# Do we have the technologies to meet the COP-21 ambitions?"

@EnergyIChemE

Prof. Stefaan Simons
Chair, Energy Centre Board

# http://www.brunel.ac.uk/colleges

**College of Engineering, Design and Physical Sciences**
Computer Science
Design
Electronic and Computer Engineering
Mathematics
Mechanical, Aerospace and Civil Engineering

**College of Business, Arts and Social Sciences**
Brunel Business School
Arts and Humanities
Economics and Finance
Education
Politics, History and Law
Social Sciences, Media and Communications

**College of Health and Life Sciences**
Clinical Sciences
Life Sciences

**Institute of Energy Futures**
Advanced Engines and Biofuels
Energy Efficient and Sustainable Technologies
Smart Power Networks
Resource Efficient Future Cities

**Institute of Environment, Health and Societies**
Health and Environment
Healthy Ageing
Health Economics
Synthetic Biology
Biomedical Engineering and Healthcare Technologies
Social Sciences and Health

**Institute of Materials and Manufacturing**
Design for Sustainable Manufacturing
Liquid Metal Engineering
Materials Characterisation and Processing
Micro-Nano Manufacturing
Structural Integrity

# NSIRC – a £90 million initiative

**The Centre**

- Led by TWI and Brunel, building on 14 year relationship
- Industrial direction/ funding from TWI, BP, Lloyds Register
- 8 UK partner universities

**Funding**

- £15M Higher Education Funding Council England
- £18.65M UK Regional Growth Fund
- £45M Industry cash (PhDs, research programmes)
- £12.5M Brunel (11 new academic posts)

**Mission**

- Train over 300 PhD students and 200 MSc students and
- Undertake industrially relevant, inter-disciplinary research in the structural integrity of materials, equipment, infra-structure and manufactured goods.

# *Energy Efficient and Sustainable Technologies (EEST)*

- **National Centre for Sustainable Energy Use in Food Chains (CSEF)** –
- funded by RCUK (2013-2018), £6.0 M.


- International profile and reputation in a number of areas (heat recovery, refrigeration, heat transfer).

# Advanced Light Metal Casting




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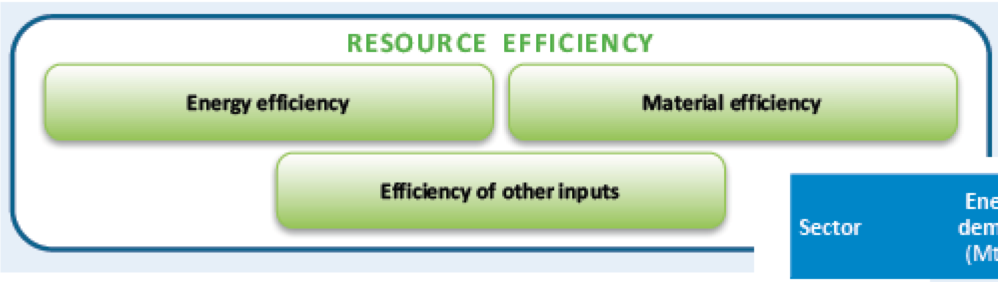
# WEO energy efficiency outlook



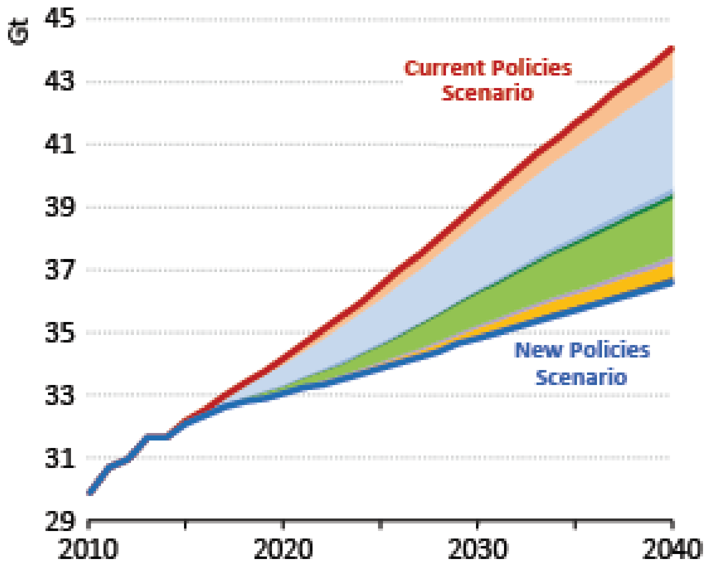

| Sector | Energy demand (Mtoe) | $CO_2$ emissions* (Mt $CO_2$) | Description |
|---|---|---|---|
| Steel | 785 (23%) | 2 706 (20%) | Majority of energy demand is coal in primary steel-making via the blast furnace and basic oxygen route. Recycled scrap metal is mainly used as an input in electric arc furnaces (secondary steel-making), which uses electricity and requires only around a fourth of the energy consumed in primary steel-making. |
| Plastics | 315 (9%) | 533 (4%) | Two-thirds of energy consumption is feedstock and the rest is mainly thermal energy. Recycled plastic production requires 70-90% less energy input (including feedstock) compared with virgin plastic. |
| Cement | 281 (8%) | 2 608 (19%) | Clinker production, the main ingredient in cement, consumes almost the entire thermal energy in cement production and currently emits around 1.5 Gt of process emissions in addition to emissions from fuel combustion. |
| Paper | 160 (5%) | 475 (3%) | The majority of energy demand is used in chemical and mechanical pulp production, mainly bioenergy. Pulp from recycled fibre requires only around 10% as much energy as chemical pulp. |
| Aluminium | 113 (3%) | 680 (5%) | Energy demand in the aluminium sector is dominated by electricity for primary aluminium production. Secondary aluminium production from scrap metal reduces energy needs by up to 90% as it avoids the energy-intensive process of alumina refining and aluminium smelting. |

"Material efficiency is an important complementary strategy to energy efficiency in energy-intensive industries, as the potential for energy savings is about twice as large."

WEO2015

# Why is Energy Efficiency such an important issue?

**Figure 10.9 ▷ World energy-related $CO_2$ emissions abatement in the New Policies Scenario relative to the Current Policies Scenario**




| $CO_2$ abatement | 2025 | 2040 |
|---|---|---|
| Energy service demand | 16% | 12% |
| End-use efficiency | 53% | 48% |
| Supply efficiency | 3% | 3% |
| Fuel and technology switching in end-uses | 2% | 2% |
| Renewables | 19% | 24% |
| Biofuels | 2% | 2% |
| Nuclear | 4% | 7% |
| CCS | 1% | 2% |
| Total (Gt $CO_2$) | 2.6 | 7.5 |

Note: CCS = carbon capture and storage.

Drivers: energy security, affordability and climate change



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# Industrial Manufacturing

- Industrial manufacturing accounts for 36% of $CO_2$ emissions
- Over 65% of industrial energy use consumed by chemicals, cement, iron and steel, primary aluminium, pulp and paper
- The importance of energy in production costs is greatest in the chemicals industry (up to 80% in some cases, incl. petrochemicals)



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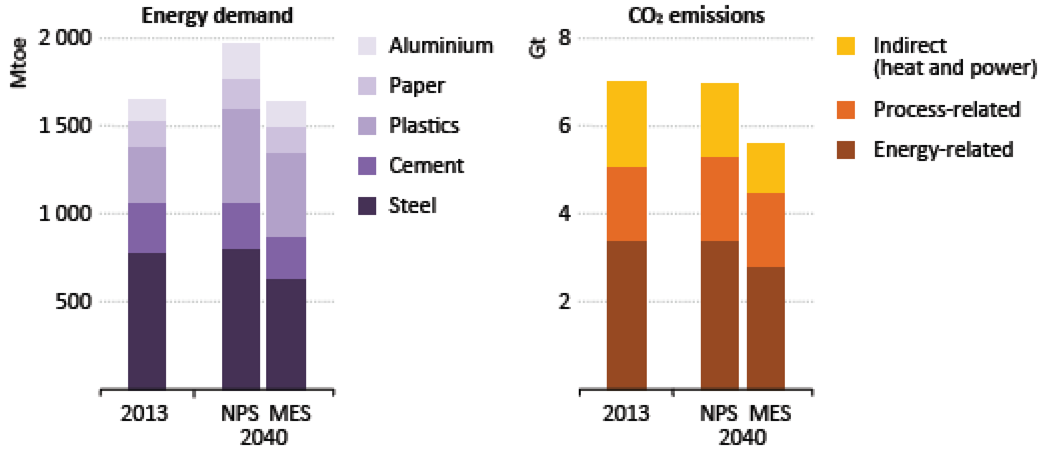
# Energy efficiency and the circular economy


**Materials efficiency** concerns the amount of a particular material needed to produce a particular product. It can be improved by either reducing the amount of the material contained in the final product ("lightweighting"), or by reducing the amount of material that enters the production process and ends up in the waste stream. Three components of material efficiency can be identified: **lightweighting** in the production process; **waste reduction** in the production process; and **recycling** of material in the production-consumption cycle.

**Figure 10.12 ▷ Energy demand and $CO_2$ emissions from the production of selected energy-intensive materials in the New Policies Scenario and Material Efficiency Scenario**




Note: NPS = New Policies Scenario; MES = Material Efficiency Scenario.

For steel: increase in lifetime, light-weighting, re-use of scrap

For plastics: light-weighting, recycling, energy recovery

Significant barriers due to investment costs. Political intervention required, such as a price on carbon. Public awareness also needs to be raised.



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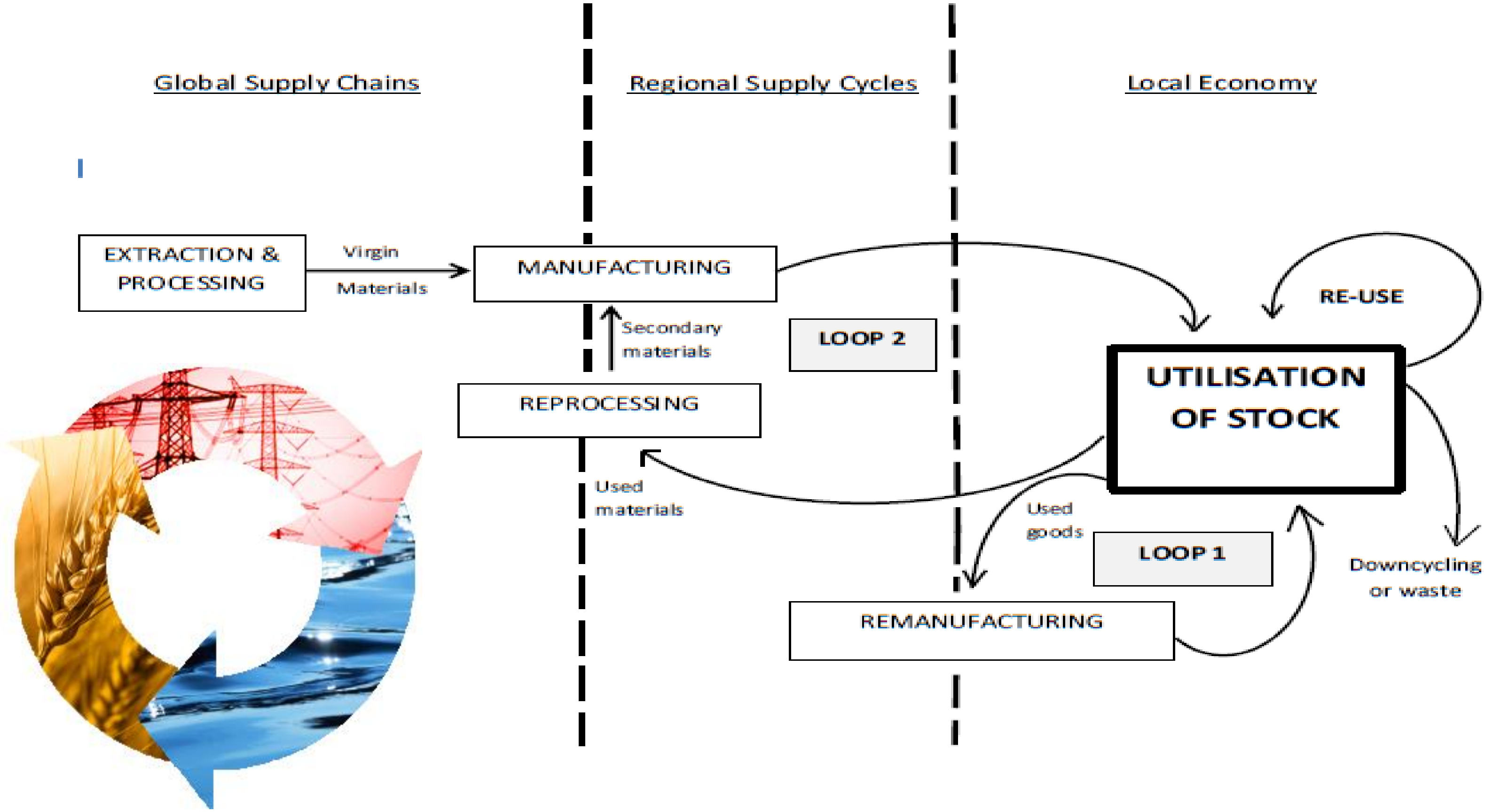
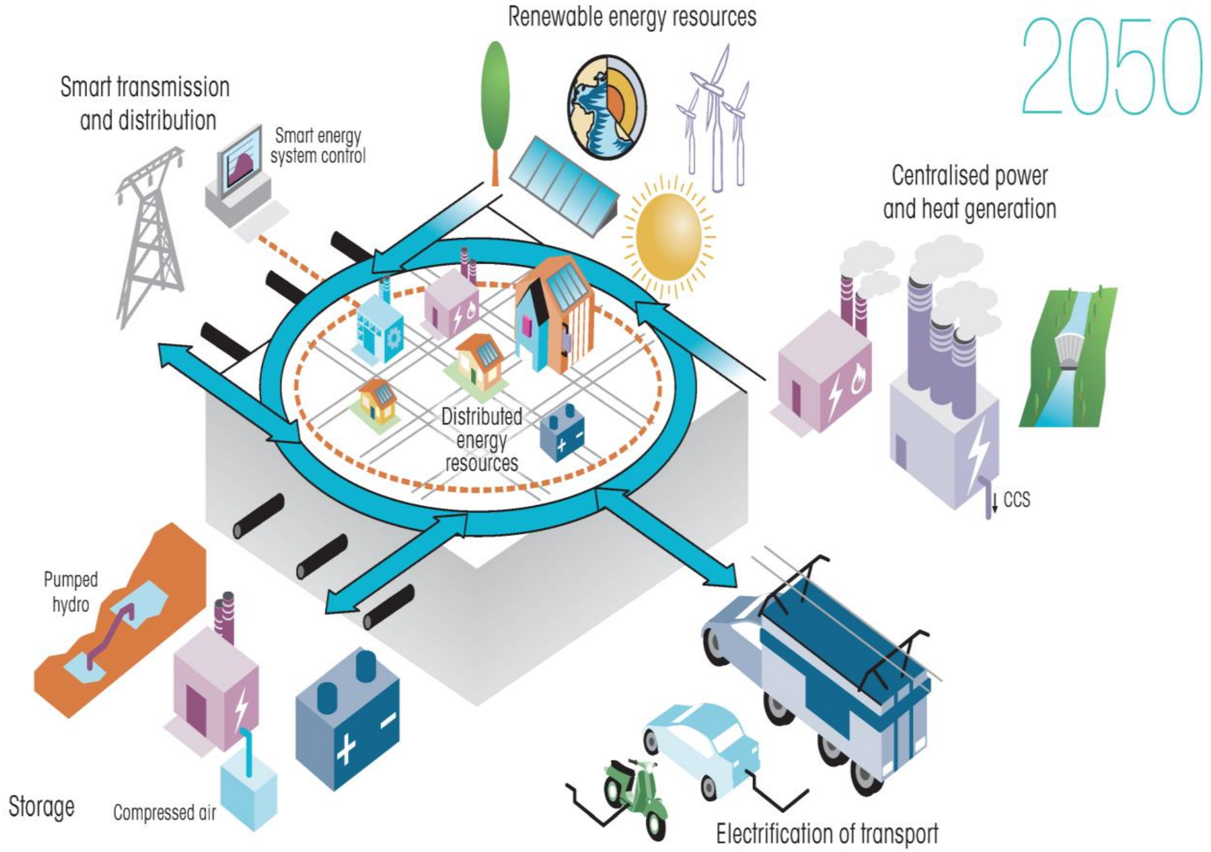
# The Performance Economy




Energy savings five-fold, compared to energy efficiency measures.

# A Community-Driven Energy System




IEA Energy Technology Perspectives 2015

# Post-COP21



## Our Hard Work Starts Now

*Chemical engineers are ideally placed to turn the words in the Paris Agreement into actions on climate change*

STEFAAN SIMONS
CHAIR OF THE ICHEME ENERGY CENTRE AND PROFESSOR OF ENERGY SYSTEMS ENGINEERING AT BRUNEL UNIVERSITY, UK

**I WAS fortunate enough to be in Paris in December to watch history in the making as the governments of the world signed up to stop climate change at the 21st Conference of the Parties (COP21). The first thought that came to my mind when the agreement was reached was shock – not that an agreement was reached at all – but the fact that it went much further than I or anyone had anticipated.**

I found the event to be eye-opening; it was a novelty to attend a congress on climate change where there was so much enthusiasm, positivity and excitement in the room.

SIMONS SPEAKING AT COP21: CHEMICAL ENGINEERS ARE READY TO SUPPORT POLICYMAKERS

After two weeks of tough negotiations, the final agreement (now the Paris Agreement) was adopted by all 190 nations, only one day later than planned – Saturday 12 December 2015. The Agreement is just that, an agreement, and whilst it means that all countries must work together to halt climate change, it doesn't tell us *how* we are going to achieve this. *Our hard work starts now.*

The Paris Agreement will come into effect in 2020, empowering all countries to act to prevent average global temperatures rising above 2°C. Each country now has to ratify the Agreement and provide emission reduction targets by 2020, which will need to be updated every five years.

The Agreement outlines global average temperature targets as: "Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels" by 2050.

However, despite this excellent news, the Agreement is only the very first step on our very long journey to decarbonising the world's energy systems. And whilst reaching the political mandate is key in driving forward change, what really matters now is our ability to apply the technological solutions that will actually have an impact.

### NUCLEAR, CCS, RENEWABLES AND ENERGY STORAGE REMAIN IN THE MIX, BUT IN THE ABSENCE OF CLEAR-CUT TECHNOLOGY PATHWAYS, IT IS DIFFICULT TO SEE HOW REAL PROGRESS ON DECARBONISATION CAN BE ACHIEVED

The reaffirmation of the 2°C target is welcome, but the route map still remains unclear. Nuclear, CCS, renewables and energy storage remain in the mix, but in the absence of clear-cut technology pathways, it is difficult to see how real progress on decarbonisation can be achieved.

The inclusion of the 1.5°C aspiration in the Agreement is a real game changer. Peak emission scenarios suggest that this limit will already be breached. If we are serious in our aim to achieve this, business-as-usual is no longer an option. The only solution is a step-change in our approach to fossil fuels, starting right now.





### THE AGREEMENT RAISES A SERIES OF QUESTIONS THAT WE AS CHEMICAL ENGINEERS ARE IDEALLY SITUATED TO ANSWER

To achieve the 1.5°C limit, CCS deployment must be progressed as an urgent priority and this will require proactive support from governments around the world. At the same time, we must redouble the R&D effort so that we can further understand the integrated low-emission energy systems needed in a post-fossil fuel era.

The Paris Agreement not only puts pressure on governments at the international stage, it means that we are all going to need to change the way we operate as individuals.

### WHAT IS THE FUTURE OF OIL AND GAS? HOW CAN WE MAKE THE SOLUTIONS TO CLIMATE CHANGE AFFORDABLE *AND* EFFICIENT? IS IT POSSIBLE TO REVOLUTIONISE OUR ENERGY PRODUCTION SYSTEMS?

Additionally, we are not going to meet our targets unless somewhere, somehow, we can reach a consensus on carbon pricing. However, this is not a technological issue and is not something chemical engineers can do alone. We need to work with other groups to collaborate on carbon pricing. This is the only thing that is going to drive energy efficiency.

The Agreement raises a series of questions that we as chemical engineers are ideally situated to answer. What is the future of oil and gas? How can we make the solutions to climate change affordable *and* efficient? Is it possible to revolutionise our energy production systems?

The political conversation will continue but this won't save the planet. Chemical engineers can turn words into actions, with the development of workable National Climate Plans – called Intended Nationally Determined Contributions (INDCs). The IChemE Energy Centre stands ready to support this process – chemical engineering matters like never before.

The only way we have managed to do this and get this far is by working together. Solving the climate challenge is a whole world problem, and a problem that can't be solved by working alone. We need to learn from each other.

Paris is not the end. It is just the beginning. ■

*Simons presented at the Paris climate talks on 10 December at an official side event, "Technology solutions for a 2°C world: Investing in renewables, storage, energy efficiency and CCS". You can watch this event on IChemE's YouTube channel: bit.ly/COP21techsolutions*

**energycentre@icheme.org**

### THE NATIONAL AGENDAS

#### UK

The UK was the first nation to implement a climate change law in 2008, so should already be on track to meet the new Paris Agreement. However, concerns have been raised about targets being missed due to the apparent lack of commitment to renewables and the implementation of CCS.

#### AUSTRALIA

Australia will face increasing pressure to revise its climate strategy and be more ambitious in terms of emissions reduction. This will require moving away from coal-fired generators and limiting the exploitation of new coal mines. The Australian government will need to join with industry and make strong commitments to low-carbon technology.

#### NEW ZEALAND

New Zealand has a strong focus on renewable energy usage, but should move away from plans for unconventional oil and gas production to limit emissions and phase out fossil fuel use to meet the Agreement. Its biggest emission source is agriculture, which is not included in their emissions trading scheme.

#### MALAYSIA

Malaysia's focus should now be on reducing emissions and making the switch to the use of renewable energy sources. Introducing carbon pricing could help to stimulate this transition and ensure that Malaysia is able to meet its Paris Agreement pledges. Its vulnerable status means that it will need to work to avert climate change impacts, such as flooding in coastal areas.

#### SINGAPORE

The Paris Agreement gives hopes to Singapore. As an island state, sea level rises are already having an impact, with about 30% of Singapore being less than 5 m above the sea level. Singapore will need to reduce its reliance on imported gas and further develop its renewable programme. Singapore could be a key technology hub for low-carbon strategies.

#### SOUTH AFRICA

South Africa will need to work to move towards increased renewables use. Focus needs to be given to the technical and financial implications that implementing the Paris Agreement will have on energy strategies. Introducing a carbon price would help to control this development and trigger a move away from fossil fuels. The government should stand by its pledge to do so this year.

#### MIDDLE EAST

Much of this region's energy strategy is price-led with economies reliant on hydrocarbons to maintain quality of life. Subsidies on utilities and fuel will be gradually reduced which will bring down emissions *per capita*, but it is only by reducing the impact on climate change of the Middle East's exported hydrocarbons that will lead to a significant emissions reduction.

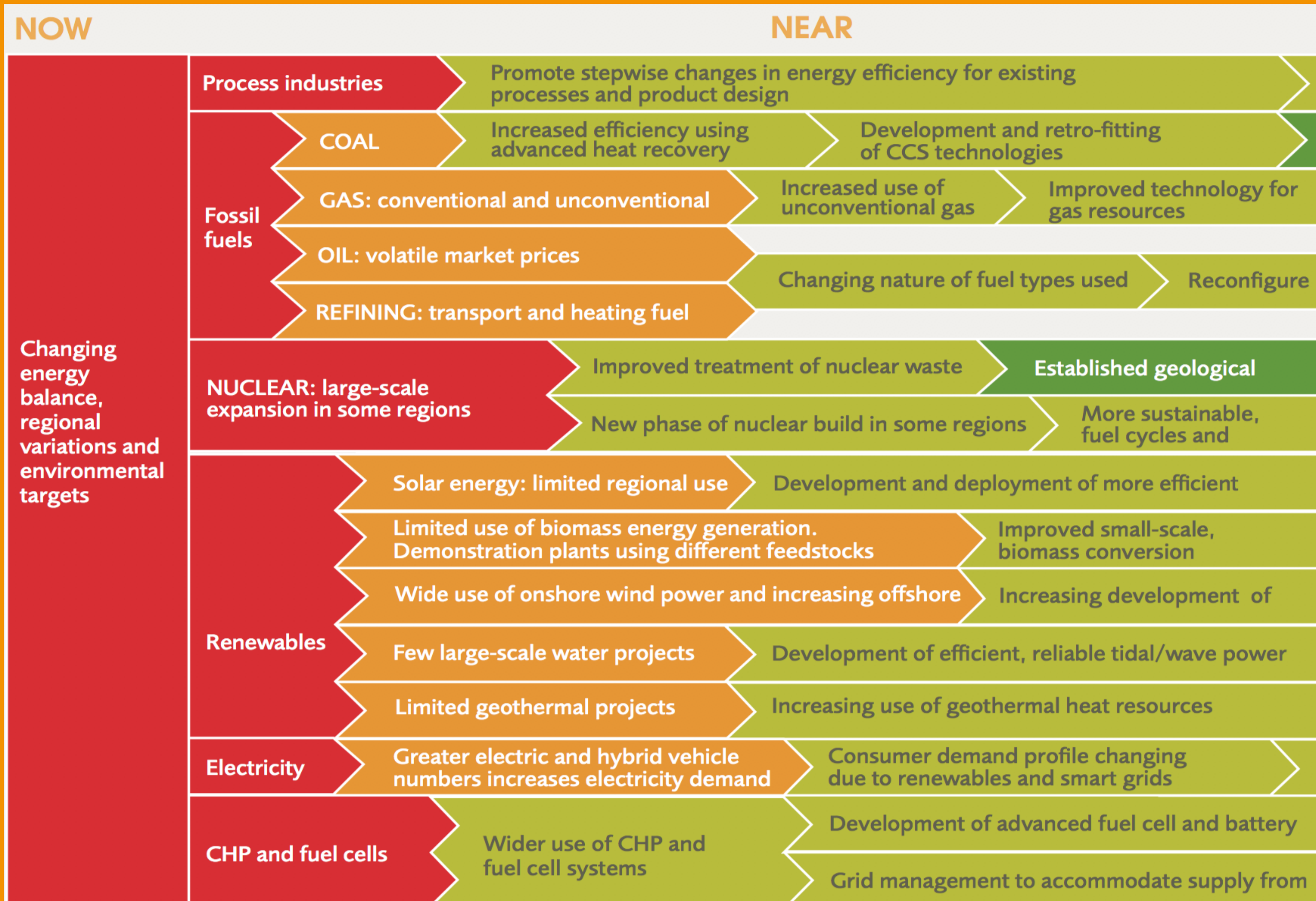
# The IChemE Energy Centre

Systems thinking solutions for the global energy economy

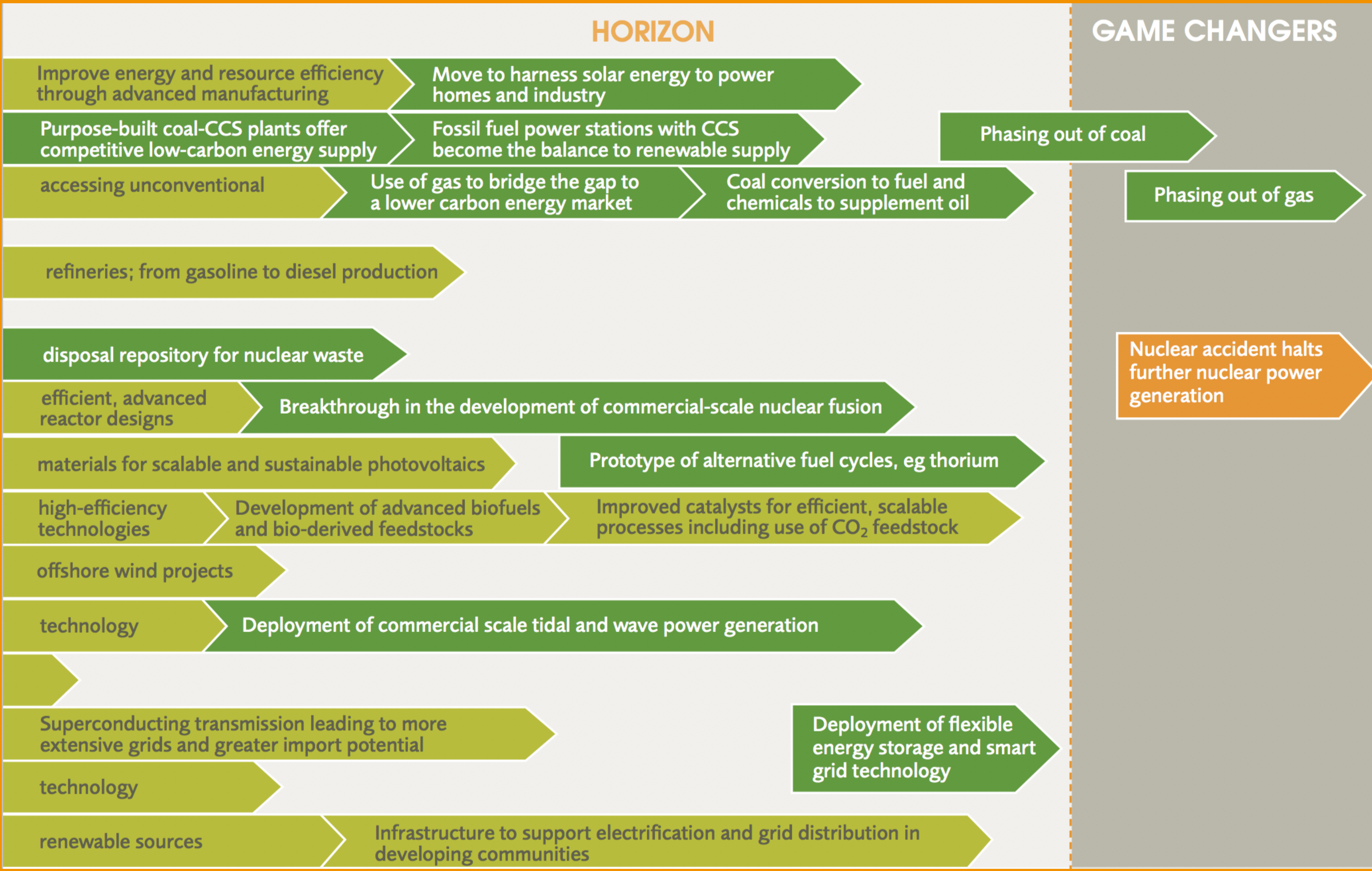
- launched in March 2015
- the Centre will provide an evidence-based chemical engineering perspective on global energy challenges

To find out more visit www.icheme.org/energycentre, email energycentre@icheme.org or tweet @EnergyIChemE

# IChemE Energy Vista



# IChemE Energy Vista



# Five priority topics

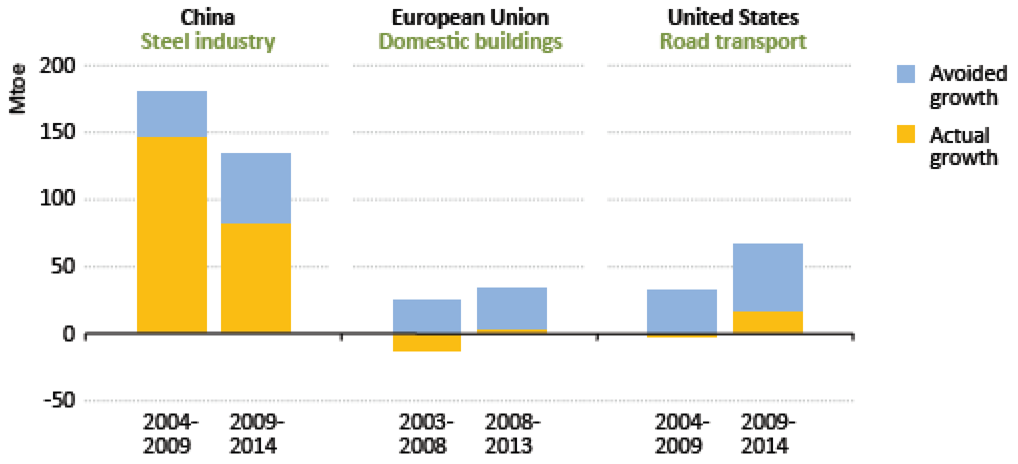
- energy efficiency
- energy storage and grid management
- nuclear
- carbon capture, storage and utilisation
- sustainable bioenergy

# EE Scenarios

- Direct efficiency measures, e.g. motors
- Energy conservation, e.g. heat integration
- Energy demand reduction, e.g. new products and processes

# Significant progress…

**Figure 10.1 ▷ Energy demand change and avoided energy demand from efficiency gains in selected sectors and regions**




- The extent of mandatory energy efficiency regulations has spread over the last ten years: from covering 14% of the world's energy consumption in 2005 to 27% in 2014. Efficiency regulations now cover 36% of industrial energy use, up from only 3% in 2005, driven by new mandatory targets in China and India, while coverage in the transport and buildings sectors is 24% and 31% respectively. China experienced the largest jump in overall coverage, from 3% in 2005 to 50% in 2014.

WEO2015



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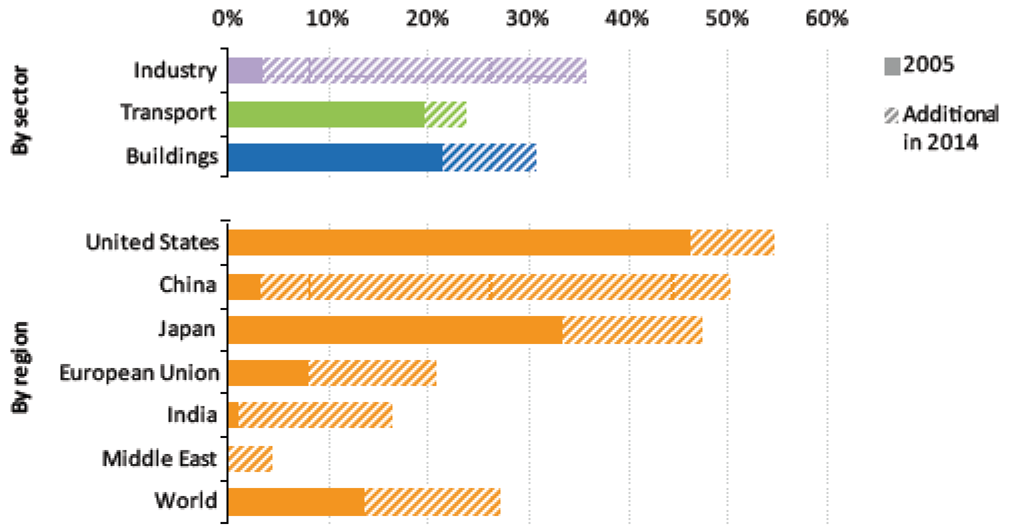
**Figure 10.2 ▹ Extent of global mandatory efficiency regulation of final energy consumption by sector and region**




Note: Non-energy use (mainly petrochemical feedstocks) accounts for 8% of total find energy consumption and is per definition not covered by energy efficiency policies.

Biggest impact has been on industry sector, specifically the energy-intensive industries. Only much smaller gains can be made purely on energy efficiency (although it is still worth doing). Focus is now on non-energy –intensive industries.



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# The Project Delivery Process

Why can't we deliver more energy efficiency and renewable energy projects faster across all types of organisation?

## Project Steps

**Origination**
- Opportunity Assessment
- Feasibility Study

**Full Business Case**
- Investment Grade Audit
- Detailed Design and Engineering

**Project Delivery and Operation**
- Construction and Commissioning
- Operations and Maintenance

## Road Blocks

- Low energy costs relative to operating costs; not looking
- No money or resource to develop opportunities; a "million" other problems
- No board level sponsorship; not core business
- Not financially attractive; better use of capital
- Fear of disruption to operations; hassle
- Concerns over savings; will measures work; will incentives change
- Short termism; no pressure to act

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# Ideas to Unblock and Accelerate Deployment

How can we help to accelerate the development and implementation of energy efficiency and renewable energy solutions?

## Encourage ("The Carrot")

**Incentives**

- Renewable Power Payment
- Renewable Heat Payment
- **Energy Saving Payment**
- Tax relief for energy efficiency equipment (both capital and operating)

**Taxes**

- Climate change tax on power
- Climate change tax on fuel

! Levels need to be material $/kWh

## Enforce ("The Stick")

Mandatory Reporting of Emissions
(Scope 1, 2, 3)

Mandatory Identification of Opportunities

Learn from Health & Safety Legislation

As Low As Reasonably Practicable (ALARP)
Direct prosecutions of individuals for failure to comply
Unlimited corporate fines

! Punitive measures need to be significant

# Ideas to Unblock and Accelerate Deployment

What about direct intervention by governments to drive change?

## Direct Government Intervention

**Project Development Assistance**
- Early stage support via a loan or grant
- Cover origination phase costs
- Get projects ready to contract, ready to invest

**New Technology Support**
- Support to accelerate development
- Realise benefits of new technology sooner
- e.g. storage, fuel cells, electric vehicles

**Guarantees**
- Provide credit guarantees to organisations
- Attract third party investors
- Projects get delivered that otherwise fail

**Education and Communication**
- Raise awareness of energy efficiency benefits
- Up to 80% energy costs wasted
- Promote funding models e.g. Energy Performance Contracts

**Investment Funds**
- Allocated government money to invest in projects
- For example, UK Green Investment Bank
- Double bottom line of carbon and profit, on market supply of money, draws in 3rd party investors

**Green Bonds**
- Provide tax breaks for issuers to fund green projects
- Cheap source of finance, successful in the US
- Can delay/distort markets as other investors wait

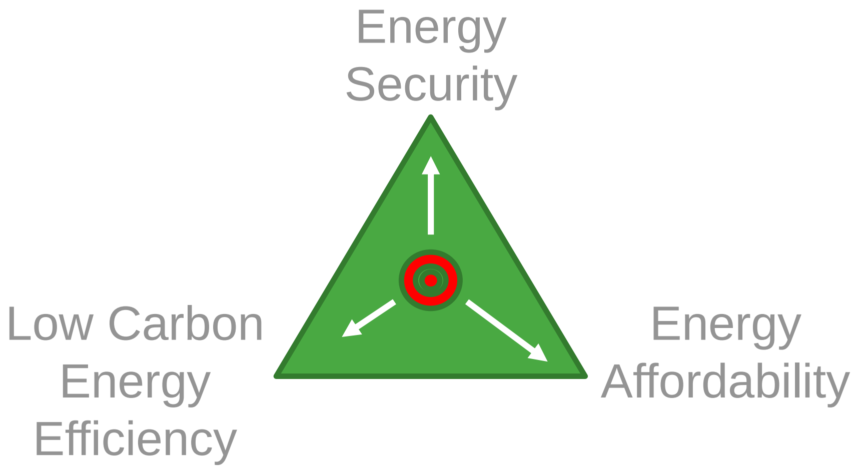
**Infrastructure Projects**
- Build the infrastructure for a low carbon future
- e.g. Smart power grids, renewable generation, vehicle charging, low carbon transport systems, hydrogen gas grids, CCS

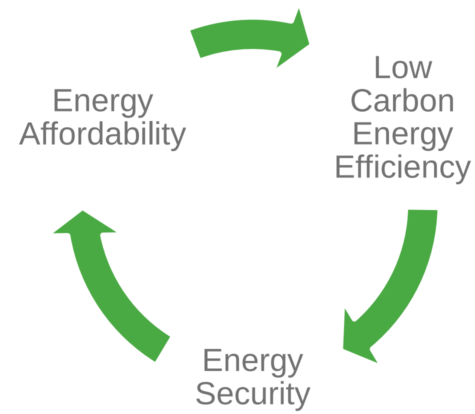
**Whatever Works!**
- Political structures vary from country to country
- Success should be measured in magnitude and speed of emissions reduction

# Look Up and Out to the Future

*"You cannot escape the responsibility of tomorrow by evading it today"*, Abraham Lincoln

## Long Term Strategy to 2050 and beyond









We need simplified long term energy strategies that give confidence to investors and organisations to implement projects



IChemE Energy Centre

15 November 2016

# Chemical engineers focus on investing in the planet at COP22


More must be done to incentivise and prioritise low-carbon technologies, concluded chemical engineers at yesterday's side event during the UNFCCC 22nd Conference of Parties (COP22) in Marrakech, Morocco. The side event, *Investing in the Planet: Green banks and other financial tools to scale-up mitigation technologies*, was hosted by the Institution of Chemical Engineers (IChemE), Imperial College London, and the Natural Resources Defense Council (NRDC).

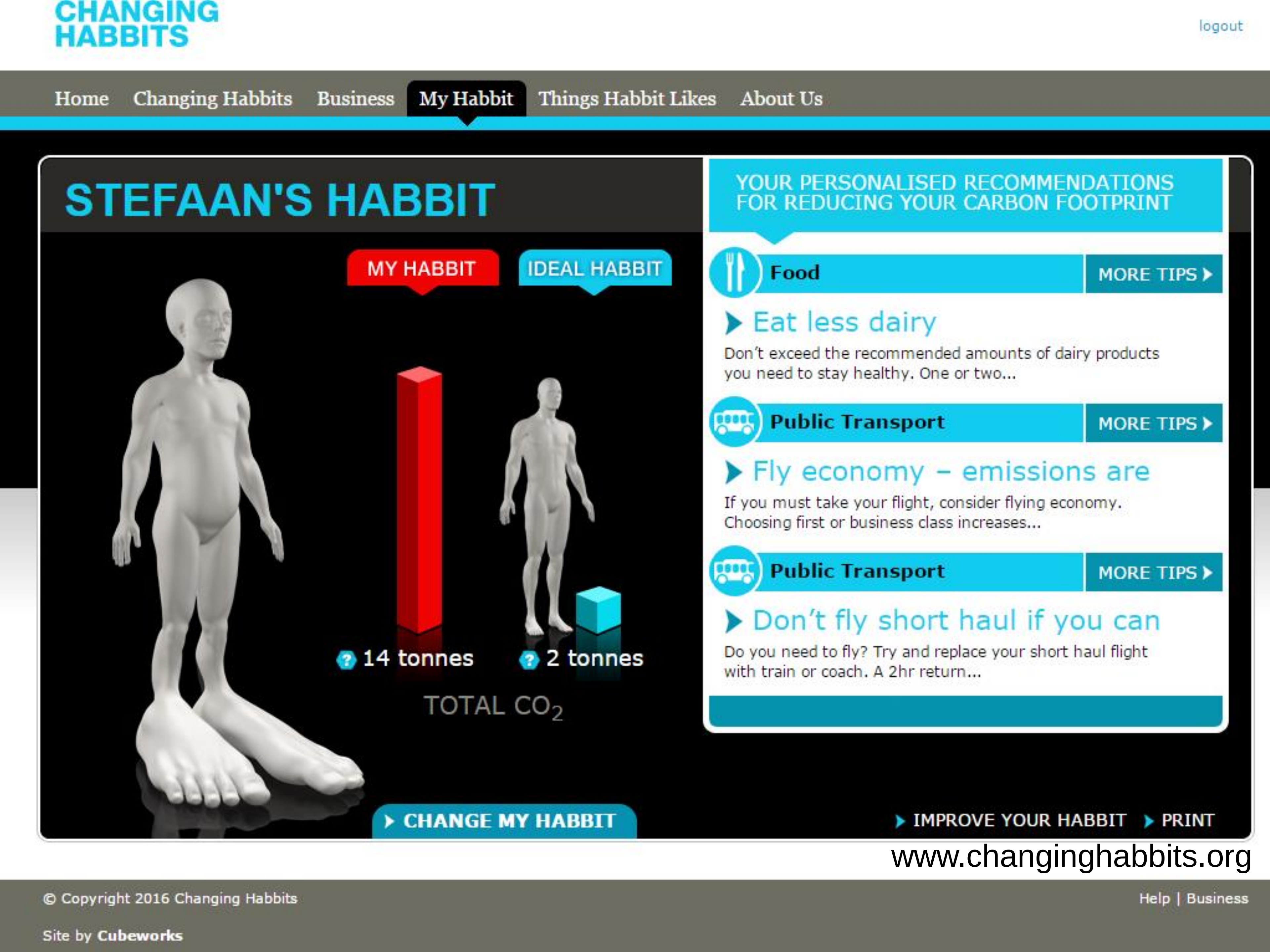
The event looked examined practical solutions to implement the Paris Agreement, with the help of chemical engineers and financial institutions. Dr Rachael Hall, from IChemE's Energy Centre Board gave the first presentation, an overview of deployment technologies available to mitigate climate change.

Outlining the various pathways to a zero-carbon economy, as demonstrated in IChemE's technical policy document *Chemical Engineering Matters*, Dr Hall said:

# Encouraging New Behaviours


New business models can lead to increased investment in clean technologies:

Share of EVs in car sharing schemes = 10%
Share of EVs in global car sales = 1%

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