

Research on low carbon energy technologies at Imperial College London

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At a glance:



18,000+
students



3,765
research and academic staff



190,000
alumni

4

faculties

Medicine
Business
Engineering
Natural Sciences

Business School

Analytics and Operations
Economics and Public
Policy
Finance
Management and
Entrepreneurship
Marketing

Natural Sciences

Chemistry
Life Sciences
Mathematics
Physics
Centre for Environmental
Policy

Medicine

Brain Sciences
Immunology and
Inflammation
Infectious Disease
Institute of Clinical
Sciences
Metabolism, Digestion and
Reproduction
National Heart and Lung
Institute
School of Public Health
Surgery and Cancer

Engineering

Aeronautics
Bioengineering
Chemical Engineering
Civil and Environmental
Engineering
Computing
Dyson School of Design
Engineering
Earth Sciences and
Engineering
Electrical and Electronic
Engineering
Materials
Mechanical Engineering



REF2021 Research
Excellence
Framework

14

Nobel
Laureates

3

Field
Medallists

73

Royal Society
Fellows

86

RAEng Fellows

85

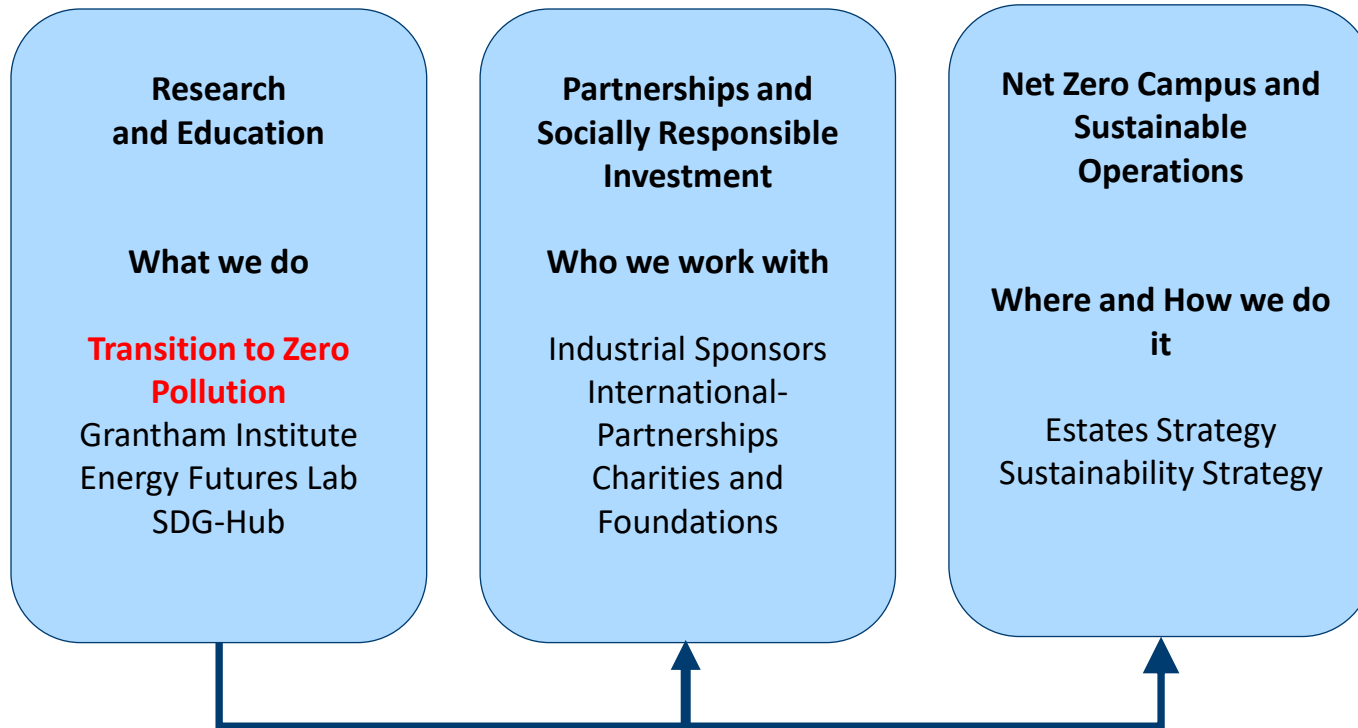
Academy of
Medical Sciences
Fellows

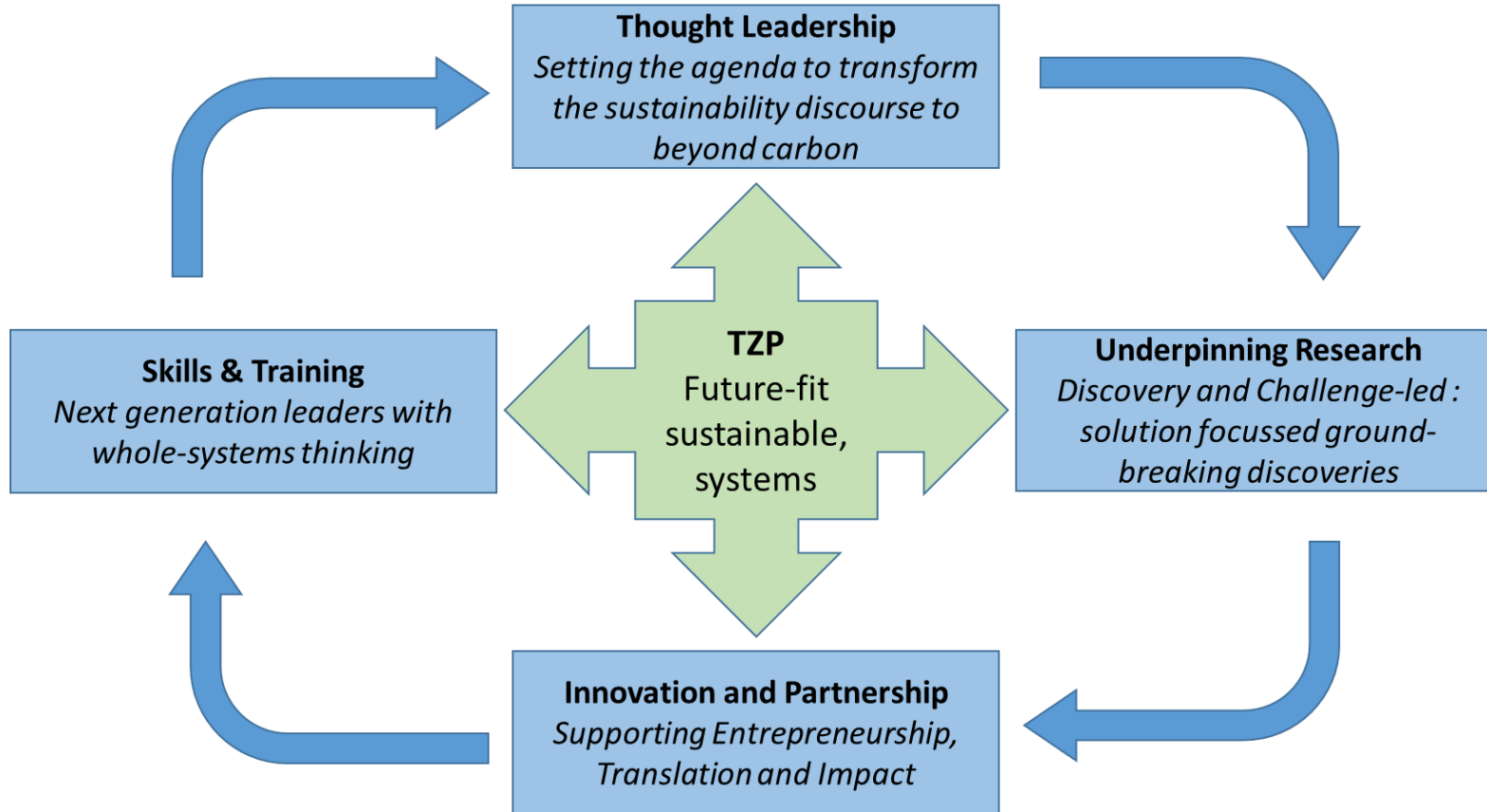
Global Challenge Institutes



Business School	Engineering	Medicine	Natural Sciences
Energy Futures Lab			
Grantham Institute for Climate Change			
I-X			
Institute for Security Science and Technology			
Institute of Molecular Sciences and Engineering			
Institute for Global Health & Innovation			
Institute of Infection			

Towards Zero Pollution – a Key Pillar of Imperial's Sustainability Framework





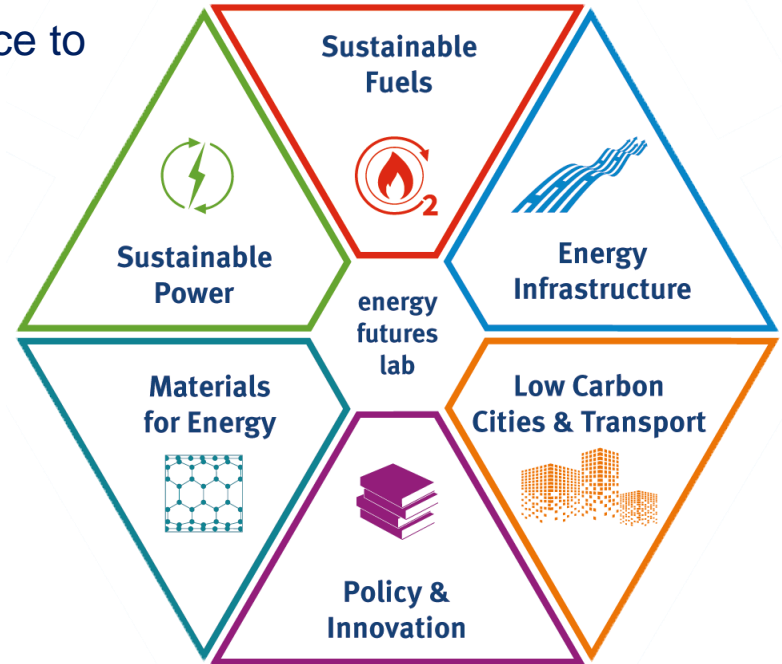
Low Carbon Energy Research at Imperial College London

Instigate and develop **world leading energy research and education** that addresses global challenges and to ensure that Imperial College remains a vibrant and stimulating place to develop ideas, innovative technologies and positively impact society in the UK and internationally

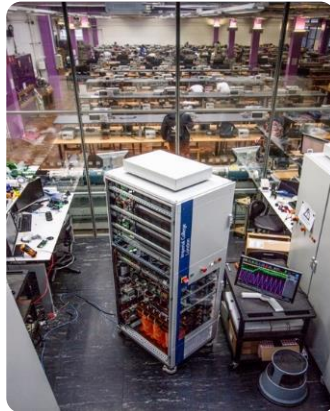
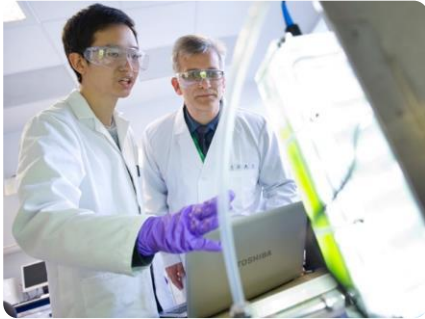


Around 1,000 Academics & Researchers
650 Sustainable Energy Futures MSc Graduates

MSc in Sustainable Energy Futures



Energy Facilities and Labs



Net-zero: hard to decarbonise sectors

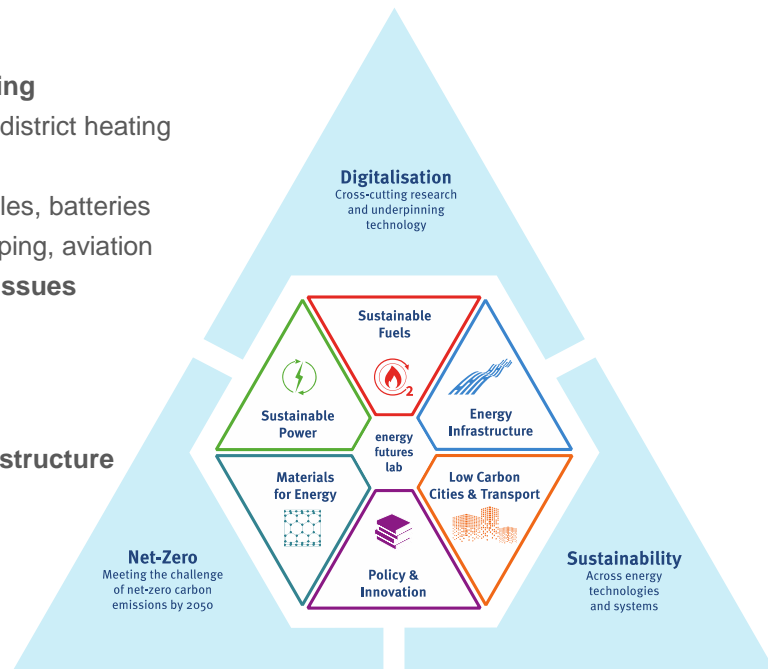
- **Electricity – the final 20 %**
- **Industry:**
 - low carbon technologies (CCUS and H₂ at scale)
 - foundation industries: resource sharing and energy efficiency
 - clean steel (renewable energy, CCUS, H₂ integration)
 - low carbon heat network
 - systems integration
- **Heating and cooling**
 - heat pumps, district heating
- **Transport**
 - electric vehicles, batteries
 - fuels for shipping, aviation
- **Socio-economic issues**

Sustainability: holistic view of resources and environment

- **Sustainable chemicals and fuels**
- **Sustainable raw materials for energy technologies, energy carriers, catalysts, infrastructure**
 - primary, secondary materials
 - life cycle performance
 - security of supply
 - circular economy
- **Environmental impacts of energy technologies and systems**
 - ecology and human health

Digitalisation: underpinning changes in energy systems

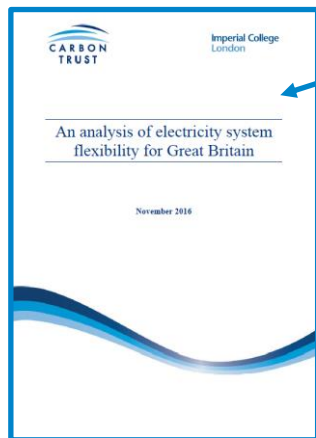
- Leveraging consumer actions
 - Data-driven models of behaviour for demand-side management
 - IoT-enabled DSR
- Accelerate materials discovery through machine learning
- Control of complex energy systems
 - Agent-based autonomous / decentralised control for many actors
 - Control room decision-support, visualisation and situational awareness
 - Modelling of extreme events
- Improved asset management and prognostics



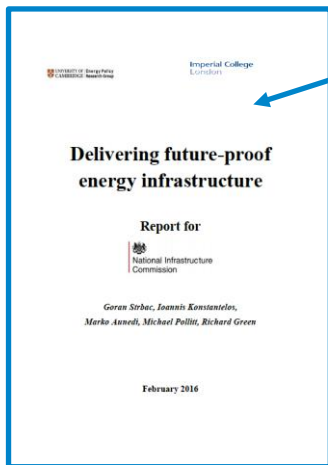
Impact: Evidence for Policy Making

WESIM – Whole Energy System Investment-Planning Model

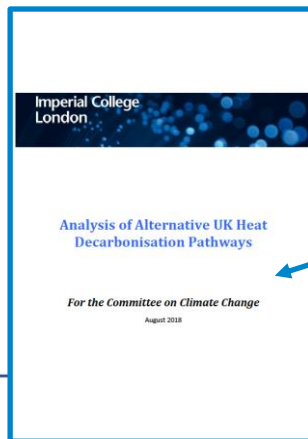
Developed in EP/I013636/1, EP/K039326/1 and EP/K002252/1



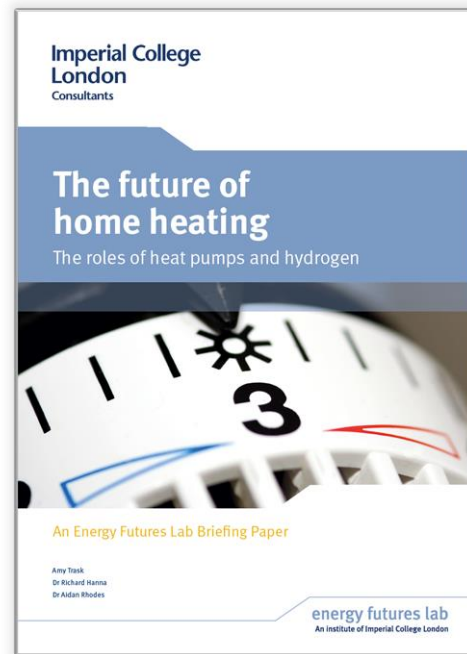
Report to BEIS on “flexibility” – BEIS and OFEGM changing policy and regulatory framework to re-shape roles and promote innovation in “Upgrading Our Energy System: Smart Systems and Flexibility Plan”



Report to National Infrastructure Commission – quoted extensively by NIC in their own “Smart Power” report.



Report to Committee on Climate Change – used for 13 figures and 30 references in CCC report on hydrogen in low-carbon economy



Jan 2022 downloaded over 1,600 times from Spiral

Partnering with industry and leading policy through roadmapping



THE ROLE OF HYDROGEN AND FUEL CELLS IN PROVIDING AFFORDABLE, SECURE LOW-CARBON HEAT

A H2FC SUPERGEN White Paper

J. Phys. Mater. 5 (2022) 032001

<https://doi.org/10.1088/2151-3758/abcf1a>

Journal of Physics: Materials

ROADMAP

The sustainable materials roadmap

Magda Titirici¹, Sterling G Baird², Taylor D Sparks³, Shirley Min Yang⁴,

J. Phys. Energy 4 (2022) 042003

<https://doi.org/10.1088/2515-7655/ac7823>

J. Phys. Energy 3 (2021) 031502

<http://dx.doi.org/10.1088/2515-7655/ac7823>

Journal of Physics: Energy

TOPICAL REVIEW

Roadmap on inorganic perovskites for energy applications

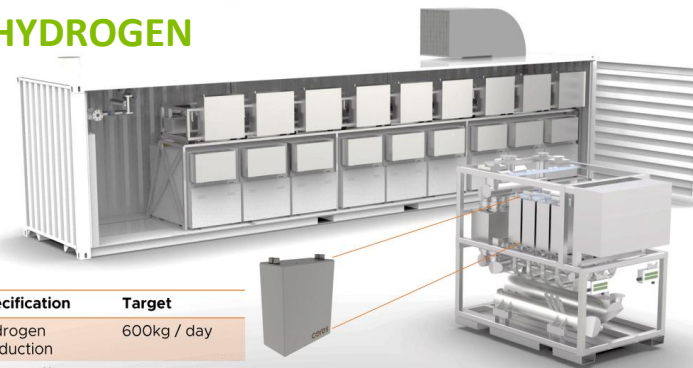
John Irvine^{1,*}, Jennifer L. M. Rupp², Gang Liu^{3,4}, Xiaoxiang Xi^{5,6}, Sossina Haile⁷, Xin Qian⁸, Alem Snyder², Robert Freer², Dursun Eken⁹, Stephen Skinner⁹, Ozden Celikbilek⁹, Shigang Chen¹⁰,

OPPORTUNITIES FOR HYDROGEN AND FUEL CELL TECHNOLOGIES TO CONTRIBUTE TO CLEAN GROWTH IN THE UK



A H2FC SUPERGEN White Paper

ceres
HYDROGEN



Specification	Target
Hydrogen production	600kg / day
System efficiency	>80%, LHV, AC

MATERIALS FOR THE ENERGY TRANSITION

MATERIALS FOR LOW-CARBON METHODS FOR GENERATION OF HYDROGEN AND OTHER RELATED ENERGY CARRIERS AND CHEMICAL FEEDSTOCKS

This publication forms part of the 'Materials for the Energy Transition' series. The Henry Royce Institute in collaboration with the Institute of Physics and the Institute for Manufacturing have convened the academic and industrial materials research communities to explore opportunities for materials to support the UK's net-zero by 2050 target.

energy futures lab
An Institute of Imperial College London

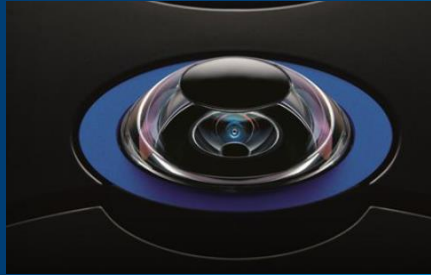
Partnerships for innovation

Imperial offers bespoke partnerships to companies all over the world to further fundamental research and solve business challenges



Hitachi Decarbonization Centre

Hitachi and Imperial signed a deal in 2022 for a new Joint Research Centre on Decarbonization and Natural Climate Solutions



Dyson Robotics Lab

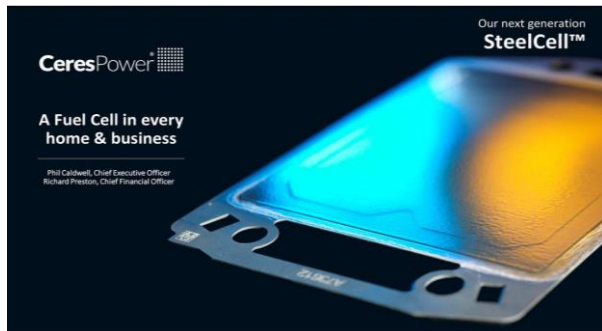
Dyson has invested in a major partnership with Imperial on real-time vision-based localization, mapping, scene understanding, spatial AI and interaction.



Turbocharger design

Mitsubishi Heavy Industries (MHI) has invested in a major partnership with Imperial that has led to substantial improvements in turbocharger design as a result of advanced measurement techniques

Impact: Examples of Spin-Out Formation



Single product to multiple applications and customers



© Ceres Power Ltd 2021

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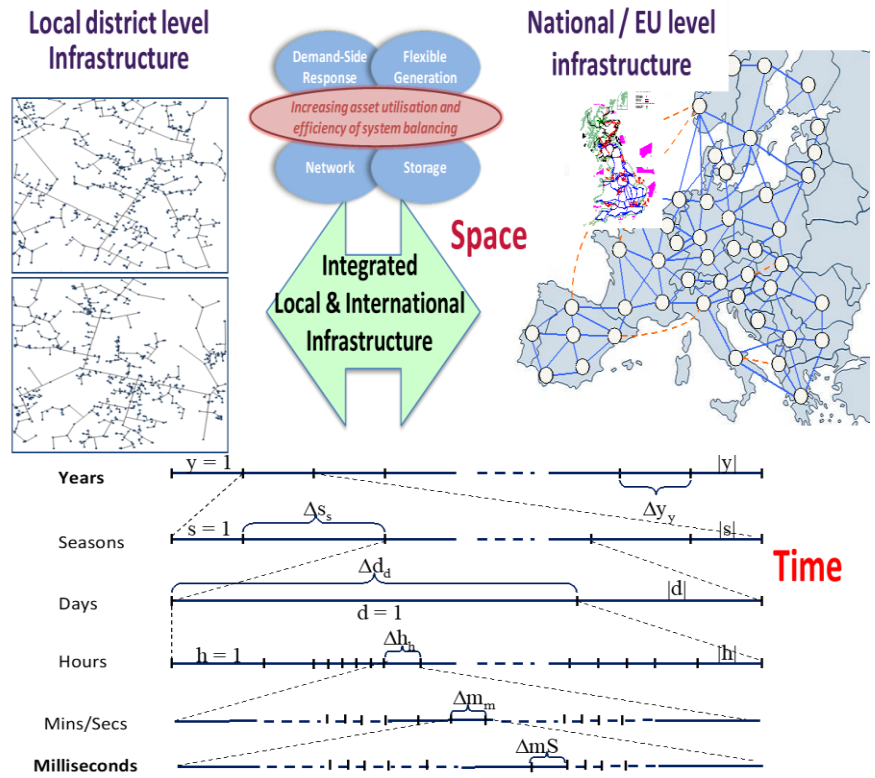
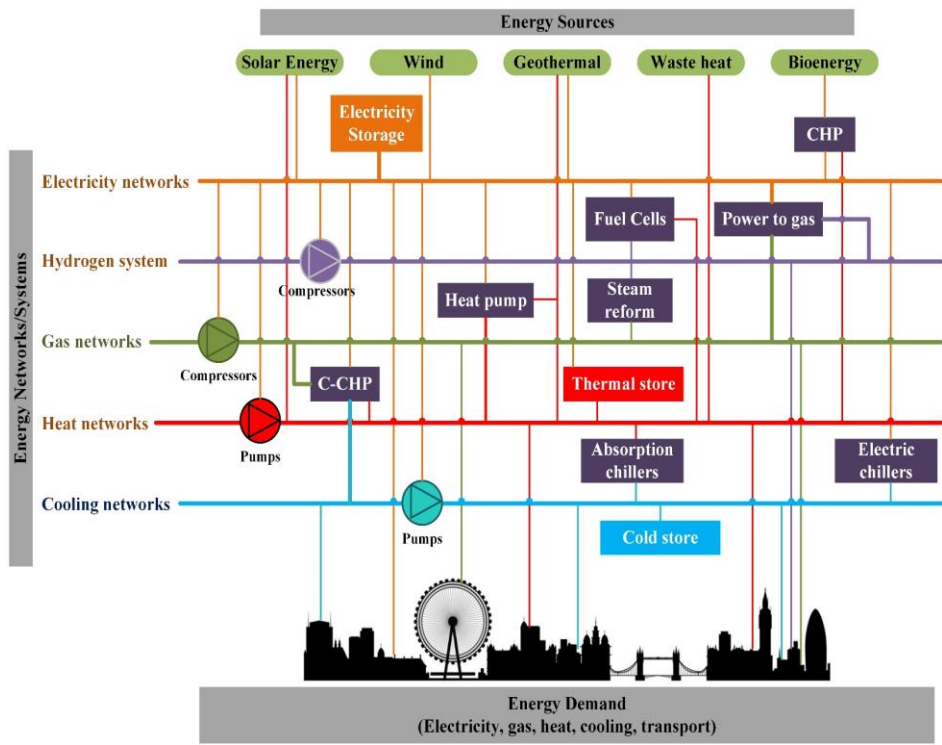


Ceres, Shell ink megascale green hydrogen deal

Having committed £100m for the development of its SOEC technology, Ceres aims to produce hydrogen at efficiencies around 20% greater than other technologies and achieve a levelized cost of hydrogen of \$1.5 per kg by 2025.

By Anthony Wright | 28 June 2022

Whole system approach is critical for cost effective decarbonisation of all energy sectors – advanced modelling



Global integrated assessment modelling (IAM, IWES)

Assessment of the role and value of emerging technologies from the whole-system requirements perspective

Green Fuels at Imperial College London

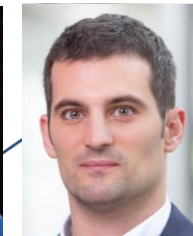
Relevant Initiatives across Imperial

- Sustainable Gas Institute
- Brahma Vasudevan Institute for Sustainable Aviation
- Interfacial Electrochemistry Group & Electrochemistry Network
- Henry Royce Institute – Materials for the Energy Transition
- BP-International Centre for Advanced Materials (low carbon energy)

Key Participants/Departments

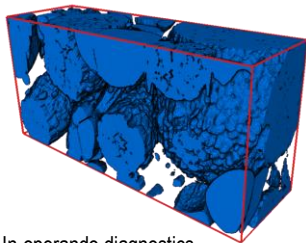
Departments of Life Sciences, Chemistry, Chem. Eng., Civ. Eng., Mech. Eng., Earth Sci. Eng., Mater. Sci. Eng.

Expertise in wide range topics related to green fuels at multiple length scales



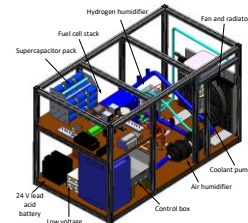
Broad research topics in energy storage technologies including batteries, fuel cells and electrolyzers

Lithium-ion batteries



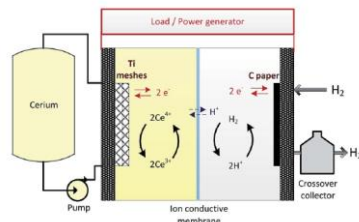
- In-operando diagnostics
- Understanding degradation
- Improving performance
- Electrode design

Fuel cells



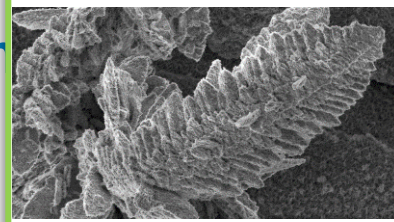
- Balance of plant modelling/control
- Flow field design
- System hybridisation
- SOFC materials

Flow batteries



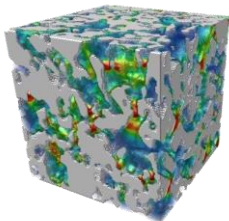
- Liquid-gas hybrid flow batteries
- Electrode design
- System modelling
- Flow field design

Future chemistries



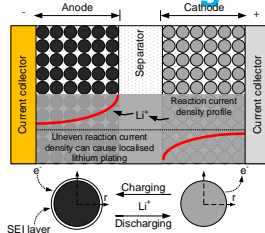
- Solid-state batteries
- Anode-free lithium-metal batteries
- Zinc-air batteries
- Silicon anodes

Microstructure



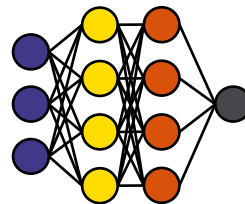
- X-ray computed tomography
- Operando imaging
- Understanding transport properties
- Characterising morphological changes

Modelling



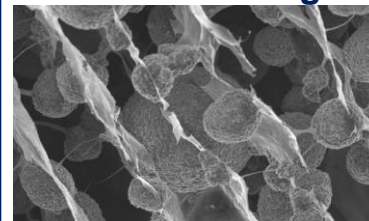
- Physics based models
- Empirical physics models
- Reduced order models
- Phase field models

Machine learning



- Neural networks for battery diagnostics
- Data driven lifetime forecasting
- Digital twins
- Data-fusion

Manufacturing



- Thick electrodes
- Electrochemical additive manufacturing
- Electrospinning
- Reactor design and manufacturing

Summary

- Imperial College London is leader in research aimed at decarbonization across a wide range of sectors
- Cross-sector coupling and integration is an important part of future decarbonization – this requires technology strengths in breadth and depth and the ability to take a systems perspective.
- We are involved in a wide range of work related to maritime, from future fuels (such as green/blue hydrogen and ammonia) through to propulsion technologies, and from lightweighting of materials to circular materials supply chains.
- We enjoy excellent links with industry and have a strong track record of delivery.
- Imperial College has long standing collaborations with partners in Singapore and we look forward to discussing these topics further.