



THE UNIVERSITY *of* EDINBURGH

Edinburgh Research Explorer

Improving the Value of Energy Storage in Electricity Systems

Citation for published version:

Kiprakis, AE 2022, 'Improving the Value of Energy Storage in Electricity Systems', 2022 Asia-Pacific Forum on Green and Low-carbon Development, Changsha, China, 8/09/22 - 9/09/22.

Link:

[Link to publication record in Edinburgh Research Explorer](#)

Document Version:

Publisher's PDF, also known as Version of record

General rights

Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.





THE UNIVERSITY of EDINBURGH
School of Engineering

Institute for Energy
Systems

Agile Energy Systems
Research Group

Improving the Value of Energy Storage in Electricity Systems

Prof Aristides Kiprakis SMIEEE MIET
University of Edinburgh

Contributors: M. Parzen, D. Kirli, F. Neumann,
A. H. Van Der Weijde, D. Friedrich

2022 Asia-Pacific Forum on Green and Low-carbon Development
8-9 September 2022, Changsha, Hunan, China



Self-introduction

Professor Aristides Kiprakis SMIEEE MIET

Chair of Agile Energy Systems
School of Engineering
University of Edinburgh

kiprakis@ed.ac.uk

<http://agileenergy.group/>



3rd
in the UK*

Joint submission between
Heriot-Watt University and the
University of Edinburgh
in Engineering
#EdinburghImpact

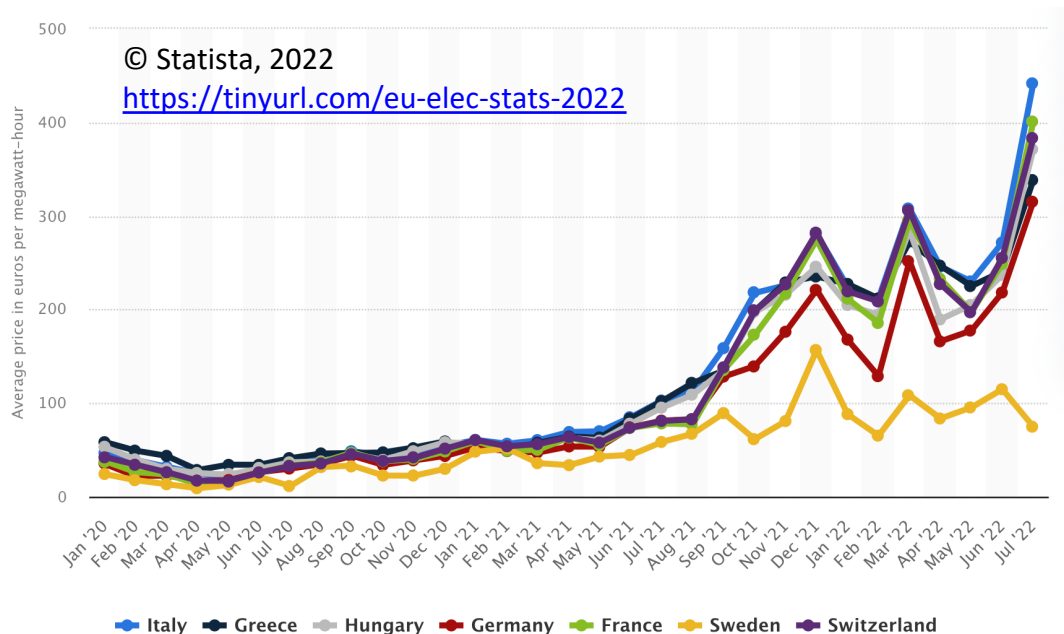
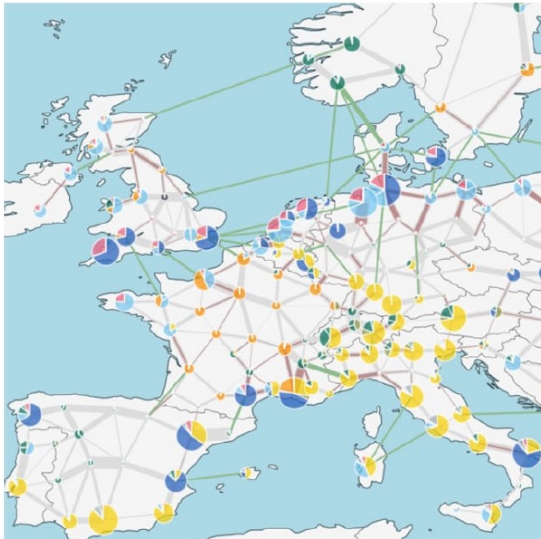
*for quality and breadth of combined
research, according to THE, based on the
REF2021 results



Overview of this Talk

- Energy balancing and the role of energy storage
- Energy storage valuation methods
- The Market Potential Valuation Method
- Performance & comparison

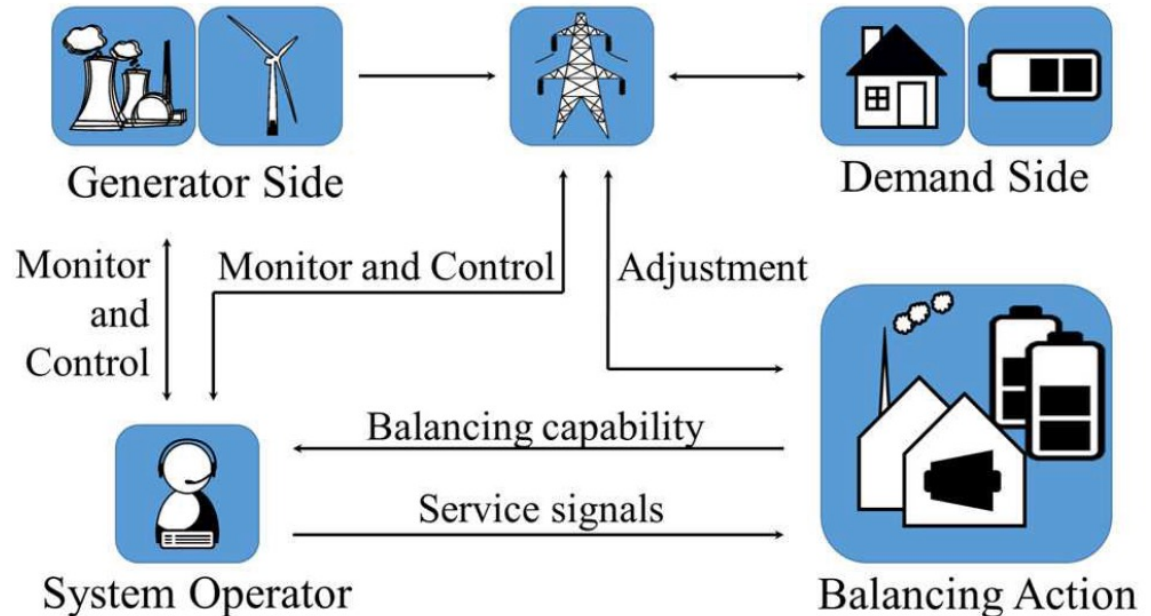
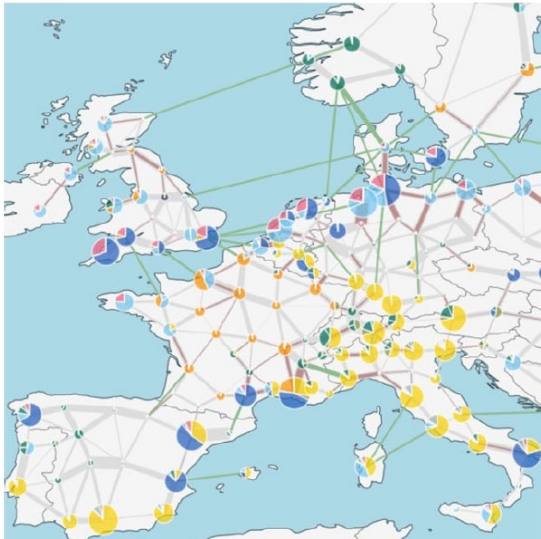
Energy System Model



Overview of this Talk

- Energy balancing and the role of energy storage
- Energy storage valuation methods
- The Market Potential Valuation Method
- Performance & comparison

Energy System Model



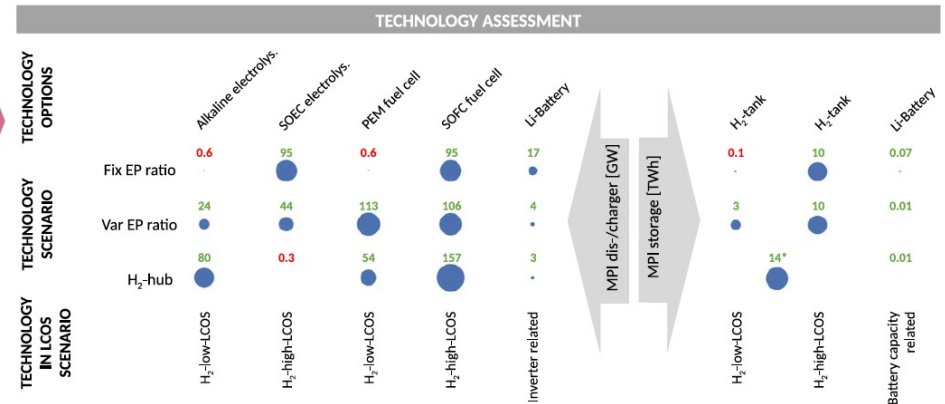
Overview of this Talk

- Energy balancing and the role of energy storage
- Energy storage valuation methods
- The Market Potential Valuation Method
- Performance & comparison

Energy System Model

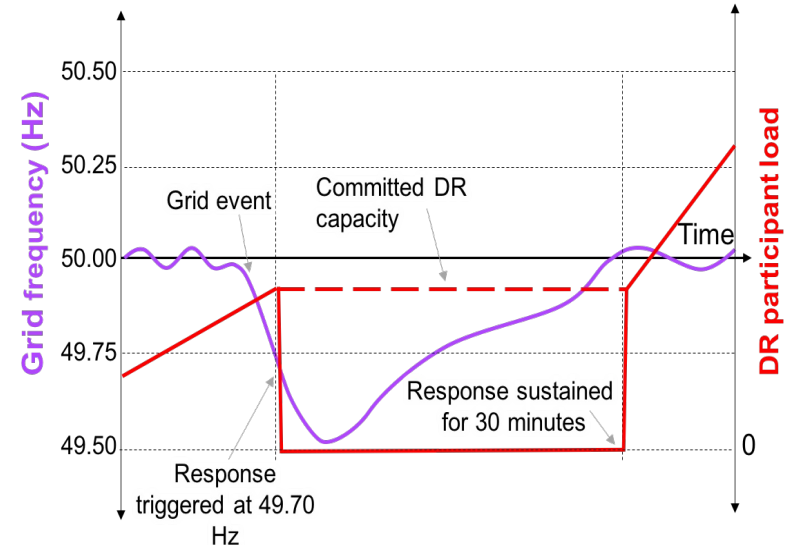
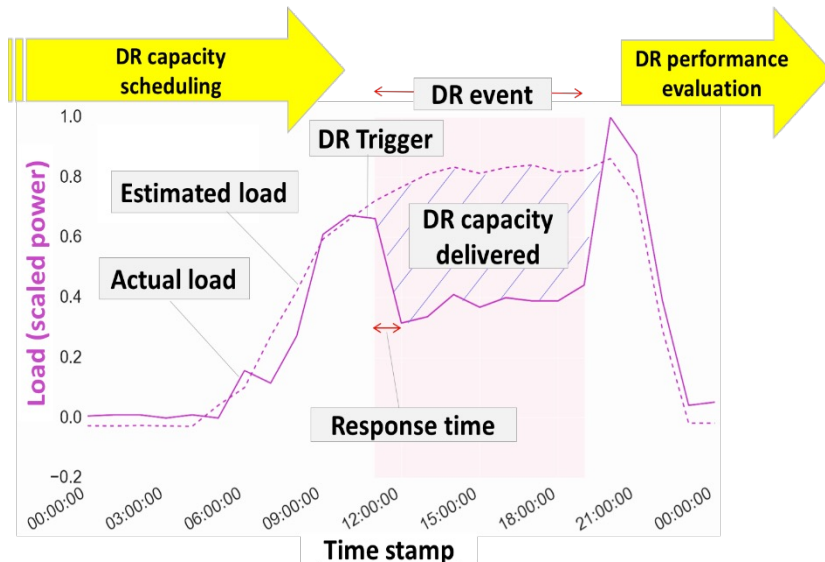
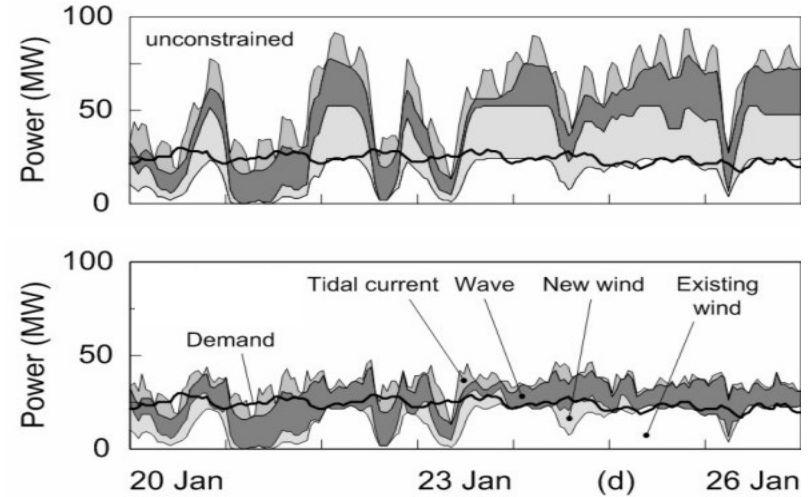


New value assessment method
“Market Potential Method”
 to guide energy storage innovation



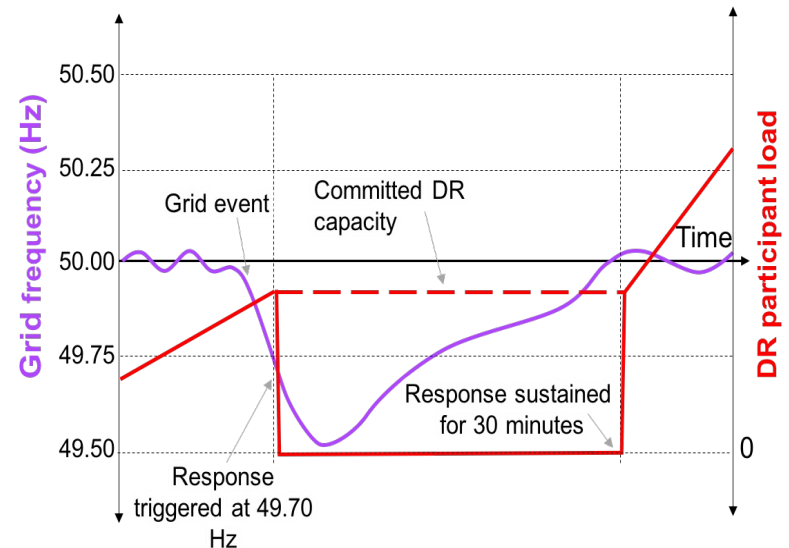
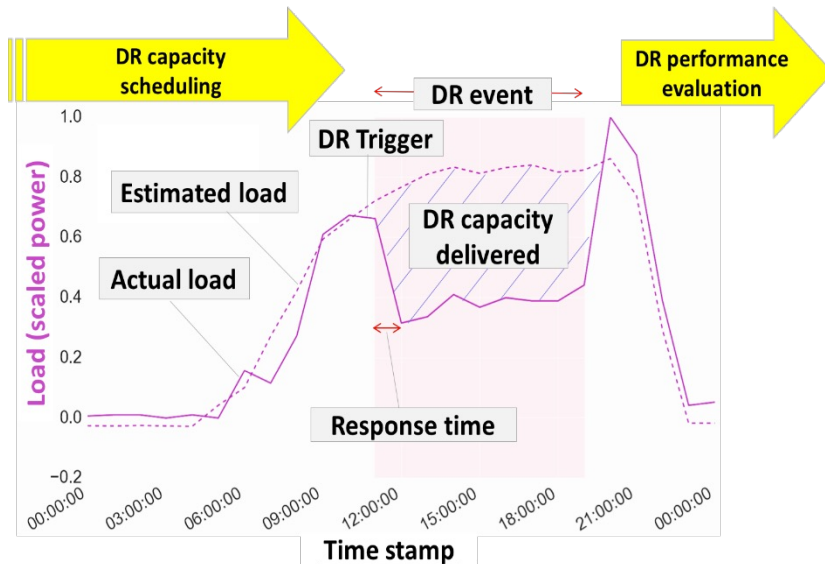
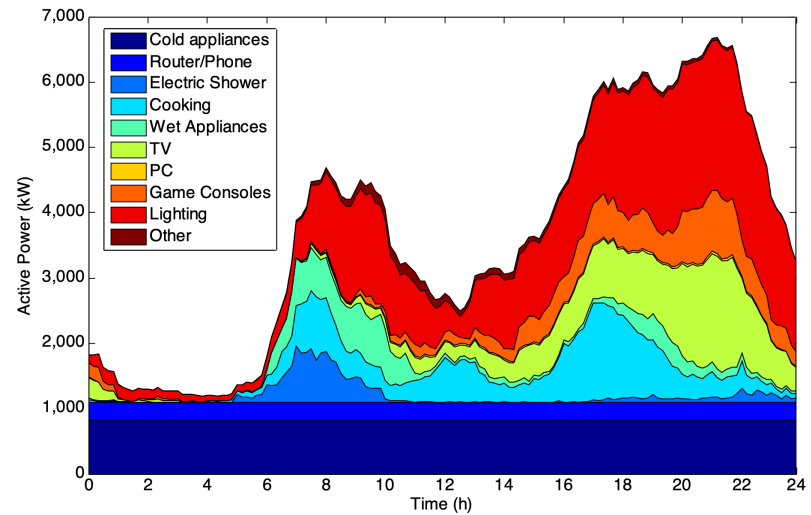
Energy Balancing: Demand Response

- How do we maximise low-carbon energy integration?
- Demand response can alleviate the impact of load/supply imbalance
- ...but it is an invasive method!



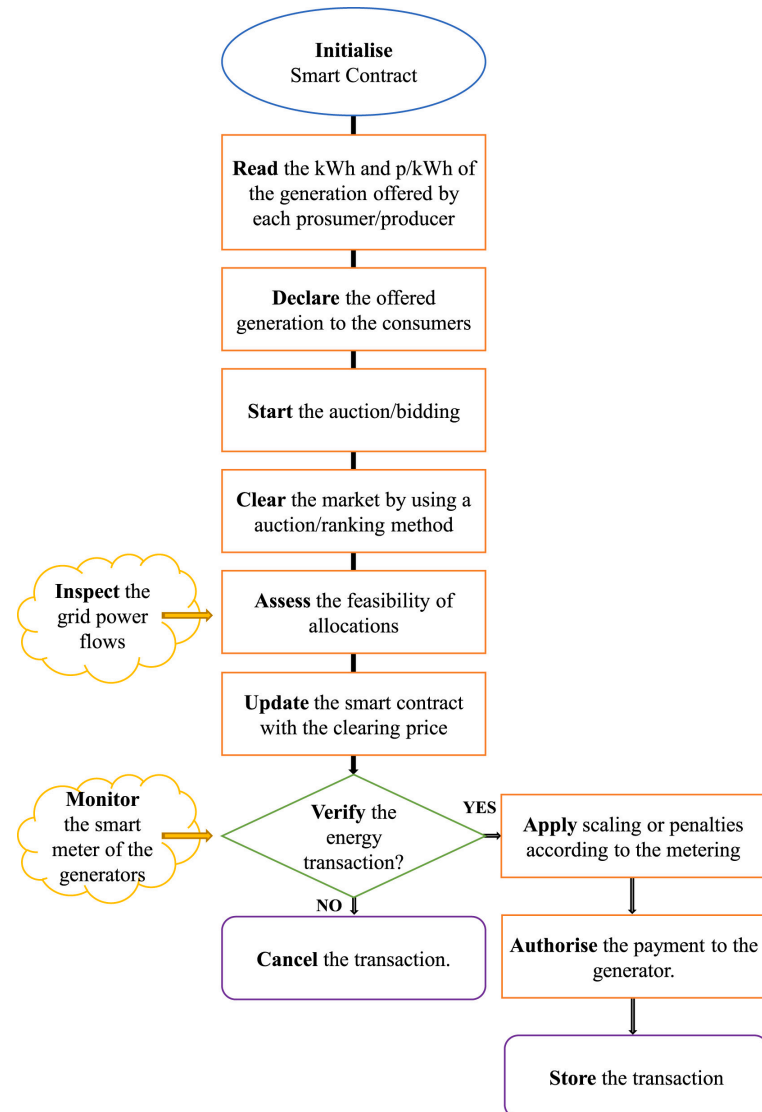
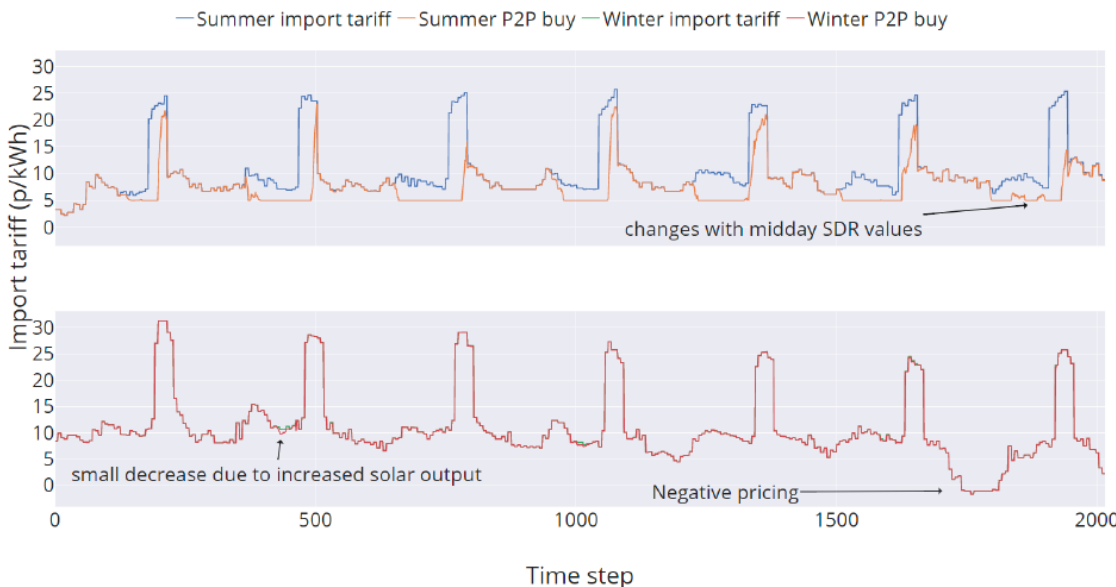
Energy Balancing: Demand Response

- How do we maximise low-carbon energy integration?
- Demand response can alleviate the impact of load/supply imbalance
- ...but it is an invasive method!



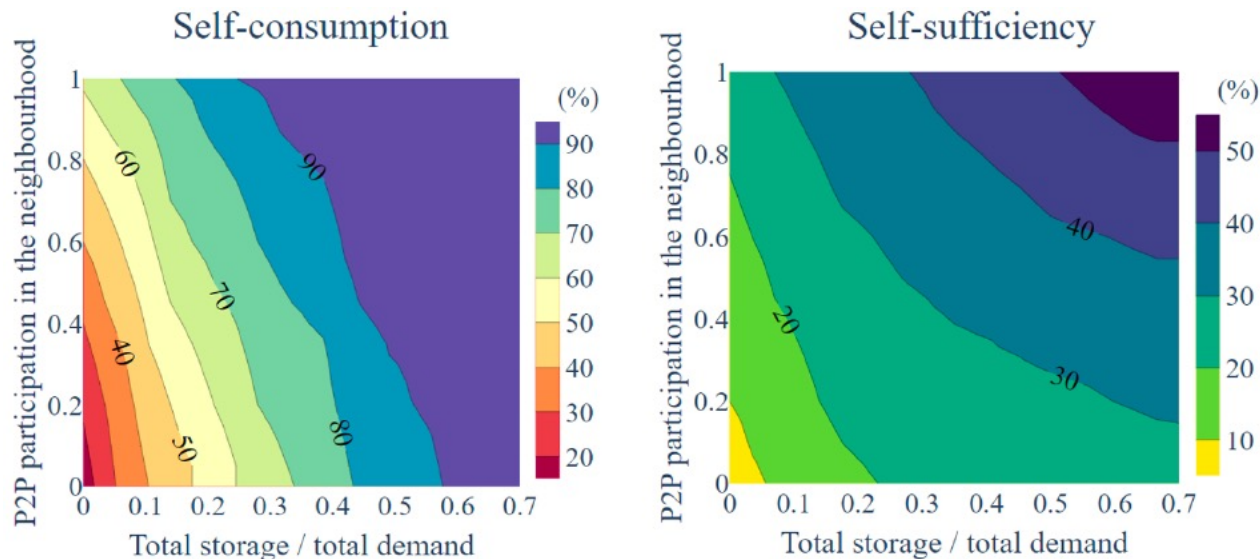
Energy Balancing: Smart Contracts & P2P trading

- How do we maximise low-carbon energy integration?
- Smart energy contracts & P2P trading can be tools for 'real-time' matching of supply & demand
- ...but they require high level of user participation

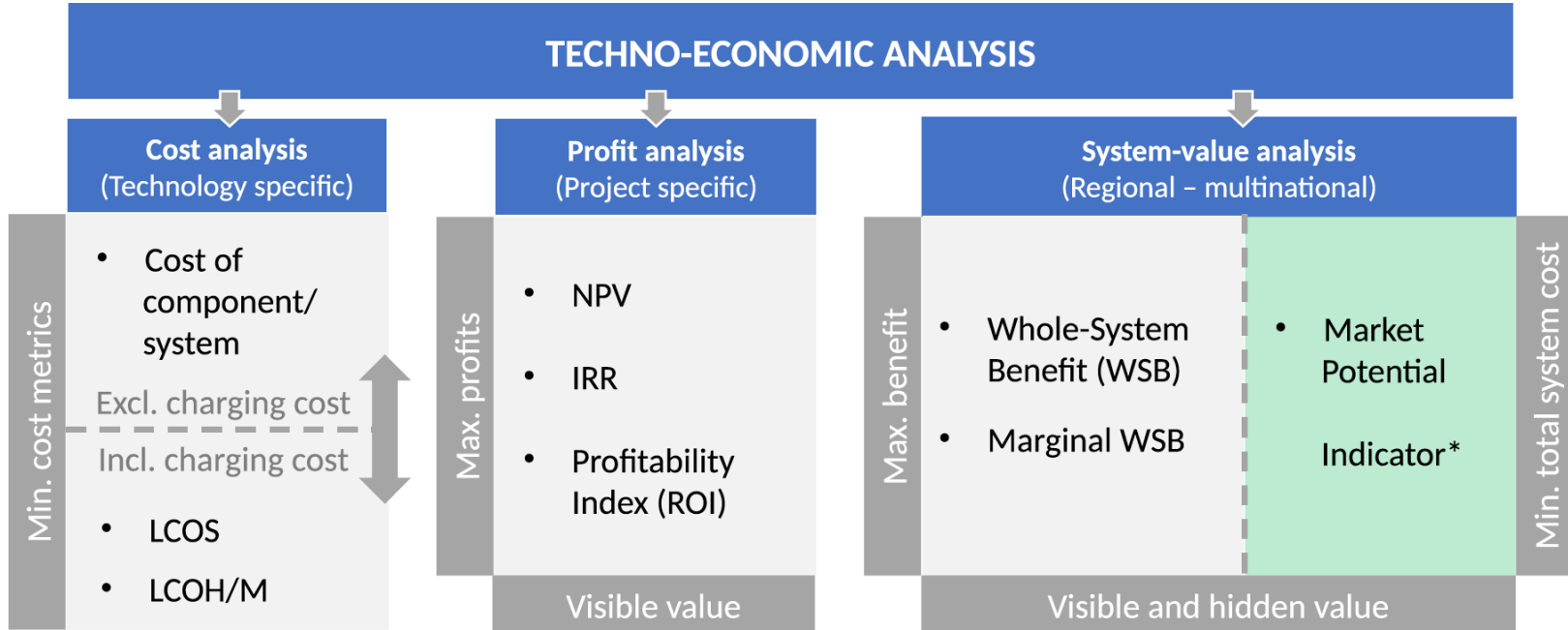


The Role of Energy Storage

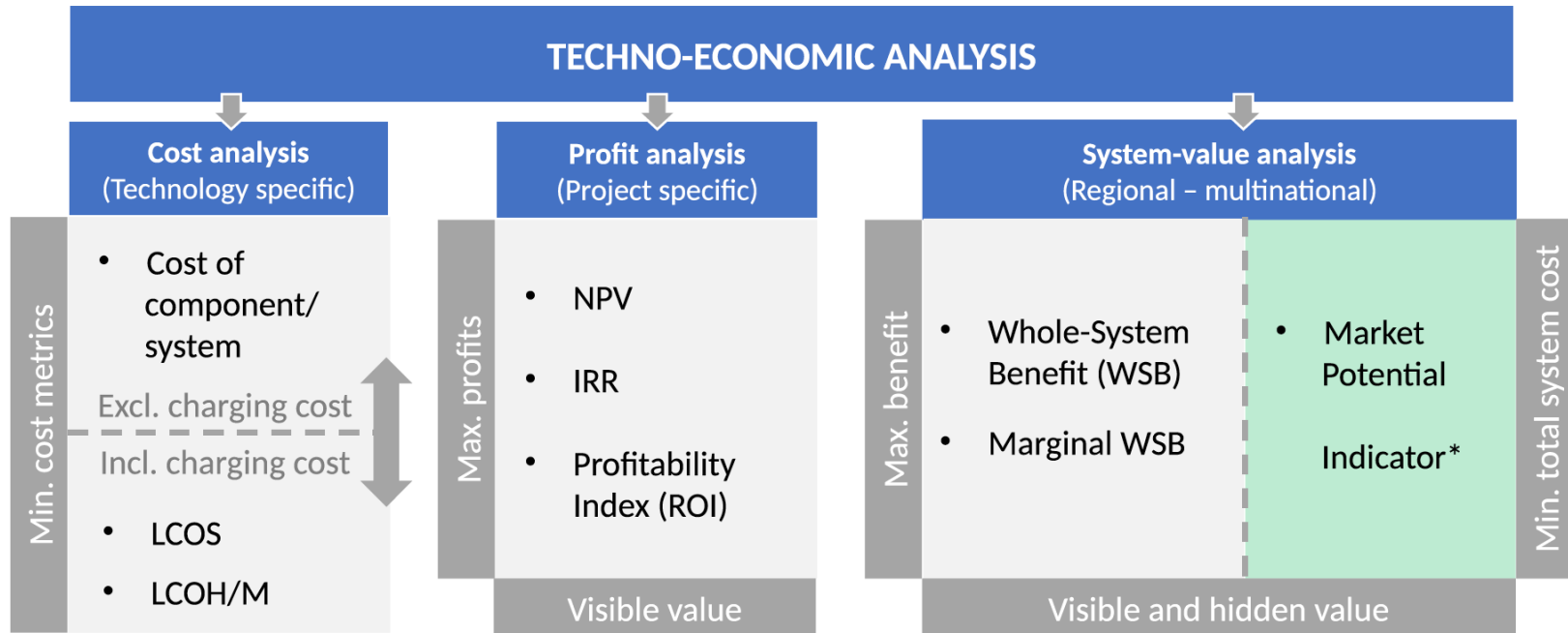
- Energy storage will defer need for network & generation expansion
- Can be combined with other flexibility mechanisms and will drastically improve their performance
- Used at all scales & energy system levels
- Comes at a cost!



Energy Storage Valuation: Methods

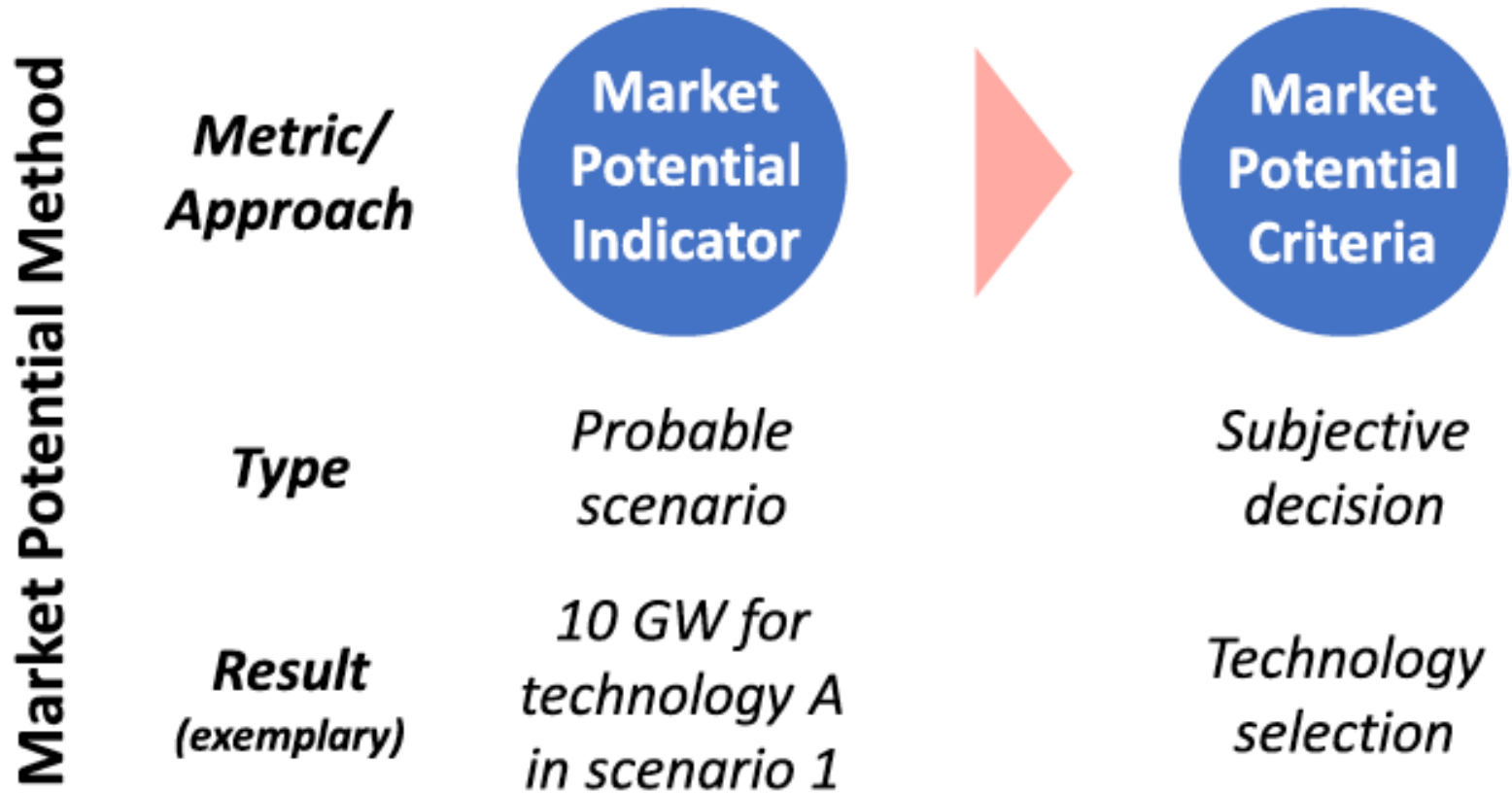


Energy Storage Valuation: Challenges



- Markets not temporally or spatially resolved
- Market power can be exploited
- Forecast information is imperfect
- Further negative and positive externalities exist

Market Potential Method



Market Potential Method

- $MPI=0$ indicates no value for the selected scenario
- $MPI>0$ indicates likelihood for value
- Thresholds can be set ($MPI>X$) to account for uncertainty
- $MPI_A > MPI_B$ indicates scenario A more valuable than scenario B

	Tech. 1	Tech. 2	Tech. 3	Tech. 4		
Scenario	A	+++	++	+++	0	Likely to be valuable
	B	+++	++	0	0	Likely to be not valuable
	C	+++	++	+	0	

← Certainty about positive value increases

'+' MPI magnitude

Case Study: Zero Carbon Europe by 2030

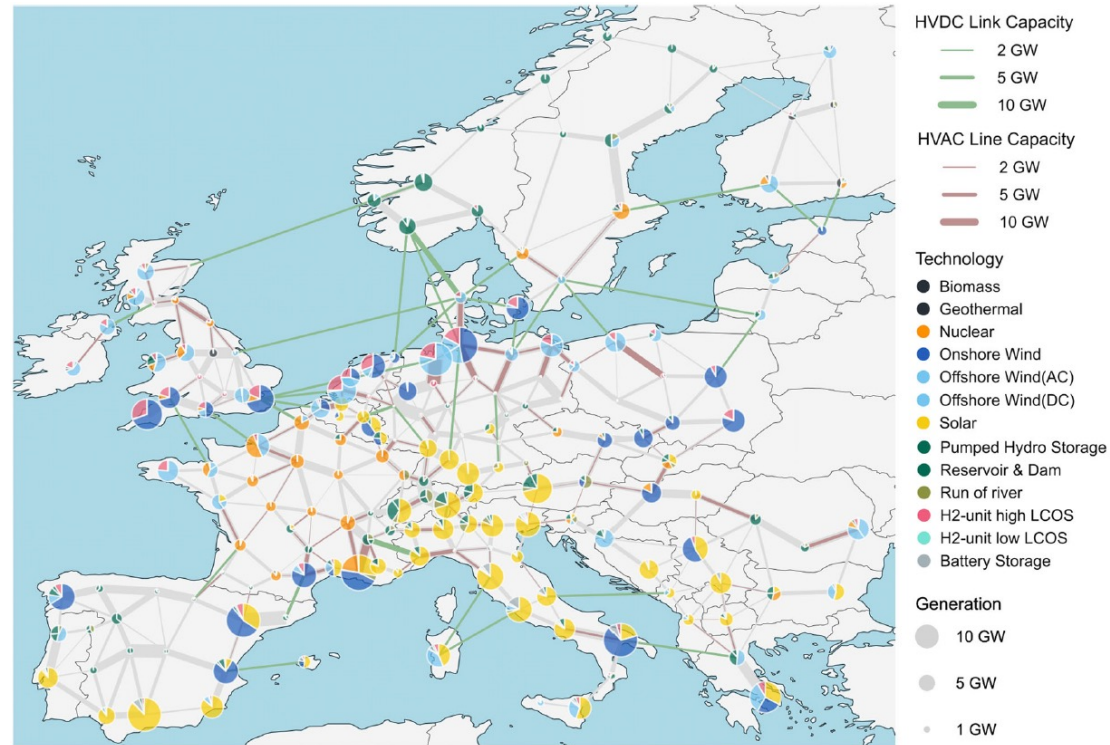
- Model of the ENSTOE-E area
- Transmission grid
- Database of power plants
- Time series of demand and RES generator availability

Energy related inputs

Energy storage components	H ₂ storage		Battery storage
	[High]	[Low]	[-]
LCOS Scenario			
Investment [EUR/kWh _{el}]	8.4	8.4	188 ^b
FOM ^a [%/year]	-	-	-
Lifetime [a]	20	20	10
Efficiency [%]	-	-	-

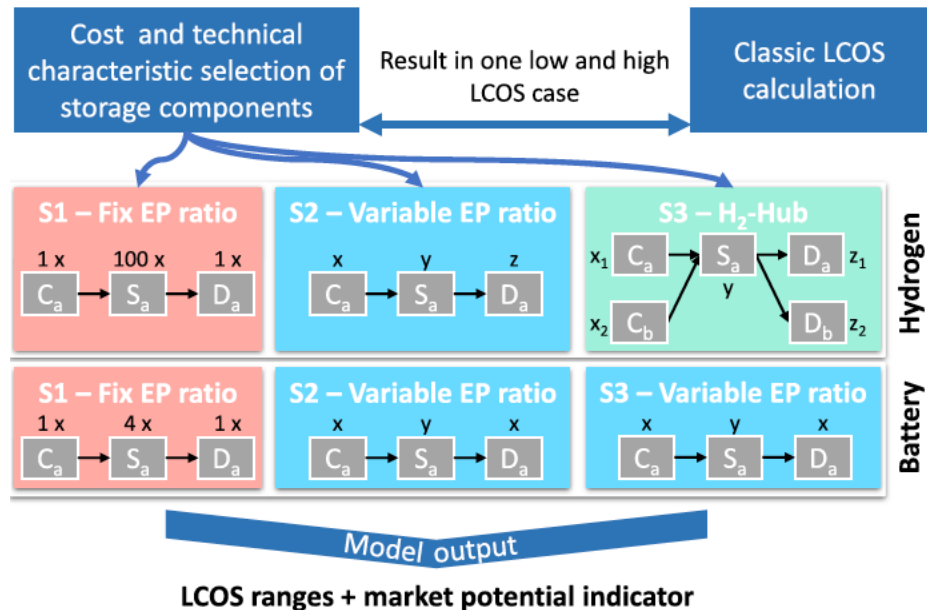
Power related inputs

Energy storage components	Electrolyser		Fuel cell		Battery Inverter
	[Low]	[High]	[Low]	[High]	[-]
LCOS Scenario					
Investment [EUR/kW _{el}]	339	677	339	423 ^b	209 ^c
FOM ^a [%/year]	2	3	2	3	3
Lifetime [a]	25	15	20	20	10
Efficiency [%]	68	79	47	58	90
Discount Rate [%]	7	7	7	7	7



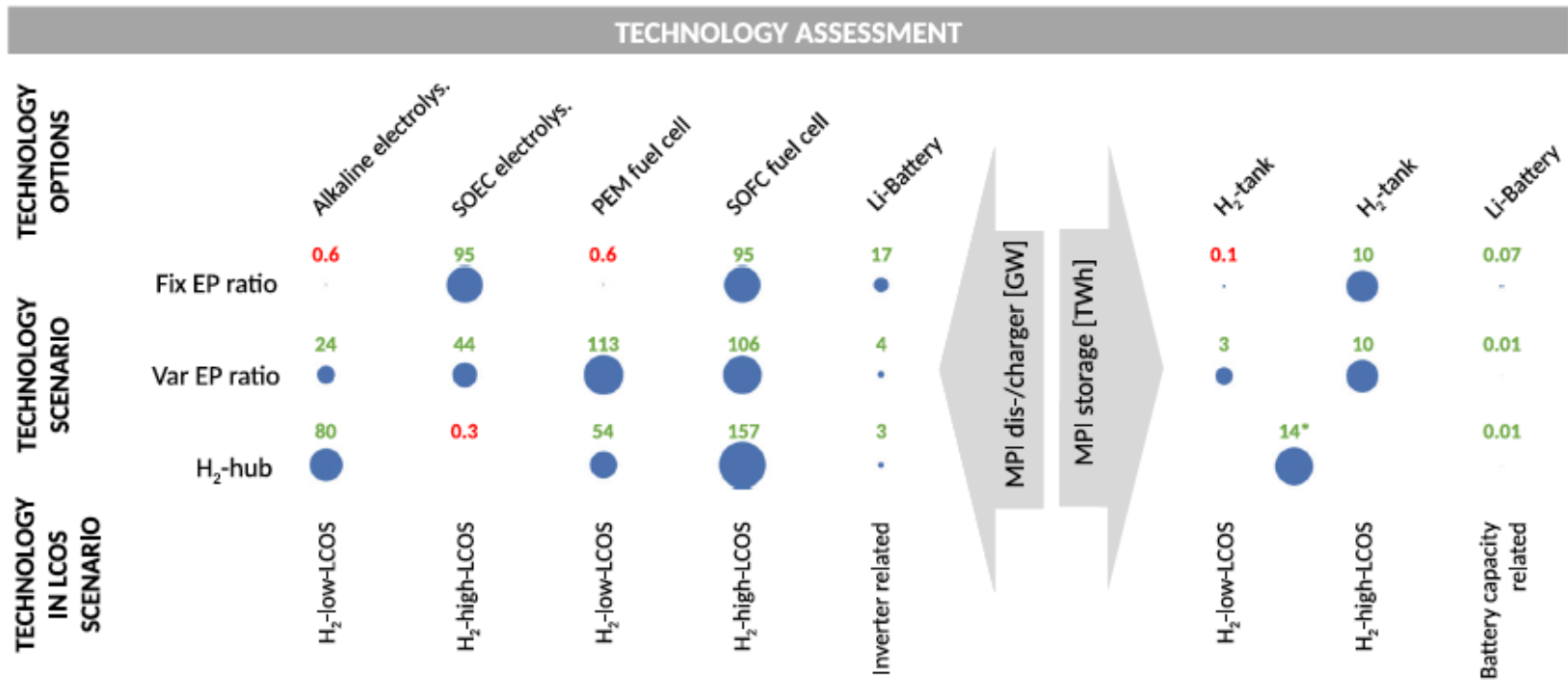
Considered Energy Storage Scenarios

- S1: Fixed energy/power ratio
- S2: Variable energy/power ratio
- S3: Variable EP, mixed technologies
- Hydrogen and battery storage considered in all scenarios



Optimisation Results

- Market Potential Indicator (MPI)





Conclusions

- Current cost metrics can be deceiving for technology design decisions
- The Market Potential Method extends current system-value approaches
- MPM systematically evaluates deployment estimations from energy models by looking at a set of probable scenarios in high spatial-temporal resolution over large regions
- This new approach could be more useful and overcomes many limitations
- Modifying the freedom of storage sizing and component interactions can lead to significant energy system benefits
- MPM enables a holistic approach in energy storage design & assessment from early stages in the design process



Further Reading

- Parzen, M., Neumann, F., Van Der Weijde, A.H., Friedrich, D., and Kiprakis, A., 'Beyond cost reduction: improving the value of energy storage in electricity systems', Carbon Neutrality 1, 26 (2022).
<https://doi.org/10.1007/s43979-022-00027-3>
- Kirli, D. and Kiprakis, A., 'Techno-economic potential of battery energy storage systems in frequency response and balancing mechanism actions', J. Eng., 2020: 774-782.
<https://doi.org/10.1049/joe.2019.1053>
- Kirli, D., 'Impact of Peer-to-Peer Trading and Flexibility on Local Energy Systems', PhD Thesis, (in press), University of Edinburgh, 2022.



Improving the Value of Energy Storage in Electricity Systems

Prof Aristides Kiprakis SMIEEE MIET
University of Edinburgh

kiprakis@ed.ac.uk

<http://agileenergy.group/>

2022 Asia-Pacific Forum on Green and Low-carbon Development
8-9 September 2022, Changsha, Hunan, China