THE RATIONALE FOR AN

INTERNATIONAL CENTRE FOR AI, ENERGY AND CLIMATE

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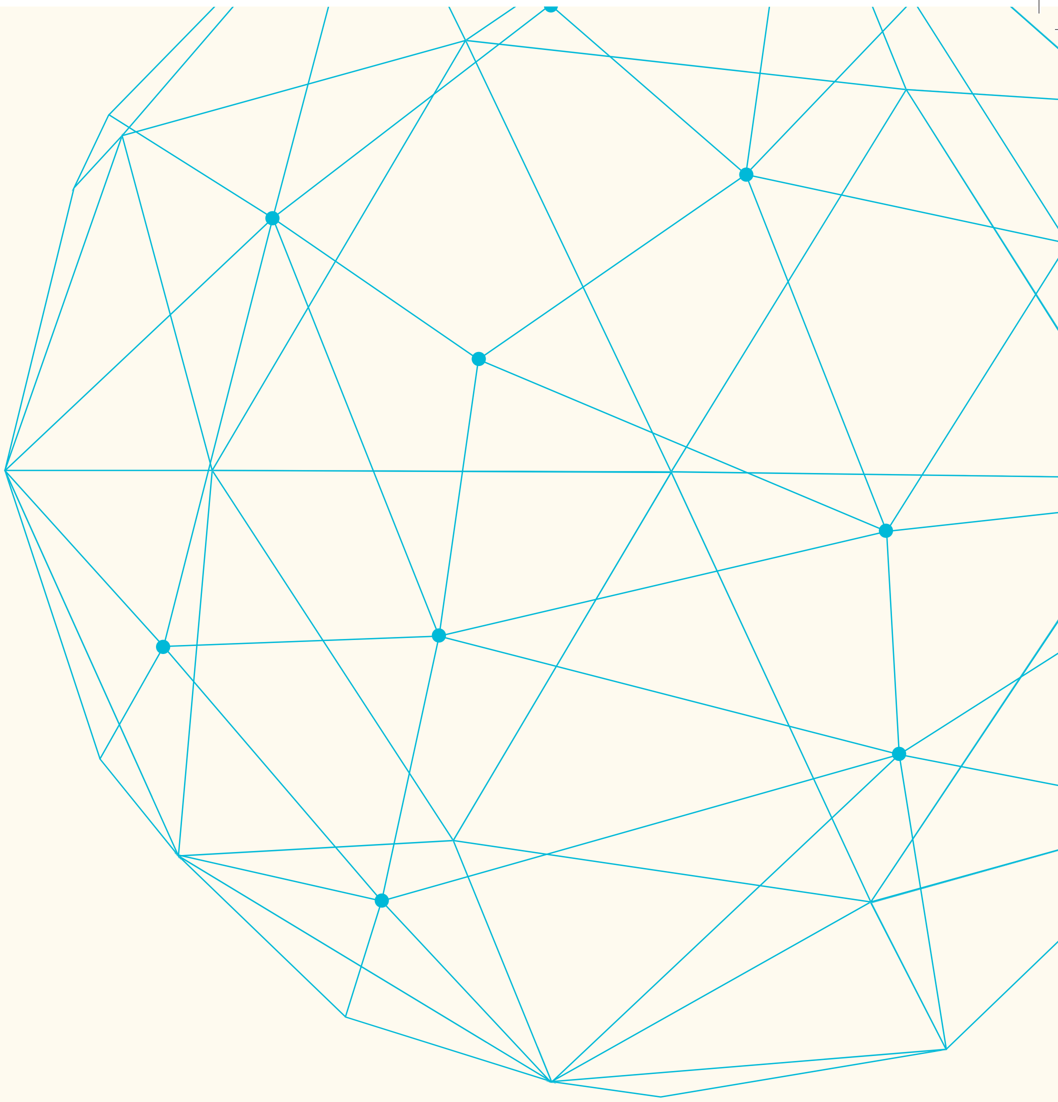

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EXECUTIVE **SUMMARY**

Over the last ten years there have been a series of advances in Artificial Intelligence technologies. These advances offer opportunities to rapidly increase the efficiency of energy systems and help reduce emissions across a wide array of climate change challenges.

Despite the commitments made in the Paris Agreement there remains a gap between the emission reductions pledged, and those needed to achieve the 1.5°C objective. Current pledges will likely result in a temperature increase of more than 3°C by 2100, with warming continuing thereafter. Substantial and rapid emission reductions are needed to close the emission gap by 2030, otherwise it is highly likely that maintaining temperature increases to below 2°C temperature will also be out of reach[1]. Countries need to urgently look for innovative ways to deliver the rapid emission reductions required.

Energy systems are transitioning from being centralised and fossil fuel dominated, to increasingly decentralised and renewables-dominated with new demands from transport and heat. As they do so there will be an increasing need to optimise and manage the many distributed and complex constituents of the energy system including renewable generation, electric vehicles (EVs), battery storage and demand-side response (DSR). AI will not only be a useful tool but will become essential as we manage this much more complex system and the data that it provides, whether it be in relation to solar and wind forecasting, dispatch optimisation, battery management or analysing smart meter data.

On aggregate, applying AI to energy and climate challenges has the potential to reduce emissions by up to 4% by 2030 against a business-as-usual baseline with a concurrent uplift of up to 4.4% to global GDP[2].

There are opportunities to apply AI to energy and climate challenges that are already being explored. Using AI, Google's DeepMind has reduced the energy consumption needed to cool Google's data centres by 30% and has increased the value of Google's wind farms by 20%. Start-ups such as Verv, Piclo, Upside Energy, Tempus Energy, and Kiwi Power, are looking to apply machine learning to analyse home and business energy demand, aggregate energy storage provision to provide flexible capacity and offer demand response solutions.

There are opportunities to apply AI to energy and climate challenges that are already being explored.

Despite the potential opportunity AI offers, a more systemic use of AI in the energy sector is being held back by existing data sharing models, market incentive structures and business models. The heavily regulated nature of energy market institutions creates a series of market failures in applying new technologies, and there is a need to ensure market incentive structures support the application of machine learning and AI. Correcting these market failures could unlock the potential for AI to improve the efficiency of energy systems worldwide and help address wider climate challenges.

To address these market failures internationally, there is a strong case for the establishment of an International Centre for AI and Climate Change to advise governments on best practice regulation and to facilitate the application of AI technology to energy and climate challenges.

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[1] *https://www.unenvironment.org/resources/emissions-gap-report-2018*

[2] *https://www.pwc.co.uk/sustainability-climate-change/assets/pdf/how-ai-can-enable-a-sustainable-future.pdf*

This paper seeks to address the following questions:

1 *What is the nature and scale of the opportunity that AI represents in helping to reduce GHG emissions?*

2 *What market failures exist that are holding back faster adoption of AI to the energy and climate change sector?*

3 *What are the tools needed to address the market failures identified?*

4 *What work is already being done in this space, and is there a need for a new institution?*

1. THE OPPORTUNITY

The Development of AI

Artificial intelligence (AI) refers to a suite of computer science techniques and technologies that allow computer systems to demonstrate intelligence. A more elaborate definition characterizes AI as "a system's ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation".

Artificial intelligence is already creating revolutionary opportunities across the global economy, from healthcare to transport. It is being used to improve cancer diagnosis[3], develop autonomous cars[4], improve translation services[5] and a vast range of other uses. These recent applications have triggered increasingly hyperbolic claims about the promise and peril of the technology. However, this is nothing new. Since intelligent machines first theorised by the mathematician Alan Turing in 1936, the technology has been developing in a series of hype cycles followed by 'winters' of relative disappointment.

The earliest research into AI was inspired by research in neuroscience, which had shown that the brain was an electrical network of neurons that fired in all-or-nothing pulses. The development of the first network of idealized artificial neurons was completed in 1951, in what would later become known as an artificial neural network (or neural net). The period between 1956 and 1974 were considered 'golden years' of AI research, as the potential of AI attracted funding and led to improvements in computer reasoning and natural language processing. However, AI researchers had failed to appreciate the difficulty of the challenges they faced, and in the 1970s, AI was subject to critiques and budget cuts, when lofty expectations were not met. The next few years would later be called an "AI winter". Key constraints at the time included limited computing power and limited availability of data.

Artificial intelligence (AI) refers to a suite of computer science techniques and technologies that allow computer systems to demonstrate intelligence.

The 1980s saw another boom in AI with the advent of expert systems - programs that could answer questions or solve problems about a specific domain of knowledge. These systems proved commercially useful, and AI started to be perceived as a business opportunity. At the same time, developments in methods for training neural networks and helping them learn and process information in new ways allowed the field of neural networks to overcome earlier constraints and criticisms.

However, the success in expert systems once again led to over-optimistic expectations about the development of AI, and 1987 saw the start of another AI 'winter'. However, despite

[3] *https://emerj.com/ai-sector-overviews/machine-learning-medical-diagnostics-4-current-applications/*
[4] *https://www.electronicdesign.com/test-measurement/how-ai-will-help-pave-way-autonomous-driving*
[5] *https://www.transperfect.com/blog/the-year-of-AI-translation*

reductions in funding, progress continued and in the '90s AI started to achieve some of its earliest objectives. Key milestones such as Deep Blue beating Gary Kasparov at chess in 1997 were not the result of a revolutionary new paradigm, but rather rigorous engineering, coupled with vast increases in computing power.

The introduction of probability and decision theory, economics, and new mathematical tools all increased the capability of AI.

The reason that AI has gained increasing prominence in recent years is due to several factors.

One of the long-standing constraints of AI development had been limits in computing power. The ongoing veracity of Moore's law, which predicts that the number of transistors on computer chips doubles every two years has meant that this constraint has gradually been overcome.

The second recent advance has been 'big data', which refers to a field that seeks to find ways to analyse, systematically extract information from, or otherwise deal with data sets that are too large or complex to be dealt with by traditional data-processing software. The ability to work with much larger datasets than previously has provided sufficient quantities of data to train neural networks, such that they could start to become more useful.

Finally, the development of 'deep learning' has moved the fundamental science of AI forward. Deep learning is a class of machine learning algorithms that uses multiple layers of neural networks to progressively extract increasingly high-level meaning from raw data. For example, in image processing, lower layers may identify the edges of objects, while higher layers may combine these edges to identify human-meaningful items such as digits/letters or faces.

These recent developments have re-sparked the long-standing ambition of AI scientists to develop an 'artificial general intelligence' (AGI), a machine that could successfully perform intelligent functions across multiple domains.

Whilst researchers disagree on the likely timeframe and possibility of achieving AGI, it is clear that purely on the basis of current techniques, AI has the potential to make substantial and rapid contributions to improving the efficiency of energy systems and addressing wider climate challenges.

How can AI help address climate change?

In general terms AI can offer the most extensive opportunities in addressing discrete problem areas with clear system boundaries, where it is possible to define unambiguous objectives, and where there are large datasets. In these scenarios AI has the capability to identify complex patterns and advise on how best to optimise system inputs in order to best achieve defined objectives. There are a range of climate change mitigation and adaptation challenges that fit this description.

A recent study developed by Microsoft and PwC estimated that globally AI can help deliver a reduction in GHG emissions of up to 4% by 2030 compared to business as usual, with a concurrent uplift of 4.4% to global GDP[6]. Such estimates are likely to become more accurate over time as the potential of AI becomes more apparent.

In 2019 Rolnick et al[7] published a paper assessing the opportunities for applying machine learning to climate related challenges. This section seeks to summarise some of the opportunities; however, it should be noted that such opportunities are likely to expand as new data becomes available and new technologies develop.

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[6] *https://www.pwc.co.uk/sustainability-climate-change/assets/pdf/how-ai-can-enable-a-sustainable-future.pdf*
[7] *Rolnick et al (2019); Tackling Climate Change with Machine Learning (pdf)*

Energy systems

Energy systems are transitioning from being centralised and fossil fuel dominated, to increasingly decentralised and renewables-dominated with new demands from transport and heat. As they do so there will be an increasing need to optimise and manage the many distributed and complex constituents of the energy system including variable renewable generation, electric vehicle charging, battery storage and demand-side-response. AI will not only be a useful tool in optimising and managing future electricity systems but will become essential in managing the increased complexity, whether it be in relation to solar and wind forecasting, dispatch optimisation, battery management or analysing smart meter data.

Dispatch and scheduling:

One of the most important roles AI could play in energy systems is to optimise grid dispatch. Grid dispatch refers to the process whereby system operators determine how much power controllable generators should produce over a range of timescales. The process is already challenging but will become even more complex as electricity systems include more variable generation, storage, and flexible demand, since operators will need to manage even more system components while simultaneously optimising scheduling more rapidly to respond to second-by-second variations in electricity production. Data science and AI can help improve the optimisation of current grid dispatch processes. In addition, AI will be needed to help develop and optimise control systems for further layers of grid balancing at the distribution network level, and at the individual substation level, which will be needed to allow for greater proportions of variable generation.

Forecasting supply and demand:

A key aspect of optimising dispatch will be the ability to improve forecasts of renewable electricity generation and forecasts of electricity demand. The more uncertainty grid operators have in either electricity supply or demand forecasts, the more back-up power, known as spinning reserve, is needed. Spinning reserve is provided by fossil fuel generation (mostly gas) and comes with associated emissions and costs. AI coupled with improving data collection have the potential to improve short-term renewable energy generation forecasts and demand forecasts allowing for reductions in spinning reserve, and reductions in the loss of expensive excess renewable energy power. Balancing the UK electricity grid currently costs end-users about £300 million per year. AI could help keep these costs under control as renewable penetration increases

Flexibility markets:

To date demand side response aggregators have focussed on aggregating flexible demand commitments from large companies, due to the cost and complexity of analysing the potential flexibility that could be offered by smaller participants. AI has the potential to allow such aggregators to act as market places for thousands of smaller players, including electric car batteries, and rooftop solar, and so help to flatten demand peaks.

Asset optimisation:

Beyond grid optimisation, there is widespread potential for AI to be used to optimise the efficiency of individual assets within the energy system. This could come in the form of optimising renewable energy generation assets or battery assets. Such optimisation is possible both in terms of the operation of existing hardware, but also has the potential optimise the design of new hardware solutions.

Asset location:

Data science and AI can help optimise the location of energy system assets, ranging from identifying optimal locations for solar and wind assets based on solar irradiance and wind speed data, to identifying locations for pumped storage assets based on improved satellite data and AI.

Improving energy access:

Many people living in developing countries do not have access to grid electricity but often rely on wood-burning, diesel generators or kerosene stoves. Supporting access to modern, clean energy sources represents an important development pathway to millions of people. This transition will rely heavily on on-the-ground assessments of needs and working with communities. However, data science and AI can help inform this work by helping to identify optimal locations for microgrids. Microgrids themselves are more challenging to balance than larger grids so connecting microgrids to improved weather forecasting and balancing systems could improve quality of service.

Industry and buildings

Industrial processes are often energy intensive and as a result are one of the leading contributors to global GHG emissions. However, they are often some of the most challenging sectors to decarbonise.

Optimise existing industrial processes:

Data science and AI can help optimise the energy efficiency of industrial processes, by for example optimising the use of energy inputs, increase the efficiency of heating and cooling systems, predict machine breakdowns, and improve production quality. However, due to the rebound effect, where increased efficiency can lead to increased production, such improvements do not necessarily lead to emission reductions on their own and need to go hand-in-hand with policies designed to limit emissions.

Support the development of new industrial processes:

Where large datasets exist for existing industrial processes, it will be possible to use data science and AI to optimise the design of new processes. This will be particularly important for some industries where there may be a need to shift to a completely new industrial process to reduce emissions.

Buildings:

Buildings are responsible for a quarter of global energy-related emissions; however, a combination of simple physical fixes and cutting-edge data science and AI have the potential to reduce emissions for existing buildings by up to 90%. Whether for domestic or commercial buildings, there are opportunities for AI to be used to optimise heating and cooling to ensure energy is not being wasted. AI can help optimise energy use based on combined data on weather and building use patterns.

Flexibility markets:

As the proportion of variable renewable energy is brought onto electricity grids, grid systems are developing flexibility markets to get help from energy users in matching energy demand to variable energy supply. Industrial processes and buildings have an important role to play in these markets and having the ability to amend energy use according to when energy supply is high or low could be financially attractive. Adopting AI to help optimise and automate such energy adjustments will be important in maximising the potential gains available and hence support a lower carbon grid.

Where large datasets exist for existing industrial processes, it will be possible to use data science and AI to optimise the design of new processes.

Transport

The transport sector accounts for about a quarter of global emissions, with passenger and freight transportation each responsible for about half of transport GHG emissions. The sector has seen limited reduction in emissions relative to the electricity sector. Data science and AI can help reduce transport emissions in a range of ways.

Informing transport decision making to help reduce demand:

Many areas of transport lack good data, and decision-makers often design policy and infrastructure with limited or poor-quality information. In recent years, new types of sensors have become available, and data science and AI can turn this raw data into useful information. Traditional ground-based traffic counters such as inductive loop detectors or pneumatic tubes are being replaced or augmented with video systems which can use computer vision to monitor traffic. Further application of data science can help determine patterns in traffic to support management decisions. Data science can be especially useful for interpreting information from new data sources, eg, understand the behaviour of public transport users from smart card data.

Freight and delivery optimisation:

Freight consolidation, through the bundling of shipments, has the potential to drastically reduce the number of shipping miles, and therefore the GHG emissions. There is potential for optimisation throughout logistics chains from shipping, rail-freight and long-distance trucking to smaller trucks and last-mile delivery solutions. Data science and AI offer opportunities to optimise freight and delivery decision making to minimise the number and distance of trips needed. In addition to optimising freight and delivery on the basis of existing infrastructure, data science and AI can help inform decision making regarding future infrastructure decisions to, for example, optimise the locations of supply depots and logistics hubs, to maximise efficiency and reduce journey distances.

Vehicle design and autonomy:

Data science and AI are becoming increasingly important in supporting the optimisation of vehicle design, from ML-based surrogate modelling for optimising aerodynamics, to engine design optimisation. Most notably, AI is a critical part of designing autonomous vehicles, although it is uncertain whether autonomous cars are likely to result in lower or higher emissions, or indeed whether they will be widely rolled out any time soon.

Optimising for EVs:

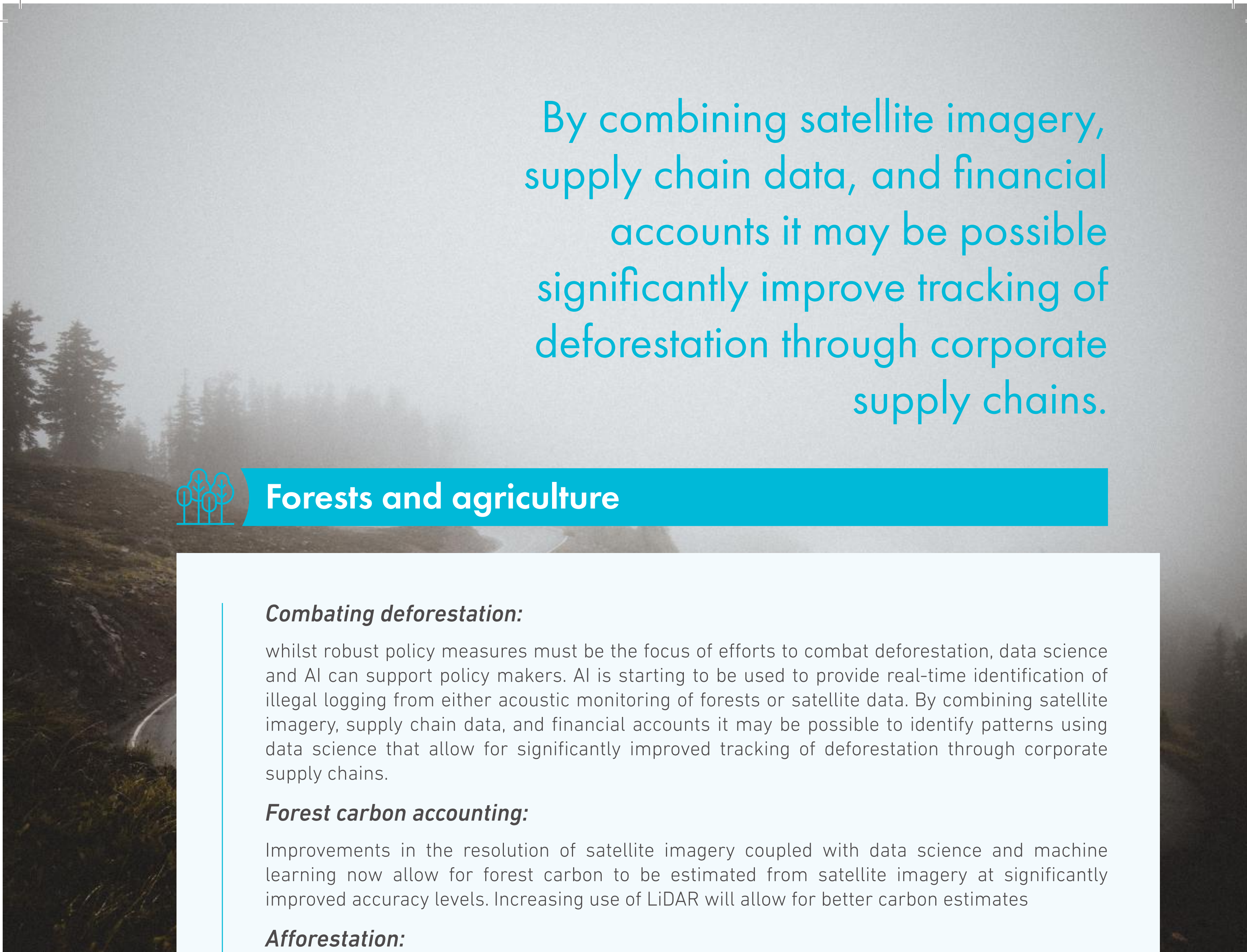
Data science and AI are vital tools for a range of different challenges related to EVs. AI techniques can improve battery energy management, battery design, charging scheduling, and vehicle-to-grid interaction. As the percentage of EVs on the roads increases data science and AI will be critical in helping the system operator and distribution networks to predict EV-related demand and potentially supply, inform decisions regarding charging infrastructure.

New fuels:

Aviation and ocean shipping require high energy density fuels and so are less conducive to electrification. Electrofuels, biofuels and hydrogen could offer potential alternatives. Data science and AI techniques could offer new opportunities for improvement at various stages of research and development of these new fuels.

Bike and scooter sharing:

Bike and electric scooter sharing services can offer low-carbon options for getting around cities that can integrate well with public transport. Data science and AI can help identify usage patterns to optimise bike stations and address the problem many bike-sharing platforms have of uneven demand for some routes resulting in an uneven distribution of bikes. Data science can help forecast demand and inform bike pricing to help create a monetary incentive for users to rebalance bike locations.



By combining satellite imagery, supply chain data, and financial accounts it may be possible significantly improve tracking of deforestation through corporate supply chains.

Forests and agriculture

Combating deforestation:

whilst robust policy measures must be the focus of efforts to combat deforestation, data science and AI can support policy makers. AI is starting to be used to provide real-time identification of illegal logging from either acoustic monitoring of forests or satellite data. By combining satellite imagery, supply chain data, and financial accounts it may be possible to identify patterns using data science that allow for significantly improved tracking of deforestation through corporate supply chains.

Forest carbon accounting:

Improvements in the resolution of satellite imagery coupled with data science and machine learning now allow for forest carbon to be estimated from satellite imagery at significantly improved accuracy levels. Increasing use of LiDAR will allow for better carbon estimates

Afforestation:

Large scale tree planting will be a key part of achieving net zero, however afforestation projects need to be sited in appropriate locations, to ensure successful tree growth and avoid competition with other land uses. Combining satellite imagery with other datasets, such as land-ownership data, flooding data, rainfall data etc and applying data science and AI, can help identify optimal planting locations.

Forest Fires:

Large scale forest fires contribute to large quantities of CO_2 entering the atmosphere. They often result from a combination of a build-up of dry biomass and are exacerbated by high temperatures and dry conditions. To avoid very large forest fires, many countries support managed burning on a small scale to avoid large build ups of dry biomass. A combination of satellite imagery, weather system modelling and data science and AI will allow for improved forecasting of areas at risk of forest fire, help determine how fires might spread, inform risk management responses.

Agriculture:

Precision agriculture, using machine learning and data science, will allow for individual plant-level assessments of phenotype and fitness to help optimise farm inputs, and is already receiving significant support and private investment. Whilst these approaches offer significant opportunities to increase growing efficiency, it is uncertain if they will reduce GHG emissions. There are also opportunities however, to focus precision agriculture techniques on optimising regenerative agriculture, a method that seeks to improve soil health, a co-benefit of which is increased soil absorption of CO_2.

Adaptation, Climate Science & Emissions monitoring

Food security:

Food insecurity due to changing climatic conditions represents one of the most acute areas of climate risk, in particular for developing countries. Linking a range of datasets and applying data science can significantly improve food security risk assessments and help inform response measures. Combining improved climate forecasting with high resolution satellite data that can identify crop types, with data science and ML techniques, can help improve spatially localized crop yield assessments, and give both long term forecasting and short-term warning of yield failure. Additional data from social media can also be deployed to uncover early warning signals about crop failure risk. Beyond risk analysis, data science and AI can improve the resilience of food supply chains by identifying supply chain weaknesses and inefficiencies.

Forecasting and tracking extreme events:

New datasets will allow for data science and AI to help improve predictions of climate-related disasters such as floods and hurricanes. For example, improving the prediction accuracy of whether and where hurricanes will make landfall would significantly support response and disaster relief efforts.

Climate Science:

Predicting how the climate will change is a key factor in making policy and investment decisions regarding adaptation and climate risk mitigation. There are opportunities for data science and AI to improve climate science to significantly improve climate predictions. The combination of improved and more affordable satellite data with data science and AI will allow for more detailed and more computationally efficient forecasting. However, there are also significant data gaps, specifically when it comes to regular monitoring of climate tipping point phenomena, such as methane release from the arctic permafrost. Machine learning models are likely to be computationally cheaper and more accurate than other models where there is plentiful data or existing models are too computationally expensive to use regularly. There are particular opportunities to reduce uncertainty in the modelling of clouds, ice-sheet dynamics and sea level rise.

Emissions monitoring:

There is significant uncertainty associated with the GHG emissions in some areas. The application of data science and AI with improving satellite data is offering new opportunities to monitor emissions at a factory or power station level. Such approaches have the potential to support international emissions monitoring efforts.

The application of data science and AI with improving satellite data is offering new opportunities to monitor emissions at a factory or power station level.

Table 1: Climate change solution domains, corresponding to sections of this paper, matched with selected areas of ML that are relevant to each.

	Casual Inference	Computer Vision	Interpretable Models	NLP	RL & Control	Time-Series Analysis	Transfer Learning	Uncertainty Qualification	Unsupervised Learning
1 Electricity Systems									
Enabling low-carbon electricity		✓	✓		✓	✓		✓	✓
Reducing current-system impacts		✓				✓		✓	✓
Ensuring global impact		✓					✓		✓
2 Transportation									
Reducing transport activity		✓				✓		✓	✓
Improving vehicle efficiency		✓			✓				
Alternative fuels & electrification					✓				✓
Modal shift	✓	✓				✓		✓	
3 Buildings and cities									
Optimizing buildings	✓				✓	✓	✓		
Urban planning		✓				✓	✓		✓
The future of cities				✓			✓	✓	✓
4 Industry									
Optimizing supply chains		✓			✓	✓			
Improving materials									✓
Production & energy		✓	✓		✓				
5 Farms & forests									
Remote sensing of emissions		✓							
Precision agriculture		✓			✓	✓			
Monitoring peatlands		✓							
Managing forests		✓			✓	✓			
6 Carbon dioxide removal									
Direct air capture									✓
Sequestering CO_2		✓						✓	✓
7 Climate prediction									
Uniting data, ML & climate science		✓	✓			✓		✓	
Forecasting extreme events		✓	✓			✓		✓	

Source: Rolnick et al; (2019), Tackling Climate Change with Machine Learning

2. ASSESSMENT OF MARKET FAILURES AND **RATIONALE FOR INTERVENTION**

Despite the clear benefit that data science and AI can offer to energy and climate change challenges, as well as clear UK Government support for the development of both AI and clean growth, there remains a significant risk that the application of AI over the coming years will fall short of what is needed to support the transition to a zero carbon economy at the required pace. In particular, the combination of a number market failures is constraining application of AI in a range of instances. This section describes the different types of market failures that exist in this space.

In applying AI to energy and climate sectors, the most relevant failures are information asymmetries, market power, and policy failures.

The theory of market failures is well-established in economic literature. It refers to a situation in which the allocation of goods and services by a free market is not efficient, often leading to a net social welfare loss. If one or more market failures affects the resources deployed in innovation, or if they limit access to the discovery of resources, then they can detract from economic growth and welfare.

There are essentially five types of market failure: information asymmetry, market power, complements, externalities and public goods (Stiglitz et al., 1993). As well as assessing market failures, mainstream economics literature seeks to explain market outcomes by also looking at market barriers. Whilst market barriers may not represent structural failures in a market, they may still justify market interventions depending on the scenario. In addition to market failures and barriers, policy and public institution failures may also need correcting.

In applying AI to energy and climate sectors, the most relevant failures are information asymmetries, market power, and policy failures.

INFORMATION ASYMMETRY occurs when one party has better information than the other during a transaction, or information is costly. The effect of this is to make markets less efficient as the greater the information asymmetry the less able market participants are to make good economic decisions.

In relation to applying AI to the sectors identified in section 1, there are a series of information asymmetries or information deficits:

- ***Data access:*** Asymmetrical access to data is a form of information asymmetry. Across all sectors, data is often not publicly available, even where there are no good security, commercial or privacy reasons for withholding it. Often data are held in silos which limits the potential for achieving efficiencies by applying AI system-wide. There is currently no market for data for energy and climate change data and as such there is no mechanism for addressing data and information asymmetries in an economic way.

- ***Data collection:*** across all sectors identified data is often unavailable because data collection and availability is not being incentivised by the market. Data on everything from energy system topology (where grid wires and assets are), to high resolution forest logging data are needed to address some of the challenges in the sectors identified.
- ***Data standards:*** There are substantial costs associated in cleaning and labelling datasets to allow for them to be used by AI algorithms. Approximately 70% of time spent on AI projects is on cleaning and labelling data. The market inefficiencies caused by a lack of applied data standards results in substantial market inefficiency.
- ***Knowledge asymmetry:*** There is a knowledge asymmetry between AI experts and energy and climate industry experts. AI experts often have limited understanding of how to engage in energy and climate challenges, and energy and climate industry leaders have limited understanding of the types of problem that AI can help solve.

MARKET POWER: In a perfectly competitive market, companies cannot influence the price that they charge, they simply have to charge the 'market rate'. They are, as the literature puts it, price takers. When a company, or a group of companies acting together, has market power then they have the ability to determine what they charge. They are no longer price takers and become price makers. Typically, they will use this market power to charge a higher price than under competitive conditions. Firms may also choose to do this by restricting output or reducing the quality of their goods and services. Typically, market power can be found where there are few incumbent companies, and where there are features of the market that prevent other companies from entering easily.

The mis-application of market power is an ongoing issue in the adoption of new technology such as AI. Market incumbents may seek to maximise rents by slowing the adoption of new technology that might act as a threat to their business model. Market power is specifically an issue in the energy and climate space due to the prevalence of monopolies and oligopolies. Specifically:

- *Incumbent monopolies:*
  - *Energy systems are often run by either heavily regulated or state-owned monopoly companies. These include companies that manage transmission & distribution networks, system operation, interconnector companies and many others.*
  - *Transport network operators are often either publicly run or involve monopoly structures.*
- *Tech companies:*
  - *The market power that the major tech companies are able to exert is capable of shaping market structures and prices and involves monopoly risks.*

POLICY AND INSTITUTIONAL FAILURE: There are a number of drivers of policy failure, including: policy frameworks limiting market incentives for innovation; legal restrictions on a government's ability to bind future administrations; the pressure of lobbying leading to changes in policy instruments on which investment decisions had been made; practical compromises which have to be made in legislation and regulatory institutions; and the cost of making firm domestic commitments while negotiating international agreements.

Many of the highly emitting sectors of the economy, such as energy and transport are either heavily regulated or involve state-owned companies. Many of the policy frameworks developed for these sectors were developed in the pre-digital era, and as a result may inadvertently hamper the application of new technology, such as AI. Data sharing restrictions, market structures and incentive mechanisms will all need re-assessing.

COMPLEMENTS: 'Compliments' involve situations where the consumption of one good requires the consumption of another. So, for example, the consumption of electricity requires both the power station to generate the power, and the transmission or distribution grid to bring it to the customer's door. Market failures where there is a failure to provide a complementary good are often termed 'co-ordination failures'. In this instance investors are unwilling to commit capital to AI for energy and climate start-ups unless there is a route to market for their services. Consequently, if the market frameworks are designed in such a way that makes it hard for new entrants to capture the value of their inventions, investors are less likely to invest, the market develops slowly and is smaller than is optimal.

AN EXTERNALITY occurs when an economic actors' actions has an impact on others, and where that impact is not reflected in the price. Where this effect is a positive one, it is referred to as a positive externality, and where it is negative, it is a negative externality. The development of powerful technologies such as AI are likely to have substantial positive and possibly negative externalities. The development of an AI talent pool focussed will support wider adoption creating a positive externality. On the other hand, applying AI may have labour market implications, that will need to be assessed.

- ***Public goods:*** A public good has two features: it is non-rival and non-excludable. Non-rival means that an individual's consumption of the good does not affect the amount available for someone else to consume. Non-excludable means that no-one can be effectively prevented from consuming the good. It is because it is difficult to prevent an individual from consuming a public good, that it is difficult to charge a price for it. If it is difficult to charge a price for a good, then the market will not supply it. As a result, public goods are typically supplied, if at all, by the state. In relation to AI, data access (specifically for AI-ready datasets) can be perceived as a public good.

Table 2: Prevalence of market failures regarding the application of AI to energy and climate

	Externalities	Information Asymmetry	Market Power	Complements	Public goods	Policy failures
Electricity	✓	✓	✓	✓		✓
Individual Assets			✓	✓		✓
Heat	✓	✓		✓		✓
Transport	✓	✓	✓	✓	✓	✓
Forests	✓	✓	✓		✓	✓
Agriculture	✓	✓	✓		✓	✓

This section has given an overview of some of the market failures that are slowing the application of AI to energy and climate challenges, however it is worth noting that it is often the case that multiple market failures interact with each other in complex ways. However, it is clear that collectively, these market failures are resulting in an under-investment (from a societal perspective) in AI for energy and climate challenges. This under-investment is both in the form of an under-investment in specific applications in this area as well as an under-investment in research and development.

3. INTERVENTIONS NEEDED TO **ADDRESS MARKET FAILURES**

In seeking to address the market failures identified, five key intervention pillars are likely to be required:

Pillar 1:

POLICY DESIGN: to address some of the policy and market power failures, a locus of expertise is needed to advise governments around the world on how to up-grade energy and climate-related policy to be AI-friendly and to align the incentives of market incumbents to support its adoption. Specific areas of advice would include:

- *Energy and climate data collection, access and standards*
- *Incentives for market incumbents to apply AI*
- *Market design and system flexibility*
- *Project specific regulations*
- *Ethical / responsible application of AI in energy / climate sector*

Pillar 2:

DATA AND TOOLS LAB: to facilitate the application of AI to key energy and climate challenges, there is a need for a group with technical AI expertise to develop processes and tools that make it easier for the wider AI community to engage in the sector. Interventions could usefully include:

- *Hosting machine learning competitions and ongoing collaborations*
- *Hosting an international energy and climate data portal / index / market*
- *Developing public interest models on which new applications could be built*
- *Incubating new research initiatives and/or start-ups*

Pillar 3:

ACCELERATOR: The under-investment in R&D projects in this area, could usefully be addressed with bespoke innovation funding to support initiatives that wouldn't otherwise be able to attract commercial investors. Interventions cold include:

- *Proof of concept challenge grant-funding*
- *Semi-commercial seed equity in collaboration with VCs*
- *Developing collaborations with start-up accelerators and incubators*
- *Incubator space for early stage projects*
- *Match-making for founders*

Pillar 4:

RESEARCH COORDINATION: This pillar sees the need for improved academic research coordination, to support cooperation in the development of academic research on AI for energy and climate.

- *Building the talent pipeline for the sector through multi-university doctoral training centres to pool collective UK expertise to support PhD students*
- *Applied training to support incumbent industries in developing the capabilities needed to adopt AI*
- *Focused academic workshops, conferences to support knowledge sharing and research coordination.*

Pillar 5:

MARKET FACILITATION: this pillar involves supporting knowledge sharing on the opportunities for AI to support decarbonisation in a range of energy system contexts, via industry events, country engagement, tech delegations, MOOCs, jobs/projects board and engagement at international fora.

4. ASSESSMENT OF **EXISTING ORGANISATIONS**

In seeking the most cost-effective approach for correcting the market failures identified, there is a need to assess whether any existing institution(s) either already has the capabilities needed to address the market failures or could reasonably be expected to develop them.

Table 2: Prevalence of market failures regarding the application of AI to energy and climate

	Energy Systems Catapult	Alan Turing Institute	Market Power	UCL / Cambridge / Oxford / Exeter	Global Green Growth Institute	World Economic Forum	Mission Innovation	International Centre for AI, Energy and Climate
Energy and climate policy expertise	✓			✓	✓	✓	✓	✓
Capability needed for technical AI facilitation		✓		✓				✓
Innovation funding provision			✓					✓
Research coordination		✓						✓
International remit				✓	✓	✓	✓	✓
Business model designed to address mkt failures					✓		✓	✓
Remit and capacity to create an AI for climate ecosystem of start-ups								

The organisations identified in Table 2 are those that have been assessed as being relevant to the application of AI in the energy and climate space. What is clear is that whilst some of the organisations have the capability to contribute to addressing some of the market failures identified, no single existing organisation has the capacity to combine all the capabilities required and deliver them in a joined-up, coordinated way. The four organisations that have most complementary capabilities in this space are the Alan Turing Institute, Innovate UK, The World Economic Forum and the Energy Systems Catapult. Below we describe in more detail the remit of these organisations and their relevance to supporting work on energy and climate change.

ALAN TURING INSTITUTE (ATI)

The ATI was founded in 2015 as the national institute of data science; as of 2017, AI was also added to their remit. The Institute funds a wide-range of activities related to AI, machine learning and data science. In 2018, the Institute set itself eight "challenges" around which to channel their research, including revolutionizing healthcare and designing greater supercomputers. Energy and climate concerns were not listed in the series of challenges[8].

Despite not listing climate change as a key challenge where the application of AI could provide a solution, the ATI does currently fund a few climate-related research projects. One such project is looking at air quality data in London.[2] The ATI also recently began a project which will use satellites and new data science techniques to create an accurate model of land use in the UK.[3]

The ATI is run by academics and has largely focussed its activities on research projects and as a result has strong links to universities in the UK.

ENERGY SYSTEMS CATAPULT

ESC was set up to support the transition of the UK's energy system. The ESC has recently been tasked with developing policy proposals on energy data policy through the Energy Data Taskforce, which published its recommendations in June 2019. These recommendations supported the case for greater digitisation of the energy system and for the accessibility of data.

The Catapult has also been developing the Home Energy Services Gateway (HESG) – a cloud-based, digital platform, using in-home sensors and data science. This provides residents with room-by-room temperature control from a mobile app and interoperability between energy service providers and device manufacturers.

The ESC's focus on UK energy data policy will be an important pre-requisite for many AI applications, however data provision in itself is insufficient to address the market failures in this space.

Whilst the ESC is well placed to advise on some of the policy aspects of addressing the identified market failures in relation to energy systems, specifically in the UK, their ability to support more facilitated applications of AI is less strong, and they are focussed exclusively on energy systems, whereas the opportunities for applying AI to climate challenges are much wider.

INNOVATE UK

Innovate UK is part of UK Research and Innovation, a non-departmental public body funded by a grant-in-aid from the UK government. Innovate UK's remit is to work with businesses to support innovation primarily by providing R&D finance to support the growth of companies of all sizes.

WORLD ECONOMIC FORUM - FOURTH INDUSTRIAL REVOLUTION CENTRE

The WEF has recently set up Centres for the Fourth Industrial Revolution (FIR) in San Francisco, Abu Dhabi, Colombia, China and Japan, with a proposed centre focused specifically on Oceans and Biodiversity in Norway. The WEF describes AI as the "electricity" of the FIR, and thus puts it at the centre of its work. WEF hopes to support decision making on governance for FIR technologies, including AI.

Annex A offers a more detailed assessment of the options for how government could support the delivery of the functions identified in this paper, looking at whether it would be most effective and efficient to develop a new institution or to work through existing organisations.

[8] *ATI, 'Challenges', https://www.turing.ac.uk/research/challenges (03/07/19)*

[9] *ATI,'London air quality', https://www.turing.ac.uk/research/research-projects/london-air-quality (03/07/19)*

[10] *ATI, 'Learning tools for analysing land use', http://turing.ac.uk/research/research-projects/learning-tools-analysing-land-use (03/07/19)*

5. CONCLUSION

On the basis of the evidence currently available this assessment concludes that while existing organisations are contributing useful work in this space, no single organisation is well positioned to expand to address the market failures identified in this space.

There is a strong case for a new institution that is able to deliver work across the spectrum required, from international policy advice, to AI technical facilitation, to industry facilitation, to ensure that synergies between these strands can be identified and captured. Beyond this, the creation of an international ecosystem of start-ups, universities, tech companies, energy companies and policy makers will be critical in overcoming the identified barriers and supporting investment and job creation in this sector. Such a role will likely require an institution with this as a core objective, rather than a side programme.

However, it may well be the case that the most cost-effective approach to addressing the market failures identified will involve a new Centre developing partnerships with existing institutions, such as the Alan Turing Institute the Energy Systems Catapult and the World Economic Forum.

There is rightly a high bar that needs to be reached to support the creation of any new institution, given the associated costs involved. Decision makers will need to assess whether the potential benefits and opportunities available in this sector warrant such an investment.

On the basis of the evidence currently available this assessment concludes that while existing organisations are contributing useful work in this space, no single organisation is well positioned to expand to address the market failures identified in this space.

6. NEXT STEPS

The concept team for this initiative has been working to gather input and feedback from actors in the data science community, the energy sector, the climate community, academics, policy makers and politicians, both within the UK and internationally. The feedback gathered has laid the foundations for the analysis in this paper. There has been a remarkably strong consensus among interviewees on the opportunity AI offers for the energy and climate sector; on the challenges that exist in applying it, and in the need for a new institution to fully address these challenges in a joined-up manner.

The concept team has been working with BEIS officials in further developing the evidence base, have drawn up a delivery plan and budget for the Centre. The next steps are:

- For BEIS Ministers to make a decision regarding funding for the Centre;
- For BEIS officials and the concept team to work together to discuss the potential for developing the Centre in collaboration with one or more other countries;
- For BEIS officials and the concept team to work together to determine how the Centre could play into COP26 processes.

ANNEX A:
IS A NEW INSTITUTION NEEDED?

Developing any new institution comes with associated costs and set-up time and as such government rightly requires that proposals for new institutions meet a high bar to ensure that the benefits are greater than the costs and that a new institution is the most effective way of meeting the proposed objectives.

There is currently consensus in BEIS and in industry that there is a gap in support for AI-for-climate applications and that no existing organisation is currently delivering the five functions identified in this proposal. There is a question as to whether it is more efficient and effective to develop a new institution that delivers these functions, or whether it is more efficient for the functions to be delivered by several existing organisations. This section looks at the two most credible models for how functions could be delivered: Option 1) the functions are delivered by the Alan Turing Institute, the Energy Systems Catapult and Innovate UK; and Option 2) the functions are delivered by a new International Centre for AI, Energy & Climate. We expect Option 1 may allow for some cost efficiencies, and will draw on existing experience, but this will need to be weighed against the fact that these organisations have not been set up with these functions in mind and pre-existing institutional design and experience may compromise the effective delivery of the necessary functions. This assessment seeks to weigh up these considerations. The options will be assessed against the following set of criteria:

- *Cost*
- *Strength of Policy Unit*
- *Strength of Data & Tools Lab*
- *Strength of research coordination*
- *Strength of Mkt Facilitation function*
- *Strength of Accelerator*
- *Ability to support synergies between functions*
- *Ability to deliver international remit*
- *Organisational priority*
- *Attract international talent*
- *Location*
- *Ability to make UK an international leader on AI for climate*

1 **OPTION 1:** NO CENTRE, FUNCTIONS DELIVERED BY ATI, ESC & UKRI

In this scenario, the five functions identified would be delivered by the Alan Turing Institute (ATI), the Energy Systems Catapult (ESC) and UK Research & Innovation (UKRI). Specifically, the Research Coordination function and the Data & Tools Lab would be delivered by the ATI, the Accelerator would be delivered by UKRI / Innovate UK and the Policy Unit and the Facilitation Unit would be delivered by the ESC.

Criteria	Assessment	Score 1-10 (10 as the highest)
Cost	The precise cost of all options is subject to the development of a detailed budget for the proposals. However, there is the potential to make some savings with this proposal as there would be no need for additional central services that are associated with a new organisation (HR, finance, comms). However, if the presumption is that all of the five functions would need to be delivered to the same standard, then all costs associated with salaries, office space, compute power, and the accelerator would be the same. These costs make up the bulk of the funding requirement, and as a result the savings associated with delivering the functions through existing organisations are likely to be comparatively small.	10

Criteria	Assessment	Score 1-10 (10 as the highest)
Strength of Policy Unit	The ESC would be in a relatively good position to advise on aspects of UK policy, specifically to policy on data access in relation to the electricity system, following their work on the Energy Data Task Force. This is useful background. However, the ESC is solely focussed on energy systems and as a result would struggle to expand its remit to address wider climate change opportunities. This would mean that if the ESC were to attempt to fulfil the policy function, they would need support from additional organisations to be addressed effectively, creating additional complexity. There is also a question as to whether the policy unit would be best located where policy is developed, rather than where the ESC is situated, in Birmingham. This applies both to attracting policy expertise and interacting with policy makers. Whilst the ESC has policy experience in the UK, they have very limited international experience in this space.	8
Strength of Data & Tools Lab	To deliver the Data & Tools Lab function successfully there is a need to combine strong technical machine learning expertise, an ability to coordinate effectively with industry over extended timeframes with a strong understanding of energy and climate systems. • *The ATI pools technical talent via its fellowship programme which creates a network of academics from a range of UK universities. The technical talent in this space can be fairly good, however there is a risk that their expertise is more on the theoretical side than the applied side.* • *The ATI themselves recognise that their expertise lies more on the research coordination side than the applied side. Further, the nature of the academic background of ATI fellows leads to scenarios where they put in sufficient time to a particular project to write an academic paper, but then have limited incentive to continue, so their ideas never get implemented in practice. Typically, applying ML takes far more work than doing the original proof-of-concept. To have climate-impact, we must ensure that ideas are implemented in practice.* • *One example is that the community needs open-source tools, for example to take patchy energy data and make it machine-learning ready, something that the Data & Tools Lab could usefully be tasked with doing. Academics have very limited incentives to build such tools and it is very unlikely that they would be developed under this option.* • *The ATI's institutional capacity to deliver work on climate change is to some extent limited by its institutional background, which to date has not included a focus on climate change.*	5
Strength of Research coordination	To deliver this function successfully requires a good network across a wide range of universities and a good understanding of training requirements to combine ML and energy/climate expertise from a theoretical and applied perspective. The ATI would be able to draw on its experience of coordinating across a range of universities to deliver this function. They should be able to deliver most of this function to a good standard.	8

Criteria	Assessment	Score 1-10 (10 as the highest)
Strength of Mkt Facilitation	To deliver this function effectively will require strong networks across the machine learning community, the energy sector and the wider climate community. It will also require a strong event management function. The ESC has fairly good networks across the UK electricity market, however, has limited or no networks within the machine learning community or across the wider climate sectors. The ESC has limited existing event management function internally and as such this would need to be developed.	6
Strength of Accelerator	To deliver this function effectively would require a combination of skills and competencies: • *An understanding of the rules for delivering public finance* • *Ability to deliver early stage equity funding* • *An incubator space in a location that could attract relevant start-ups* Innovate UK clearly has a very good understanding of the rules for delivering public finance. Innovate UK's expertise is mostly limited to the provision of grants, and to some extent loans, but it has limited experience in delivering early stage equity investments. Innovate UK is based in Swindon, creating a challenge in the development of an incubator space, which would need to be located somewhere with a strong talent base, and which could act as a hub for talent.	7
Ability to support synergies between functions	Having the different functions in different cities, let alone different buildings, would reduce the potential for identifying synergies between functions significantly. ATI is based in London, Innovate UK is based in Swindon, and the ESC is based in Birmingham. This separation of functions could severely hamper the effectiveness of the delivery of the functions.	2
Ability to deliver international remit	This model focuses on working with UK based institutions, and as a result would be very challenging to bring in international interest in collaborating as it precludes any joint ownership of the project. However, there would be the potential to support some international work, however this would likely remain a marginal focus.	4
Organisational priority	For the functions identified to be delivered successfully they will need to be given a high level of organisational priority, including strong engagement from senior management and the CEO. This option does not perform highly on this criterion because: • *The ATI has set itself eight "challenges" around which to channel their research. Energy and climate were not included in these. As such it is challenging to imagine it becoming a top-tier priority.* • *The ESC is focussed on a range of areas of work streams. This work could be included in their remit, but it is uncertain as to whether it would be a high priority.* • *UKRI have a wide range of funding work they deliver. This work would be one of many such streams of work.*	4

Criteria	Assessment	Score 1-10 (10 as the highest)
Attract international AI talent	There is strong interest in the data science and AI community in climate change and there is the potential for this initiative to act as a lightning rod for international AI talent. This option would likely struggle to attract international talent as it would limit the perception that the UK sees this area as a top-tier priority	5
UK as an international leader?	For the UK to be perceived as an international leader in this space, it will need to: • *make a significant investment in the sector;* • *Deliver international projects;* • *be an initiator of international collaboration and cooperation in the space;* • *Have a focal organisation to lead work in this space.* This option would not deliver effectively against these three indicators.	3
	TOTAL	66/120

2 OPTION 2: A NEW CENTRE DELIVERS ALL FUNCTIONS

In this scenario all five functions would be delivered by a new International Centre for AI, Energy & Climate.

Criteria	Assessment	Score 1-10 (10 as the highest)
Cost	As mentioned for Option 1, the precise cost of this and all options is subject to the development of a detailed budget for the proposals. However, the development of a new institution does come with some associated costs. Specifically, there would be a need for additional central services that are associated with a new organisation (HR, finance, comms). However, if the presumption is that all of the five functions would need to be delivered to the same standard, then all costs associated with salaries, office space, compute power, and the accelerator would be the same. These costs make up the bulk of the funding requirement, and as a result the additional costs associated with delivering the functions through a new institution are likely to be comparatively small.	7
Strength of Policy Unit	To deliver this function to a high standard a new institution would need to be able to recruit high quality policy advisors and policy managers. Our assessment is that if the Government decided to establish a flagship organisation in this space it would have the ability to attract strong talent that could deliver this function to a high standard, especially if it were located in a city with a strong policy-focussed talent pool to draw from, such as London. A new organisation would have the ability to focus on recruiting talent with a specific focus, allowing for increased specialisation	9

Criteria	Assessment	Score 1-10 (10 as the highest)
Strength of Data & Tools Lab	To deliver the Data & Tools Lab function successfully there is a need to combine strong technical machine learning expertise, an ability to coordinate effectively with industry over extended timeframes with a strong understanding of energy and climate systems. • *Our assessment is that a new flagship institution would be easily able to recruit the necessary technical talent on a full-time basis.* • *The concept team already has good links with industry, and these would be built further over time. The full-time nature of staff would allow for ongoing relationships on key projects.* • *The Lab's purpose would be to serve industry and help them with problems that they are struggling to solve. Developing a bespoke model for this would almost certainly be more effective. No other model explicitly attempts this.* • *The focus and background of the new Centre's management would be rooted in the Energy and Climate space allowing for strong organisational support.* • *One of the key contributions a Centre could make is brokering data access and sharing to allow for technical expertise to be brought to bear on key challenges. A flagship institution, with engaged management would be better able to broker such arrangements.*	10
Strength of Research coordination	The concept team behind the Centre has already built strong links with key UK universities including Cambridge, Oxford, UCL, Sheffield, Newcastle, Birmingham & Imperial. Our assessment is that universities are keenly interested in collaboration in this space and developing a network would not take too much time if the resources were there to develop it. When it comes to supporting the talent pipeline in this space, we see there being benefits of having a team with in-depth knowledge of energy and climate change working with Universities, and industry to support the development of applied skills in this space. A new Centre could usefully complement existing organisations such as the ATI, by helping support the translation of their theoretical work into an applied context, allowing the ATI to focus on what they are good at – research.	9
Strength of Mkt Facilitation	To deliver this function effectively will require strong networks across the machine learning community, the energy sector and the wider climate community. It will also require a strong event management function. A flagship Centre, acting as a focal point for activity on AI for Energy and Climate, would likely find it easier to act as a convener for the sector than the ESC, by dint of perception and location. A new Centre could also design the necessary event management functions to meet the needs of the sector and would be able to work across all relevant climate sectors, creating a more efficient solution.	9

Criteria	Assessment	Score 1-10 (10 as the highest)
Strength of Accelerator	To deliver this function effectively would require a combination of skills and competencies: • *An understanding of the rules for delivering public finance* • *Ability to deliver early stage equity funding* • *An incubator space in a location that could attract relevant start-ups* Whilst a new Centre would not have the background in delivering public grant finance that Innovate UK has, the settlement with BEIS would likely need to set clear rules for the Centre to operate in, to ensure that it remains within EU State Aid rules (if these still apply). Our assessment is that this would not be a major issue. However, there could be a significant benefit in a new Centre developing a bespoke function to offer early stage equity finance to help de-risk investments in the space. Having this function based in a city where AI-related start-ups are being established will be critical for its success. Finally, the ability of a new Centre to set up an incubator, that offers space and advice to companies in the sector, again in a city in which they want to work, will be particularly important in creating an Ai-for-climate talent and start-up ecosystem.	10
Ability to support synergies between functions	A new Centre would allow for all the necessary functions to be located in the same building which will be critical for realising the potential synergies between functions. Such synergies would allow for the result to be greater than the sum of its parts. Examples of key synergies that could be realised include: • *A strong link between the Data & Tools Lab and the Accelerator, such that projects that come out of the Lab, could apply for space in the incubator and seamlessly apply for funding to take their project to the next stage;* • *The policy function could advise projects in the incubator space about relevant policy for their project;* • *The Market facilitation unit, working with industry could unearth a key challenge from an incumbent energy company, and then work with that company and the Data & Tools Lab to develop a machine learning competition to help address that challenge.* • *Ultimately it is likely that the most important synergies will be those that we are unable to predict at this stage.* • *Data & Tools Lab with domain experts in energy, AI, and meteorology; could spend a day a week mentoring the startups in the accelerator; and could support the policy team.*	10
Ability to deliver international remit	The development of a new flagship Centre would offer the flexibility to develop an international capacity in the form most needed to support the institution's aims. This could be in the form of collaboration with other countries, or the delivery of UK Overseas Development Aid. Regardless, a new organisation can be specifically designed to best support the desired model.	10

Criteria	Assessment	Score 1-10 (10 as the highest)
Organisational priority	For the functions identified to be delivered successfully they will need to be given a high level of organisational priority, including strong engagement from senior management and the CEO. The organisational priority of a new Centre would be total in that there would be no additional activity that would distract from the focus on supporting AI for climate.	10
Attract international AI talent	From anecdotal conversations in the data science and AI community there is potential for a new Centre to act as a lightning rod for international AI talent, who are looking for a conduit to work on climate change. The announcement of a flagship Centre would demonstrate a seriousness of intent and support from the UK Government in the same way that the Green Investment Bank and the Green Finance Institute have helped ensure that London is seen as an international hub for work on green finance.	10
Location	A new Centre could determine the optimum location to fulfil its objectives: a significant benefit over a model where existing institutions might struggle to move from their current locations. At present the UK has the initial makings of a hub of AI activity in the Knowledge Quarter, by Kings Cross in London. Given the over-riding importance of supporting the development of an AI hub in the UK, with all of the associated network effects that create a self-reinforcing dynamic, it would be problematic if a new Centre did not have a presence in London.	10
UK as an international leader?	For the UK to be perceived as an international leader in this space, it will need to: • *Make a significant investment in the sector;* • *Deliver international projects;* • *be an initiator of international collaboration and cooperation in the space;* • *Have a focal organisation to lead work in this space.* This option would be able to meet all of these criteria effectively	10
	TOTAL	**114/120**

CONCLUSION:

This assessment looked at the potential for the function's identified to be delivered in the two most credible ways.

The key points to note from this assessment include:

- The highest scoring option was the development of a new International Centre for AI, Energy & Climate;
- Ultimately the cost efficiencies achieved through working through existing organisations are likely to be comparatively small whereas working through existing organisations would likely significantly compromise the delivery of the needed functions.
- There is a significant benefit in the five functions being delivered by the same organisation;
- A new flagship Centre would ensure the UK is perceived as a leader in this space, attracting international AI talent and companies to the UK.

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