integration			Production and commissioning of rectenna sites
Phase E1: Launch and Commissioning				
	Spacecraft related activities	Production of launchers Production of propellants Stage assembly and/or refurbishments Launch campaign Launch event		
Phase E2: Utilisation Phase				
	Maintenance and operation of SPS systems		LEOP Commissioning Routine: Mission control	Maintenance and operation of rectenna sites
Phase F: End of Life				
	Disposal of SPS	Launcher refurbishment	Ground operations for SPS disposal	Decommissioning of rectenna

Source: Adapted from ESA LCA Handbook

Case Study

Results

- The results indicate that the manufacturing & production of the offshore rectennas is a particular hotspot, drawing similarities to the findings of Wilson et al. (2020).
- This was mainly due to the significance of their size, which cover an area of 76.97km2 each.
- More specifically, the most impacting area of the rectenna manufacturing & production is the turning and casting of aluminium, the turning of steel and the transmission network.
- However, based on a planetary boundary perspective, impacts stemming from ozone depletion and freshwater aquatic ecotoxicity could potentially be considered as even more significant environmental hotspots.

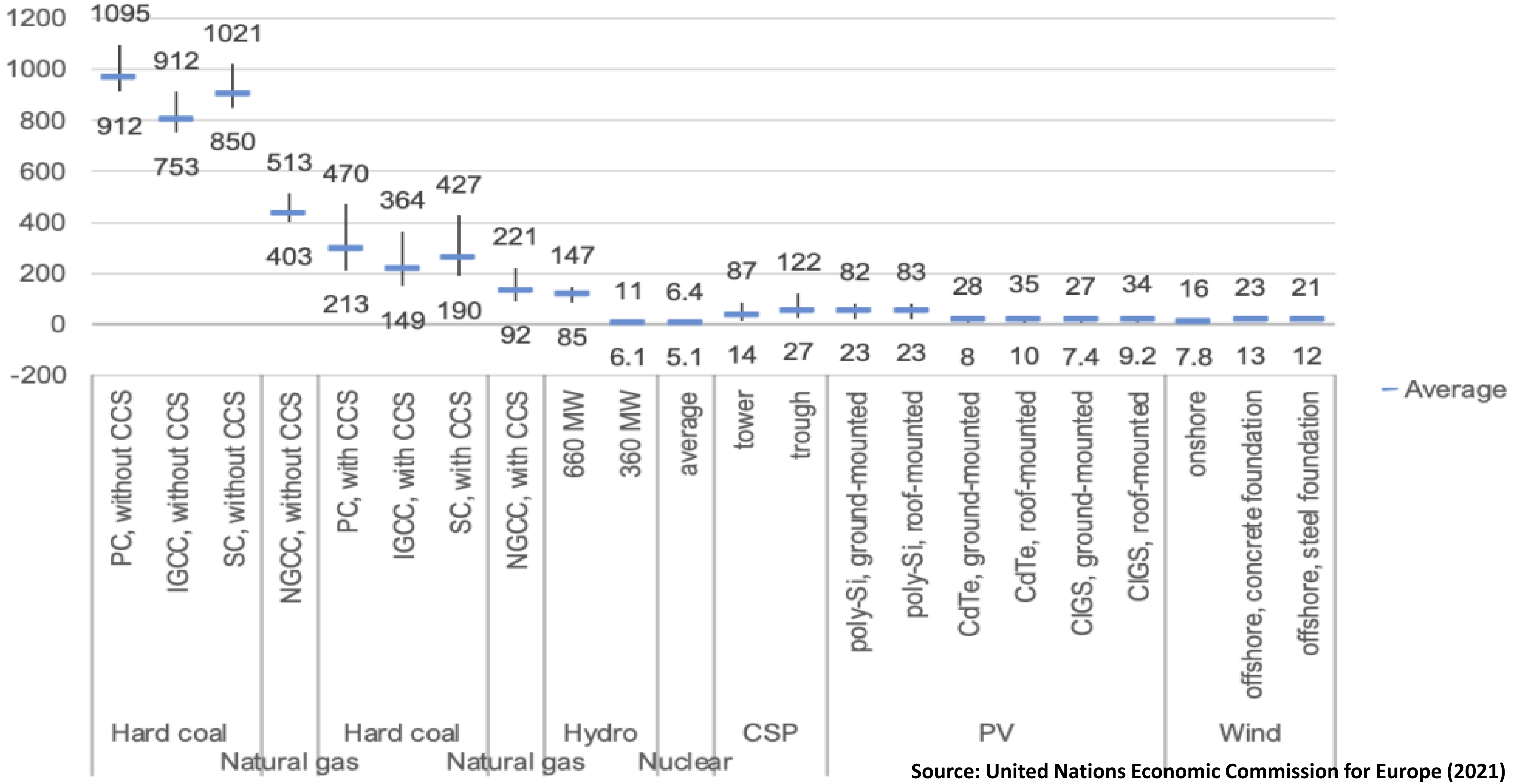
Impact Categories	Unit	LCIA Method	Mission Phase					
			A+B	C+D	E1	E2	F	TOTAL
Air Acidification	kg SO_2 eq	CML (2001)	1.91E+04	1.27E+09	1.40E+08	8.38E+04	6.56E+07	**1.48E+09**
Aluminium Oxide Emissions	kg Al_2O_3	ESA (2016)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Critical Raw Material Depletion	kg	SSSD (2019)	3.69E+03	2.04E+08	1.23E+07	1.94E+04	2.32E+06	**2.19E+08**
Freshwater Aquatic Ecotoxicity Potential	PAF.m^3.day	USEtox	5.39E+07	1.53E+13	8.30E+10	3.41E+08	2.85E+10	**1.54E+13**
Freshwater Eutrophication Potential	kg P eq	ReCiPe	2.44E+03	2.21E+08	9.58E+06	2.30E+04	4.23E+06	**2.34E+08**
Global Warming Potential (GWP100)	kg CO_2 eq.	IPCC (2013)	5.57E+06	2.77E+11	3.51E+10	3.37E+07	9.61E+09	**3.22E+11**
Human Toxicity Potential	cases	USEtox	2.10E+00	2.66E+09	6.69E+03	1.41E+01	2.00E+03	**2.66E+09**
Ionising Radiation Potential	kg U^{235} eq	ReCiPe	1.88E+06	5.40E+10	6.50E+09	5.08E+06	2.48E+09	**6.30E+10**
Marine Ecotoxicity Potential	kg 1,4-DB eq	CML (2001)	6.08E+09	2.78E+16	2.45E+13	4.15E+10	1.45E+13	**2.78E+16**
Marine Eutrophication Potential	kg N eq	ReCiPe	4.76E+03	2.55E+08	3.43E+07	2.74E+04	1.06E+07	**3.00E+08**
Ozone Depletion Potential (Steady State)	kg CFC-11 eq.	CML (2001)	6.07E-01	1.67E+04	1.73E+08	3.77E+00	4.01E+02	**1.73E+08**
Particulate Matter Formation Potential	kg PM_{10}	ReCiPe	6.97E+03	7.27E+08	4.88E+07	3.27E+04	1.68E+07	**7.92E+08**
Photochemical Oxidation Potential	kg NMVOC	ReCiPe	1.43E+04	8.81E+08	1.06E+08	7.36E+04	3.23E+07	**1.02E+09**
Resource Depletion Potential (Fossil)	MJ fossil	CML (2001)	7.05E+07	2.98E+12	4.59E+11	4.13E+08	1.09E+11	**3.55E+12**
Resource Depletion Potential (Mineral and Metal)	kg Sb eq	CML (2001)	1.76E+03	3.61E+11	1.85E+06	9.73E+03	8.41E+04	**3.61E+11**
Water Depletion Potential	m^3	ReCiPe	2.08E+07	2.22E+12	9.61E+10	7.71E+07	3.31E+10	**2.35E+12**

Case Study

Comparison of Results

- Since one of the main purposes of implementing this technology is to address climate change, this places an added importance on the Global Warming Potential (GWP) impact category.
- In this regard, for the stated time period, the life cycle carbon footprint of the SEI technology roadmap was found to be 3.22E+11 kg CO2 eq., which equates to 79.4% of the UK's entire carbon footprint in 2020.
- However, considering the vast amount of energy delivered, this produces a value of 23.6 gCO2e/kWh which is found to be highly comparable with terrestrial-based energy systems.
- This produces a carbon payback period of less than 6 years based on the current carbon intensity of the UK energy fuel mix.

Lifecycle GHG emissions, in g CO_2 eq. per kWh, regional variation, 2020



Source: United Nations Economic Commission for Europe (2021)

Case Study

Study Conclusions

- The findings of this report suggest that SEI technology roadmap provides a credible solution for the assisting UK efforts on net-zero commitments, at least from an environmental viewpoint.
- However, several design improvements could be made to lessen its environmental impact further.
- For this reason, it is recommended that a set of environmental guidelines and requirements should be established for future SPS development.
- This includes conducting regular LCA reviews at various points in the development cycle to assist in lowering the carbon footprint and making the system as eco-friendly as technically possible.
- By integrating such as approach into the SEI technology roadmap may allow environmental considerations to be one of the primary design drivers, thereby ensuring that the entire system (including the rectenna) is produced in a manner where sustainable development is a fundamental principle.

The next few months

Examples of ongoing space LCA work

- Developing guidelines for the SEI technology roadmap to ensure eco-friendly SBSP development based on the LCA results of last year.
- Performing Environmental Product Declarations (EPD) for our clients.
- Performing LCA studies on space applications for our clients and on our own technologies.
- Building new LCI datasets and creating our own PCRs for space systems.
- Deploying our own in-house LCA software, building from the SSSD and additional tools focused on Space Sustainability
- Helping new partners and customers to improve their products and services.

Conclusion

- LCA process is a driver for innovation for the space industry - providing a more robust approach for stakeholders to assess their current and future activities and ensure they comply and remine in compliance with the changing landscape of national, continental and international norms and standards.
- Tools for Space Sustainability for measuring the environmental footprint of products across their entire life cycle and taking a cradle to grave approach (cradle to gate) empowers space actors to reduce their footprint for future space missions.
- With the decision of the European commission to agree on the new Green Deal as major policy direction of Europe comes the goal to reach carbon neutrality in the year 2050. It is very much-expressed wish that Europe is leading in this direction and becomes the first carbon neutral continent. Europe has seen a decline in carbon emissions, still the goal to become carbon neutral requires a fundamental change of the way the European economy and life is organized. A very central role is the transformation of the whole energy supply sector. The necessary pace of the change and strength of the inertia require new technologies.
    - Space-based Solar Power (SBSP) offers an alternative energy pathway for Europe to meet Net Zero Carbon by 2050. This system provides dispatchable power to help the transition away from carbon fossil fuels, and balance the supply and demand of an increasing population to fight climate change.
    - SBSP has not been taken into account as an option in many energy modelling to support Net Zero by 2050 for Europe.
    - Many concepts do not have sufficient technical data available and have not been developed to a level where meaningful comparisons between the various ideas can be performed through the LCA process.
    - While technology (manufacturing and declining launch costs) has advanced on several fronts to remove some of the technological and economic barriers to a practical implementation, the lack of credible or perceived unrealistic system parameters hinder a material assessment.
    - New carbon free technologies to supply electricity and all the other necessary energy carriers need to be developed and implemented.
- Reducing the carbon footprint is critical to achieving the Net Zero goals, a full life cycle assessment and life cycle costing analysis needs to be taken into account while considering the full implementation of modern designs, with special attention to reducing hot spots for CO2 generation on Earth and in Space. **We can build a more sustainable future for everyone!**

Q&A

Any questions?

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