CATAPULT Energy Systems

E3G

REPORT January 2017

THE CLEAN ENERGY TRANSITION AND INDUSTRIAL STRATEGY

DEVELOPING A COHERENT APPROACH

SIMON SKILLINGS AND NICK SMAILES

Supported by:

UKERC UK Energy Research Centre

wholeSEM

energy technologies institute

Acknowledgements

This paper was developed through collaboration between E3G and the Energy System Catapult. The authors are grateful to the extensive input from Jim Watson from UKERC, Neil Strachan from WholeSEM and George Day from ETI.

About E3G

E3G is an independent organisation working in the public interest to accelerate the transition to a low-carbon economy. E3G specializes in climate diplomacy, climate risk, energy policy, governance and climate finance. We work closely with like-minded partners in government, politics, civil society, science, the media, public interest foundations and elsewhere. E3G is a European organisation with a global outlook and reach. We currently have offices in London, Brussels, Berlin and Washington DC, together with a regular presence in China. **www.e3g.org**

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EXECUTIVE SUMMARY

The Government has identified the need for a new industrial strategy to meet a number of pressing economic and political objectives. It also needs to enable and support a clean energy transition whilst keeping energy costs to consumers as low as possible. This note contains some preliminary high level thinking from a network convened by the Energy Systems Catapult and E3G on how the UK's government's action to promote a clean energy transition can be aligned with its emerging industrial strategy.

There appears to be a number of areas where strategic action by government can deliver multiple benefits spanning both the transformation of the energy system and the industrial strategy. There is, therefore, a strong case for making this alignment an explicit driver of the approach to building a long term industrial strategy.

The note also sets out some proposals for how this initial thinking could be developed and refined – potentially as an input to the government's ongoing work on energy and industrial strategy.

CONTEXT

The Government has identified the creation of a new industrial strategy as an important political priority. This is not only required to drive improvements in overall economic productivity and close the gap emerging with key international competitors, but also to enable specific regions, sectors and parts of the labour market to progress tangibly in a changing global economy. This, in turn, requires a rebalancing in the economy between regions and sectors and a focus on training to equip people with the skills necessary to be productive in the new economic environment.

The Brexit process, and the associated uncertainties, creates an additional imperative for the industrial strategy in underpinning investors' continued confidence to invest in the UK economy.

At a political level, the Government has established an over-arching objective to 'create an economy that works for everyone'. This suggests a particular focus on delivering clear and direct benefits to particular groups and regions who have suffered as a result of the changes in the economy over the last few decades. For example, lower skilled workers should gain more opportunities for employment in roles that have better remuneration and working conditions.

However, Government resources are constrained and it needs to focus effort on those areas that deliver as many short-term benefits as possible whilst putting the economy in the best shape possible to compete in the long term. This will inevitably involve making some difficult choices. This note explains how aligning industrial strategy policies with those needed to address the challenge of creating a clean energy system can deliver multiple benefits.

INDUSTRIAL STRATEGY OPTIONS

'Industrial strategy' refers to government intervention which seeks to support or develop some industries to enhance economic growth and this intervention can occur with varying degrees of intensity. Interventions can take a number of forms:

1. *Horizontal policies* designed to address market-wide issues and provide the resources and economic environment that make it easier for individuals and businesses to be productive. For example:
    - Adjusting regulatory rules
    - Fiscal incentives (tax)
    - Encouraging, co-funding and supporting cross-cutting research and innovation.
    - Promoting skill development and education.
2. *Sectoral policies* targeted on particular sector in the economy.

- Production-based subsidies
- Seed-funding for particular technologies
- Support for research and development in particular sectors
- Investment banks
- Infrastructure investment

3. *Regional policies* targeted on a particular geographic area.
    - Encourage inward investment
    - Investment in technology clusters
    - Create links between research and industrial base
4. *Mission related* where a range of mechanisms are combined to achieve a particular outcome
    - E.g. creation of low carbon economy

In practise, industrial strategy often involves elements from a number of these categories where these can be combined in a complementary way. Indeed, seeking multiple benefits from limited interventions is an important objective for industrial strategy design.

THE ROLE OF ENERGY

The Government has committed to decarbonise the economy in line with statutory carbon budgets and that means that the UK energy system must change. Indeed, the decarbonisation imperative embodied within the Paris Agreement and the rapid fall in the cost of renewable energy, along with the replacement of analogue with digital technology, means that energy systems across the world are being transformed.

Whilst there is a risk that the UK is left behind in this global transition, there are also opportunities. The UK has been in the vanguard of institutional innovation in the energy sector, leading the way with market liberalisation and reform over the past 25 years, and more recently with Climate Change Act. Countries across the world look to the UK for guidance given this experience. It is, therefore, in an excellent position to use this experience to maintain leadership as energy systems continue to change.

The way the UK manages the clean energy transition will have a critical impact on the economy as a whole. Not only is energy a key sector in its own right (generating 5% of GDP[1]) but it accounts for a large slice of GDP in other sectors: 8% of which is spent of energy and fuels alone. This means that it is a key determinant of living standards for all and an important cost – directly or indirectly - faced by business[2]. Innovation in the energy sector is

[1] E&Y: Powering the UK economy; **http://www.ey.com/uk/en/industries/power---utilities/ey-powering-the-uk-2015-the-economic-contribution-of-the-energy-sector**

[2] The significance of energy costs in driving international competitiveness for business is, however, oftern overstated. Energy intensive sectors value added as a percentage of GDP is low for the UK and, in other sectors, factors such as the exchange rate tend to dominate energy costs from a competitiveness perspective. Assessments of the US shale revolution also show that cheaper energy tends to produce a one off 'level effect' rather

also important as a way to meet consumers' evolving needs and aspirations for comfort, mobility and control in everyday life.

The industrial strategy must, therefore, address the issue of energy system transformation[3]. Ideally, actions need to be taken in the energy sector that will deliver as many of the shorter term industrial strategy objectives whilst minimising the risk of high energy costs in the longer term that would lead to a broader negative impact on productivity and competitiveness. This not only involves identifying where the UK must take strategic action to enable an efficient transition in its domestic energy infrastructure, it is also necessary to recognise where the UK has a real chance of winning in global markets for energy related products and services and where it cannot risk waiting to 'piggy back' progress made in other countries. This will ensure that the short-term anticipated gains from the industrial strategy will be consistent with the long-term achievability of decarbonisation targets. It is also important to recognise that energy is a system and consideration needs to consequential effects of measures taken in one part of the system (e.g. investment crowding out or market creation, complementary labour skills, enabling infrastructures etc.)

This same challenge is being faced by economies around the world. The appendix includes an overview assessment of the linkages between overall industrial strategy and the approach to the energy transition in the US, Germany and South Korea. Whilst it may be difficult to draw conclusions from the US given its' unique character (abundance of domestic energy, historical focus on innovation, significant public funding available/high level of public procurement, decentralisation/separation of power), it is interesting to assess the effectiveness of the approaches adopted. For example, it highlights the value of public-private partnerships and of building networks between government, research institutions and the private sector. Germany and South Korea have economies of a similar scale to that in the UK and they demonstrate a greater need to focus and align industrial strategy approaches around domestic needs and strengths - in particular, wind and solar in Germany and smart grids in South Korea. In both cases, the focus has tapped into particular national strengths: in Germany, the strong public desire to take a direct financial stake in the future of the energy system and, in South Korea, building on the historical strength in electronics and taking advantage of the relatively high population density.

It is likely that there is much more to learn from a detailed analysis of international experience and this knowledge should be used help inform the approach to be taken in the UK.

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than a 'growth effect' (such as in Houser, T. and Mahon, S. (2014) 'Fuelling Up: The Economic Implications of the American Oil and Gas Boom' Petersen Institute, Washington DC")

[3] This connection was recognised by many (78) contributions to the recent BEIS committee industrial strategy inquiry.

UK ENERGY SYSTEM AUDIT – STRENGTHS AND WEAKNESSES

Countries across the globe face the challenge of weaning the energy system off unabated fossil fuels and each face differing opportunities and challenges in undertaking this transition.

The UK energy system has some particular strengths:

- *Large renewable energy resources*, particularly in the surrounding seas (wind and, possibly, wave and tidal) with renewables now accounting for more than 25% of the electricity generated in the UK.
- *Leading edge research and development capability.* Whilst it is necessary to be cautious, since moving technologies from R&D to commercial deployment takes a long time[4], the UK research base on energy is much healthier than it was 10+ years ago with much more applied research. It creates an important set of capabilities in a variety of areas, some of which are being applied in conjunction with industry to help with commercialisation and early deployment[5].
- *Geology that allows large quantities of captured CO_2 to be permanently stored underground and the workforce, skills and experience to exploit it,* thereby presenting the option for industrial scale carbon capture and storage.
- *World class motor manufacturing and offshore energy engineering industries* which could both see the development of big new global markets.
- *Strong international presence in services markets.* The UK is number two in the world for service exports as a result of expertise in engineering, architecture, law and finance[6].
- *Leading position in innovation in energy system institutional architecture* allowing the UK to shape energy markets worldwide.

However, there are also challenges which must be addressed in our own domestic transition to a low carbon future and some of these are unique to the UK. This means that it will not always be possible to rely on straightforward adoption of technological developments elsewhere.

- *Aging and poorly insulated housing stock* which significantly increases the demand for heat.

[4] See: **http://www.ukerc.ac.uk/programmes/technology-and-policy-assessment/innovation-timelines-from-invention-to-maturity-a-review-of-the-evidence-on-the-time-taken-for-new-technologies-to-reach-widespread-commercialisation.html**

[5] See, for example, research undertaken at the London School of Economics into 'green growth', R&D and its contribution to productivity **http://www.lse.ac.uk/GranthamInstitute/publication/green-growth-an-assessment/**

[6] World Trade Organisation, World trade report 2015, 'Leading exporters of commercial services 2014', p28; ONS, International trade in services 2014, 'Total trade in services, all industries (excluding travel, transport, and banking) analysed by product 2014'

- *Strong customer affinity to existing gas heating systems.* Currently around 85% of the population are served by gas central heating with little appetite to change – particularly where significant disruption might be involved. This affinity is increase since Governments have been reluctant apply full VAT rates to gas, let alone apply any form of carbon price.
- *Largely 'islanded' power system* with relatively low levels of interconnection to neighbouring power systems, thereby increasing the costs of integrating variable renewables and inflexible nuclear onto the power system.
- *A large number of power stations that require replacement over the next decade*[7]. This is not restricted to coal-fired power plant but also to a number of nuclear power stations.
- *A decline in fossil fuel extraction from the North Sea* leading to increased dependence on imported fuel and the need to manage the impact on the regional economy.
- *A road transport network that is often heavily congested* – creating a big drag on productivity and competitiveness.

Roadmap analyses for decarbonisation of the UK energy system have traditionally concluded that the initial imperative in the period up to 2030 is to decarbonise the power system (including deployment of low carbon generation and the creation of a smart flexible power system) and to create options (including electrification) for the decarbonisation of heating and transport which can be tackled later. However, recent developments suggest that this received wisdom may be wrong in the case of road transport and attractive consumer offerings could drive the adoption of low carbon (especially electric) vehicles more rapidly than expected a few years ago. These developments, coupled with the opportunities presented by export markets for electric vehicles, suggest that it might be appropriate to reassess this prioritisation[8]. It is, therefore, important to review the actions necessary to create a clean energy system in light of the industrial strategy agenda.

ALIGNMENT OF INDUSTRIAL STRATEGY WITH CLEAN ENERGY TRANSITION

The table below sets out the results of an initial analysis of where actions could be aligned to deliver clear multiple benefits for both industrial strategy and the clean energy transition.

[7] This may be considered a strength since it is not necessary to shut down high carbon plant before end of life.

[8] Electric vehicle deployment should, of course, not be prioritised ahead of further power system decarbonisation since electric cars powered by fossil derived electricity do not reduce emissions.

Potential areas for strategic action	Importance in addressing decarbonisation challenges	Type of industrial strategy intervention[9]	Creating opportunities to export UK energy system expertise	Wider industrial strategy benefits
Major funded retrofit program to improve thermal efficiency of housing stock – through local authorities competing for central government funding on basis of a number of delivery objectives. (Can be linked to city scale whole-system decarbonisation demonstrations described below).	• Significantly reduces cost of decarbonising heat • May be opportunities to install low carbon heating during retrofit process	• Sectoral and, possibly, regional		• Creates employment for installers across UK • Improve skills of installers to ensure integration of capabilities and that work is of sufficient quality. • Build local supply chains in equipment and materials. • Can be focused on particular areas and framed as putting money in the pockets of the less well-off
Develop offshore grid in North Sea to establish connection points for offshore wind and interconnections to neighbouring countries – implemented through direction placed on Ofgem	• Ability to exploit off-shore wind resource at least cost • Reduce system integration costs of renewables (and nuclear) through interconnections	• Sectoral and regional	• Encourage investment that ensures UK is world leader in offshore wind design and manufacturing capability	• Build local supply chain - helps regeneration of key East Coast towns. • Attract offshore wind construction facilities
Drive forward deployment of building automation and demand flexibility – through program of obligations and standards	• Reduce system integration costs of renewables (and nuclear) through system flexibility	• Sectoral and regional	• New exportable IP and capabilities associated with products and services in demand flexibility	• Create new skilled jobs in equipment installation
Implement initial CCS power and industrial hub on East Coast –	• Ensure CCS is a credible option for	• Sectoral and regional		• Build local supply chain - helps regeneration of

[9] Whilst most are sectoral and regional, it could be argued that the set of priorities in the table as a whole could be framed as a good example of a 'mission oriented' strategy.

determine location strategically and identify appropriate delivery body	decarbonisation of power industry and, ultimately, high temperature industrial heat e.g. chemical and process industry complexes in Teesside, Grangemouth (& potentially Runcorn/NW cluster) • Create option for low carbon production of hydrogen for future use in heating and transport and ultimately negative emissions			regions in decline (Humber, Aberdeen, etc) • Creation of new high skilled jobs leveraging existing skills and supply chains in offshore oil and gas and beginning process of repurposing to a low carbon future as North Sea declines
City scale whole-system decarbonisation demonstrations – funding allocated through competition between city authorities	• Test whole-system governance and delivery requirement for decarbonisation of heat and transport	• Sectoral and regional	• Develop world leading expertise in low carbon energy system integration and market design	• Targeted regeneration opportunity on cities in decline • Creation of locally based jobs (design, systems engineering, installation, etc.)
Major programme to deploy electric vehicle charging infrastructure and smart systems and integrate into existing energy networks - through local authorities competing for central government funding on basis of a number of delivery objectives	• Increase attractiveness and early deployment of electric vehicles	• Sectoral and cross sectoral (electricity, ICTs and transport)	• Develop world leading expertise in system integration of electric vehicles	• Build local demand in electric vehicles to encourage manufacturers to produce models in UK • Creation of locally based jobs (design, systems engineering, installation, etc.)

This table does not represent a complete set of actions necessary to deliver either industrial strategy or the clean energy transition. For example, deployment of large capacities of solar PV may be important in decarbonising the power system but relies largely on imported equipment and technologies and does not represent a strategic industrial sector for the UK. Similarly, there are many aspects of an effective industrial strategy that are unrelated to the energy transition. However, this analysis does serve to highlight that there are a number of low regret measures that deliver multiple benefits across both areas.

CONCLUSIONS

The Government has identified the need for an industrial strategy that has a number of goals. It also needs to enable and support a clean energy transition whilst keeping energy costs to consumers as low as possible. This initial analysis suggests that there are a number of areas where strategic action by government can deliver multiple benefits spanning both the transformation of the energy system and the industrial strategy. There is a strong case for making this alignment an explicit driver of the approach to building a long term industrial strategy.

Further work is required to sense check, test, refine and integrate a coherent set of proposals to form the basis of strategic action planning. In particular:

- Build case studies on the strategic decisions being taken by other countries as they transform their energy systems to help provide insights on where multiple benefits can be delivered and the actions that are effective in realising the benefits.
- Confirm prioritisation of clean energy-related areas offering most promise for strategic action as a basis for a more detailed assessment.
- Develop a process for collaborative identification, design and sense-checking of proposals for strategic action in high priority areas.
- Elaborate the specific actions that Government would need to take to ensure effective and efficient delivery of objectives.
- Review and update assessments of UK research and industrial capabilities in ‘clean energy’ and how these map onto areas that could be required for our own low carbon transition and/or provide promising routes for export revenue.

APPENDIX – INTERNATIONAL INDUSTRIAL STRATEGY ANALYSIS

	United States	**Germany**	**South Korea**
Context on industrial policy	• Long history of government intervention to support sectors and firms but largely decentralized. Industrial policy is politically contentious so is usually framed as innovation policy. • Evidence shows that many technological innovations in US received some form of public support and many new products emerged directly from government agencies, laboratories, and universities • Industrial policy has not been based on a centralized "vision" from government or single federal program. At least a dozen different federal agencies are involved in innovation and there are also state and local policies. • Several initiatives are often highlighted as successful examples of industrial/innovation policy, including the US national laboratories, The Defense Advanced Research Projects Agency (DARPA), and the Small Business Administration • One of the world's largest funders of R&D including in energy sector,	• Strong industrial base and manufacturing sector (roughly one third of GDP), and one of the world's largest exporters including of automobiles, mechanical equipment and electrical engineering • Has increased R&D especially since 2007 for key German export sectors. 55% of R&D activity is concentrated in the vehicle manufacturing, computing / electronics and mechanical engineering sectors. Trails only Japan and South Korea in R&D intensity. • High importance and influence of the 'mittelstands' which make up the majority of German companies • Industrial and innovation policies are balanced between the German Central state and the 16 Länder states • Strong focus on vocational training and continuing education • Coal and nuclear industries historically supported by government due to	• "Miracle on the Han River" success story of industrialization over past half century • Strong top down national 'vision' • Approach to industrial policy has evolved from selective promotion of key industrial sectors where there was a comparative advantage, to raw materials, to light industry, to heavy machinery, to 'technology intensive' industry; • Involved the creation of industrial complexes to targeting to R&D support; South Korea has one of the highest ratios of R&D intensity in the world • Economic growth is fueled by exports, most notably exports of electronics and semiconductors. • Promotion of regional innovation and cluster policies • Recognised for having a highly educated and skilled

	including all along innovation chain from basic R&D to technology diffusion/commercialization. • Success in building networks between public and private sector, investors, government, researchers, academics etc.	abundance of the resource and German expertise in nuclear sector. More recently energy policy interventions have shifted towards mass deployment of renewables.	workforce • Mission-oriented programmes aimed at developing strategic technologies
Energy transformation	• Major energy producer and consumer. Energy security was a dominant narrative until discovery of tight oil and gas. • Obama administration has pursued an "All-of-the-above" energy strategy that in recent years has shifted more towards low carbon sources of energy • Energy system characterized in recent years by strong growth in unconventional gas and renewables and large decrease in coal • Heavy focus in the energy sector on R&D (including with hydraulic fracking backed by P-P initiatives from DOE as well as solar PV innovation) • National level policy is only part of the story. US states also have range of tax credits, policies and fiscal incentives for both low carbon and fossil based energy	• Largest energy consumer in Europe but heavy reliance on imports to meet demand; imports account for 90% of energy supply • Most abundant indigenous resource is coal which accounted for one quarter of primary energy consumption in 2015 • In 2015, 30% of the electricity generated in Germany came from renewables • Germany energy system increasingly decentralized and made up of small-scale renewables although coal covers the supply gap • Planned phase out of nuclear power by 2022 • Focus on scale up of renewables but not on reduction of emissions • RES resources not necessarily near energy consumers; need grid infrastructure	• Very high energy consumption but few natural resources – 96% of energy comes from imports (primarily oil, LNG, coal) • South Korea is the world's second largest LNG importer so sees gas as a strategic priority • Energy-intensive industries such as petrochemicals and steel, energy intensity is relatively high and rising electricity consumption • The state-owned Korea Electric Power Corporation (KEPCO) controls all aspects of electricity generation, retail sales, transmission, and distribution. • Has recognized need to address the growth in electricity demand by working to improve efficiency and demand management

		• High cost for consumers as energy intensives have exemptions	• Has a national strategy and five year plans for green growth
Policies and interventions	• **Fiscal stimulus**: $112bn (12%) of the fiscal stimulus was devoted to "green" projects including renewable energy generation, clean transportation, energy efficiency, grid modernization, advanced vehicles and fuels, carbon capture and storage, green innovation and job training, and clean energy manufacturing. Government has provided an assessment of the stimulus on energy including indicators of success for example job creation • **Production tax credit (PTC)** and **Investment tax credits (ITC)** for renewables have recently been extended • Global leader in energy **R&D investment**. In 2015, $6.4bn in clean energy R&D energy efficiency, renewable power generation, electric grid systems, and advanced transportation systems. • **ARPA-E** investment in transformative technologies. Since founded in 2009 has invested in 475 transformative energy technologies that have secured	• **Energiewende**: long term plan to move to a low carbon economy including a Climate Action Plan with long term emission reduction and renewable energy targets for 2050. Also designed to strengthen Germany's market position in renewable energy, boost innovation in industry and create jobs • **Renewable Energy Sources Act** (2000) has been critical to the success of wind and solar in particular. Core policy was the FiT: 20 year **Feed-in tariff** for renewables including wind, Onshore, Bioenergy, Biomass for heat, Hydropower, Geothermal, Power, Solar, Solar photovoltaic, Wind, with priority grid access. Recent adjustments made due to falling cost of RES (solar e.g.) and high prices. FiT designed to support wide spectrum of technologies although boom was most visible with solar PV. Targets sectors and technologies rather than	• **Framework Act on Low Carbon, Green Growth**. The Framework Act, passed in 2009, builds on the National Strategy for Green Growth (2009-2050) and the **Five-Year Plan for Green Growth** (2009-2013). Targets for market share in certain technologies and export targets. • **FiT** phased into a **Renewable Portfolio Standard** in 2012 • **R&D** support and **soft loans** for renewables plus **energy distribution support** • **Environmental tax** (oil) but limited with respect to industry which has been protected • Government plans to spend approximately 2% of annual GDP on green growth programmes and projects. Investments will initially be geared towards **infrastructure systems** in order to boost the economy. Increase in private R&D investment since launch of

	over $1.25 billion in cumulative follow-on funding from the private sector.	firms. • New Renewables Act: Balance between RES subsidies and market integration to preserve competitiveness: 100% **auctioning** from 2017; Targets/corridors for solar PV, wind onshore and offshore, and biomass; • **Renewable energy loans** • Sophisticated **R&D network** including Helmholtz and Fraunhofer Institute. Specialized institutes for renewables on basic research including in renewables, efficiency, storage and management. The Fraunhofer-Gesellschaft employs a staff of 24,000, who work with an annual research budget totaling more than 2.1 billion euros. Supported by Federal Energy Research Programme. • **Federal Energy Research Programme** also makes capital available for furthering energy and climate policy targets • The government has a goal of putting **one million electric vehicles on the road by 2020** and six million by 2030. At the end of 2015, there were approximately 25,000 electric	Green Growth plan. • **Fiscal stimulus**: Green New Job Creation Plan, a KRW50trn (USD36bn) Highest percentage of stimulus package (80%) of the plan is allocated to climate-related investment themes including energy efficiency, waste water, and low carbon power. Building efficiency, low carbon vehicles and railways received most of the investment. • Smart grid has been identified as a priority. **The Smart Grid Act** 2011 plans to increase demand management • Renewable energy is targeted for an increase so that it constitutes 20 percent of generating units and 12 percent of all energy consumed by 2027. • Developing and investing in technologies such as **integrated gasification combined cycle with carbon capture and storage** • **Shale gas** development strategy

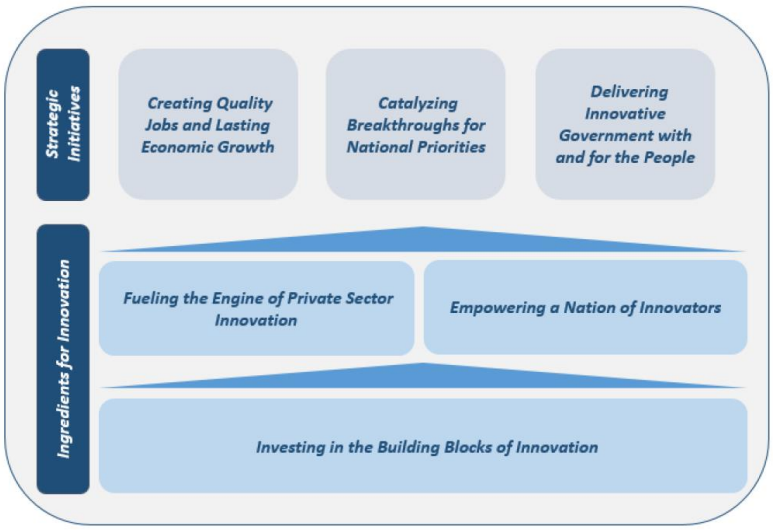
		vehicles registered in Germany. • No government procurement or renewables purchase obligations	
Long term strategy	See "**Strategy for American Innovation**" below	• Energiewende (see above) • "German High-tech strategy 2020" • Original strategy (2006) focused on market potential for specific technologies. New approach is a move to more **mission-orientated** development of industrial policy based on finding solutions to challenges that create social benefits; pillars of the strategy include environmentally friendly energy • New initiatives in **STEM**/MINT subject areas • The Government's energy research measures are combined within its **6th energy research programme,** which places a central focus on implementing the "Energiewende" the potential that exports of modern energy technologies "made in Germany" have for powering employment and prosperity in	

		Germany
		• Several **priority strategic areas** have been identified including
		  ○ **energy storage systems**
		  ○ **sustainable electrical grid**
		  ○ **solar construction and energy efficient cities**
		• In the framework of its energy policy and the "10-Point Energy Agenda", the Federal Government plans to reorganise existing measures and activities in the "Energy Research Policy Coordination Platform", and conduct them through a "Research and Innovation" platform.	

United States

Strategy for American Innovation (October 2015)

- One of the most pressing challenges for the US is the energy transition
- Role of the government is provide seed investments that allow private sector to create the industries of the future
- Three sets of strategy initiatives:
    - Creating quality jobs and lasting economic growth
    - Catalyzing breakthroughs for national priorities
    - Delivering innovative government with and for the people



Examples of energy interventions in national innovation strategy:

- Building blocks of innovation:
    - The Budget includes $325 million for the Advanced Research Projects Agency–Energy (**ARPA-E**), a program that accelerates innovation by investing in transformative energy technologies in order to create a more secure, affordable and sustainable energy future.
    - Boosting Access to High-Quality **STEM** Education
    - Building a Leading 21st Century **Physical Infrastructure**

- Fueling the engine of private sector innovation:
    - DOE announced the **National Incubator Initiative for Clean Energy** (NIICE), a $3 million program to fund up to five specialized business incubators that help entrepreneurs commercialize clean-energy technologies. NIICE will also support a national organization to coordinate these efforts.
    - DOE also recently implemented a $20 million pilot program across several National Labs to provide vouchers to small businesses. These vouchers, redeemable for technical assistance at participating Labs, are targeted at those small businesses developing promising clean-energy technologies.
- Creating quality jobs and long lasting economic growth
    - The Advanced Research Projects Agency – Energy (ARPA-E) is driving the development of transformational energy technologies. ARPA-E has invested approximately $1.1 billion across more than 400 such projects, which have generated over $850 million in follow-on funding and resulted in the formation of 30 new companies.
- Catalyzing Breakthroughs for National Priorities
    - A number of agencies are supporting **Grand Challenges** related to their missions. For example, DOE's SunShot Grand Challenge seeks to make solar energy cost competitive with coal by the end of the decade
    - **Building Smart Cities** Nearly $70 million in new spending and over $45 million in proposed investments to unlock new solutions in safety, energy, climate preparedness, transportation, health, and more, by DHS, Department of Transportation, DOE, DOC, and EPA; and
    - Promoting Clean Energy Technologies and Advancing Energy Efficiency: The Administration's **Clean Energy Investment Initiative** has catalyzed more than $4 billion in independent commitments. The funding, by major foundations, institutional investors, and other long-term investors, will support climate-change solutions, including innovative technologies with breakthrough potential to reduce carbon pollution.
    - The Federal Government will continue to update and improve **energy efficiency standards**. These standards for buildings, commercial

equipment, and consumer appliances are part of a goal to double U.S. energy productivity—the amount of economic activity generated per unit of energy used—by 2030.

    - Clean-energy **R&D investments** helped launch five energy innovation hubs spanning more than $1 billion in public-private investment to pursue advances in clean energy technologies.

- The Trump administration will take office in January 2017 and appears likely to have significantly different energy priorities than the current government, and will likely focus more on promoting infrastructure and permitting rules for gas, coal and oil with less emphasis on clean energy options. However it is still unclear exactly what shape industrial and energy policy will take over the next 4 year cycle.