HSE

Health and Safety Executive

Health and safety in the new energy economy:

Meeting the challenge of major change

A report to the HSE Board on 15 December 2010

Contents

About this report

Over the next decade and beyond, the UK is set to take significant steps towards a new energy economy. This will be an economy where the technologies meeting our electricity, heat and fuel needs have to deliver against three key criteria: sustainability, security and affordability.

In this context, a wide range of emerging energy technologies are expected to play an important role in reshaping the way we satisfy our energy requirements. The extent to which they do so, however, will depend fundamentally on their ability to be harnessed safely.

Compiled by HSE's Emerging Energy Technologies Programme, this report provides a current assessment of the health and safety hazards that key emerging energy technologies could pose, both to workers and to the public at large. (Nuclear energy technologies fall outside the scope of this report.) But it also highlights how an appropriate framework can be, and is being, put in place to help ensure that these hazards are managed and controlled effectively – an essential element in enabling the technologies to make a major contribution to the UK's energy future.

A new era for energy

For decades, the UK's energy landscape had three defining characteristics: an overwhelming reliance on coal, gas, oil and nuclear power; the pre-eminence of large, centralised electricity generation projects; and dominance by a relatively limited number of primarily large organisations.

But a process of transformation has already begun. Concerns over greenhouse gas emissions, energy security and other issues have combined to catalyse change, with a steady increase in the use of renewable energy, for instance, just one reflection of the emergence of new priorities and new possibilities.

Consistent with the Coalition Government's mission to support the transition to a secure, safe, low-carbon, affordable energy system in the UK (as stated in *The Government's Annual Energy Statement – DECC Departmental Memorandum* July 2010), and in step with the firm commitment of the Devolved Administrations to reducing carbon emissions, this process is set to continue and, indeed, gather pace. The ultimate vision is of an energy landscape unlike any preceding it – a less centralised landscape of diversity and dramatic contrasts, where an unprecedented range of energy technologies, old and new, co-exist and are harnessed in an unprecedented variety of ways.

The exact nature of that landscape will depend on many factors. For example, some of today's emerging energy technologies may prove unsuited to commercial deployment, while scope still exists for new and as-yet unknown technologies to have a significant impact. Nevertheless, some of the ways in which this new era for energy could unfold in the years ahead are summarised below:

A new energy mix

- Coal-fired electricity generation becomes increasingly cleaner, with advanced technologies widely deployed as many existing coal power stations reach the end of their lives. Storage of imported natural gas extends available gas reserves, while imports of liquefied natural gas (LNG) grow.
- Increasing amounts of the carbon produced by fossil fuel power stations are securely deposited deep underground using carbon capture and storage (CCS) technologies.
- Renewable energy technologies such as offshore and onshore wind power, wave energy, tidal energy, biomass, combined heat and power (CHP) and solar energy see significantly greater take-up. Heat pumps become increasingly widespread as a means of meeting small-scale energy needs.
- Biofuels, electric vehicles and other emerging low-carbon technologies change the face of transport. Hydrogen starts to have an impact as an energy carrier, in the transport, domestic and other sectors.

New approaches to supply and demand

- Decentralised local and community electricity generation projects account for a growing proportion of the energy market. Local heating schemes also become common.
- More schools, hospitals, local authorities and commercial and industrial premises meet at least some of their energy needs using technologies such as wind and solar power.

- More domestic consumers meet at least a proportion of their energy requirements via solar and/or wind-based microgeneration, for example. Increasing numbers of microgenerators feed excess 'green' electricity into local networks.
- New methods of demand management include 'smart' grids and meters (47 million 'smart' meters are planned to be installed in all domestic premises by 2020). Enabling technologies, for energy transmission, distribution, storage etc, allow efficient integration of new patterns of supply and demand.

A changing energy industry

- Businesses already active in the energy sector extend their operations to include new technologies and new markets. A growing number of small and medium-sized businesses become involved in the sector. Hundreds of thousands of jobs are created in the 'green' energy industry.
- New entrants to the energy industry include farmers, waste management companies and others diversifying into areas beyond their traditional, non-energy spheres of specialism.
- The offshore energy sector grows and diversifies as CCS, offshore renewables, natural gas storage, LNG regasification etc have an increasing impact.
- Long supply chains become more common as the energy industry diversifies and becomes more complex.

These examples give an indication of just how different the energy landscape of tomorrow is likely to look and feel. Innovative technologies, different philosophies, new perspectives – all will play their part and permeate not just the energy economy but also society as a whole in a way never previously experienced in the UK.

HSE's role: safeguarding and enabling

From a health and safety perspective, the scale and speed of the changes catalysed by the drive towards a new energy economy will pose a significant challenge. As emerging technologies arrive in the marketplace, new players join the energy industry and smaller businesses play a greater role within it, some new hazards will supplement longer-standing ones associated with energy production and use. In addition, many familiar hazards will extend into new environments and new contexts. All of these have the potential to impede the anticipated transformation of the UK's energy sector.

A question of confidence

Working impartially and independently in the public interest, and in partnership with government, industry and other regulators, HSE has a statutory responsibility to help ensure the safe development, deployment, operation and maintenance of emerging energy technologies.

This is not a marginal issue. Sound health and safety credentials will be vital to the technologies' ability to secure the public, investor and wider industrial/commercial confidence crucial to their successful introduction and expansion. The need to protect workforces and the public at large, from the outset, from accidents and incidents that could undermine this confidence will be especially acute where potentially pivotal but essentially unfamiliar technologies such as CCS are concerned.

The process of identifying, managing and controlling hazards, then, should not be regarded as a barrier hampering deployment of emerging energy technologies. On the contrary, it is a process specifically designed to prevent and eliminate problems that might otherwise retard the transition to a radically new UK energy system which is the Coalition Government's policy aim. In other words, failure to tackle health and safety issues could compromise efforts to develop sustainable, secure and affordable energy supplies for the future.

Pinpointing the issues

So, from its technology-neutral position (ie not advocating any particular energy technology or technology mix), HSE's role with respect to emerging energy technologies is one of enabling safeguarder. On this basis, HSE will draw on its 35-year track record of protecting people from risks to health and safety arising out of work activities. With expertise and experience encompassing all technologies, all industrial sectors and all phases of the industrial lifecycle, and with a secure reputation as an authoritative source of information and insight on work-related hazards and risks, HSE is well-placed to extend its current activities to embrace the full range of emerging energy technologies relevant to the UK.

Ultimately, however, the level of health and safety achieved in the sphere of emerging energy technologies will be determined by how well those creating the hazards and risks (ie 'dutyholders') manage and control them, in line with their legal duty to do so. As a responsible and enabling regulator, HSE's overriding aim is not just to reassure the public; it is also to help all parties involved in developing, deploying, operating and maintaining the technologies to foresee hazards, recognise risks and implement appropriate management and control measures.

In particular, wherever possible, organisations involved in the emerging energy sector need to focus on ‘designing in’ safety and addressing it as an integral part of the development and roll-out of a new technology. This is generally a much easier and cheaper option than ‘retrofitting’ safety as a bolt-on measure at the operation and maintenance stage. In the final analysis, the earlier hazards and risks are addressed, the easier it will be for the UK to move positively towards a new energy future.

Against this overall background, the following four chapters of this report present HSE’s current appraisal of health and safety hazards and risks posed by emerging energy technologies – hazards and risks that have the potential to impact adversely on individuals, on communities and, ultimately, on the acceptability and take-up of emerging energy technologies in the UK.

Understanding hazards, recognising risks

Although accurately identifying hazards and risks constitutes the crucial first step towards managing and controlling them effectively, it is not necessarily a straightforward task where emerging energy technologies are concerned. The key reason is the intrinsic novelty of the technologies themselves. There is, for instance, a relative lack of safety data available (eg on wind turbine failure rates) that can be used in risk assessments. In addition, significant uncertainties surround the nature and extent of hazards that may accompany the scaling up of technologies – even those that are already being deployed commercially – as developers seek to install generating equipment with higher power ratings. Again, wind power provides just one example.

Moreover, the deployment of many emerging energy technologies is still conditional on the successful completion of research, testing and/or demonstration programmes. Many have yet to be deployed on a serious scale anywhere in the world. CCS is a case in point. This potentially key technology involves capturing carbon dioxide (CO_2) at its point of production in a power station, compressing it, transporting it and then injecting it into underground geological structures where it can be stored securely. But in a commercial-scale CCS project, CO_2 would be present in volumes and concentrations never previously handled, creating a toxic hazard. More work is still needed, for instance, to investigate CO_2's effect on plant integrity and to understand exactly how clouds of CO_2 might behave if their containment were breached.

As noted in the previous chapter, however, HSE has a track record of successful health and safety regulation across a multiplicity of industrial sectors. In many of these, hazards and risks similar to those posed by emerging energy technologies already exist. Furthermore, some of the key sectors of the UK economy that are set to be prominently involved in the new energy framework are those where fatality and injury rates are already relatively high and where HSE has been closely involved for many years – agriculture, manufacturing, transport and waste management are key examples. HSE also has in-depth experience of working with the construction and offshore/port industries, both of which are likely to see a particularly marked increase in energy-related activity as more complex energy infrastructure is built, extended, connected and maintained.

HSE has harnessed its knowledge and experience to undertake an evidence-based assessment of both new and familiar hazards associated with emerging energy technologies. In this report, the hazards and risks identified are broken down into three categories:

- Major hazards.
- Occupational hazards.
- Hazards to the public.

In addition to these specific hazards, a range of generic factors will combine with underlying features of the new energy economy to extend its risk profile. The following list highlights some of the most significant of these factors and features:

- The **rapid expansion** that is expected to take place in the development and deployment of emerging energy technologies means activity volumes will be high, generating a sharp increase in the potential for health and safety-related incidents and accidents to occur.
- This speed of expansion will also lead to a **skills gap** that is difficult to fill quickly (eg 4000 extra operatives will be needed to install 'smart' meters) and to a reliance on large numbers of inexperienced and/or under-skilled workers who will be handling and interacting with new or unfamiliar technologies.

- **New companies** set up specifically to exploit new opportunities in the energy sector may face difficulties in rapidly establishing an adequate health and safety culture.
- Linked with this issue, many dutyholders within the energy sector may be managing some **unfamiliar hazardous activities** and encountering some types of health and safety risk for the very first time, especially where energy generation is not part of their organisation's core business.
- Small-scale, **'embedded' power projects** could increase on-site risks (eg related to equipment failure) for schools, hospitals, farms etc.
- **Financial and other pressures** (eg shortage of materials) may cause extension to the original working life of facilities by means of upgrading, retrofitting etc, thereby increasing maintenance needs and maintenance-related risks.
- The effect of **time pressures** (eg the availability of offshore weather windows) in relation to construction and maintenance activities, in particular, could militate against compliance with safe working practices.
- Greater reliance on **multiple contractors** and multiple contractor interfaces, due to the increased complexity of the energy landscape, is likely to increase the potential for accidents to occur as a result of poor communication etc.
- Higher levels of **domestic energy generation** (which is on the fringes of what might be defined as work-related activity) are likely to increase the hazards and risks to which householders are exposed.

Clearly, not only the scale and speed of the growth but also the increasing diversity of the energy sector will stimulate a corresponding growth and increase in diversity in the hazards and risks that the sector has to address.

Risk specifics: major hazards

Major health and safety hazards are defined as those that could result in multiple fatalities and serious injuries and/or widespread damage to property and the environment as a result of a single incident.

Because the effects of these incidents have the potential to be felt both inside and outside the perimeter of the sites where they occur, major hazards represent a risk not just for on-site workforces but also for the general public.

Typically, the accidents caused by such hazards are low in frequency but high in impact. Past energy-related examples include:

- the explosion and resulting fire on the Piper Alpha oil and gas production platform in the North Sea, which killed 167 people (1988);
- the explosions at the Buncefield oil storage depot in Hertfordshire, which resulted in over 40 injuries and considerable damage to residential and commercial properties (2005); and
- the explosion and resulting fire on the Deepwater Horizon oil rig in the Gulf of Mexico, which killed 11 people and caused the largest offshore oil spill in US history (2010).

Table 1 summarises the major hazards associated with the use of emerging energy technologies. It does not, however, include the health and safety consequences of energy blackouts that have the potential to result from difficulties in balancing supply and demand across the more complex infrastructure likely to characterise the UK's new energy economy.

It is also important to recognise that large-scale accidents can be caused by a 'domino effect' in which a relatively minor initial incident ultimately results in a catastrophic event. This occurred, for instance, in the Piper Alpha disaster where a modest release of gas condensate triggered a chain of events of increasing intensity, ultimately rupturing the main oil and gas lines and bringing about the complete destruction of the platform.

Scope for 'domino effects' exists in the emerging energy technologies sector. For instance, where CCS technology is deployed, an initial release of CO_2 could conceivably lead to the failure of adjacent pipework carrying flammable gas which then ignites, further extending the incident on site and possibly off site too.

Table 1 Key major hazards/risks

Energy technology/ energy source	Key examples of major hazards/risks
Biogas, biodiesel and bioethanol production	■ Fire and explosion during large-scale production. ■ Fire and explosion caused by sparking of electrical equipment in explosive atmospheres. ■ Explosion of pressure vessels. ■ Biogas or syngas not meeting gas specifications (this could have an adverse impact on gas network pipelines).
Carbon capture and storage (CCS)	■ Presence of large volumes of CO_2 requiring compression, transportation and underground injection. ■ Presence of toxic, flammable and explosive substances (eg amines, ammonia, oxygen) in coal combustion plant as part of the carbon capture process. ■ Handling CO_2 in its dense (ie liquid) or supercritical phase. ■ CO_2 escape due to loss of plant integrity or embrittlement of equipment caused by the gas.
Coal: coal bed methane extraction	■ Fire and explosion caused by gas leakage at the surface during blending, transportation, storage and use. ■ Well-related fire and explosion.
Coal: co-firing of coal and biomass	■ Spontaneous combustion of large-scale stores of biomass. ■ Explosion and deflagration during co-milling of coal and biomass. ■ Acid gas removal.
Coal: integrated gasification combined cycle (IGCC)	■ Presence of toxic and flammable substances (hydrogen sulphide and oxygen). ■ Catastrophic failure of gasifiers/pressure vessels.
Coal: supercritical coal power plant	■ Catastrophic failure of high-temperature/high-pressure boilers.
Coal: underground coal gasification	■ Fire and explosion caused by on-site presence of oxygen. ■ Fire and explosion caused by syngas leakage at the surface. ■ High (up to 1000 °C) combustion temperatures.
Hydrogen generation, distribution, storage and use	■ Fire and explosion during transportation, storage and use.
Liquefied natural gas (LNG) import and regasification	■ Fire and explosion during transportation, storage and regasification (eg when feeding gas directly from ships into the grid).
Offshore renewables (wind, wave, tidal)	■ Collapse of offshore working platforms during turbine/ substation construction.
Underground gas storage (offshore or onshore)	■ Fire and explosion during gas transportation and storage.

Risk specifics: occupational hazards

In addition to major hazards which could impact on workforces developing, installing, operating and maintaining emerging energy technologies, a range of lower-level occupational hazards also pose a potential threat to health and safety in the workplace:

- Occupational health presents significant challenges that must be addressed effectively if workers are to enjoy appropriate protection from short-term and long-term health impacts.
- Workforces need to be safeguarded from a diverse range of on-site safety hazards, some of which could pose a risk of death or serious injury.

Many of these occupational health and safety hazards are familiar ones that will now be replicated in unfamiliar environments; others have never been encountered on a meaningful scale before.

Table 2 Key occupational and workplace health hazards

Energy technology/ energy source	Key examples of occupational health hazards/risks
Advanced thermal treatment of biomass or refuse-derived fuels	■ Exposure to potentially carcinogenic aromatic compounds, as well as heavy metals, acid gases and hydrogen sulphide.
Biogas, biodiesel and bioethanol production	■ Asphyxiation in confined spaces (eg anaerobic digesters). ■ Exposure to CO_2 generated during the fermentation process, to chemicals/solvents used in fuel production and plant clean up, and to volatile by-products generated by microbiological processes.
Biomass combustion	■ Asphyxiation, impaired functioning etc caused by aldehydes and carbon monoxide generated during feedstock storage and transportation. ■ Respiratory allergies caused by handling biomass fuel which has degraded. ■ Dock-related hazards during biomass importation (eg oxygen depletion in confined spaces; exposure to hazardous VOC emissions, dusts, moulds and endotoxins).
Carbon capture and storage (CCS)	■ Acute and chronic health problems caused by exposure to high CO_2 concentrations (eg inhalation may affect respiratory, cardio-vascular and central nervous systems). ■ Exposure to chemicals and solvents (amines, methanol etc) which can cause irritation to eyes, skin and the respiratory tract.
Coal: co-firing of coal and biomass	■ Exposure to micro-organisms and metal residues. ■ Dock-related hazards during biomass importation (eg oxygen depletion in confined spaces; exposure to hazardous VOC emissions, dusts, moulds and endotoxins).
Coal: integrated gasification combined cycle (IGCC), underground coal gasification, or supercritical power plant	■ Exposure to toxic substances during syngas or flue gas processing or plant maintenance work.
Hydrogen fuel cells, hydrogen storage systems, batteries and supercapacitors	■ Exposure to potentially toxic nanomaterials during manufacture, disposal and recycling.
Solar energy	■ Exposure to toxic chemicals and metals (eg cadmium – a known carcinogen) during solar panel manufacture, disposal and recycling.
Wind power	■ Exposure to epoxy resins, styrene and other hazardous chemicals/solvents during wind turbine manufacture.

Table 3 Key occupational and workplace safety hazards

Energy technology/ energy source	Key examples of occupational safety hazards/risks
Biogas, biodiesel and bioethanol production	■ Fire and explosion during small-scale manufacture of biofuels.
Carbon capture and storage (CCS)	■ Severe burns/frostbite caused by accidental contact with liquid CO_2.
Coal: integrated gasification combined cycle (IGCC), underground coal gasification, or supercritical power plant	■ Fire and explosion caused by leaks in high-pressure pipes and vessels.
Electricity infrastructure, distribution and connectivity	■ 'Flashover' burns, falls and electrocution during installation, connection and maintenance of new power sources. ■ 'Flashover' burns, electrocution etc due to more 'live' working as systems become more complex. ■ Falls when installing, connecting or repairing roof-mounted micro wind turbines or solar panels. ■ Construction and excavation risks during cable laying, substation construction and other activities (onshore and offshore).
Hydrogen generation, distribution, storage and use	■ Burns from cryogenic storage. ■ Electrical risks from fuel cells.
Renewables (wind, wave, tidal)	■ Falls, electrocution and other accidents (eg entrapment) during construction and maintenance. ■ Dockside assembly and loading of offshore turbine equipment; dockside importation of turbine parts. ■ Use of lift vessels and of ships' crews not suited to conditions in the North Sea etc.
'Smart' metering/grids	■ Installation, maintenance and use of meters.
Solar energy	■ Falls from height during installation of panels on roofs. ■ Manual handling issues.

Risk specifics: hazards to the public

Emerging energy technologies pose a variety of health and safety risks to members of the public living or working near them. While some of these can be defined as major hazards (see chapter 'Risk specifics: major hazards'), others are more localised in their possible effects, although still potentially of extreme seriousness for those individuals affected.

Many of these hazards are rooted in the fundamental nature of the energy generation technologies concerned. Some, though, are primarily attributable to the fact that many emerging energy technologies will be harnessed in comparatively innovative, more decentralised ways, with a large number of small-scale projects 'embedded' into communities and a substantial increase in the number of householders involved in energy generation for their own use and for export to the grid. Lower-level risks to the public are also likely to increase due to energy blackouts attributable to the difficulties involved in balancing supply and demand in a much more complex energy system.

Table 4 Key potential hazards to the public

Energy technology/ energy source	Key examples of hazards/risks to the public
Biodiesel production	■ Fire, explosion etc during small-scale production.
Biomass combustion	■ Burns from boilers and other equipment installed as part of a local or district heating scheme.
Electricity infrastructure, distribution and connectivity	■ Falls or electrocution when householders are connecting roof-mounted micro wind turbines or solar panels.
Hydrogen generation, distribution, storage and use	■ Electrical risks from fuel cells (eg used to power vehicles).
Onshore renewables (wind, solar)	■ Blade throw or turbine collapse where wind turbines are sited at schools, hospitals etc. ■ Falls or electrocution when householders are installing or repairing roof-mounted micro wind turbines or solar panels.
'Smart' metering/grids	■ Electrical risks from poorly installed meters in domestic premises.

The right response

HSE aims to develop a supportive regulatory framework for emerging energy technologies and to promote sensible, proportionate management and control of hazards and risks. Fundamentally, this means seeking to regulate the technologies to the same standards as existing industries with comparable hazard and risk profiles, while simplifying the framework wherever possible and avoiding the imposition of unnecessary burdens. Indeed, the starting point is a presumption that further regulation will not be required unless it becomes obvious that current regulation is insufficient.

A firm foundation

HSE is confident that the general provisions of the existing Health and Safety at Work etc Act (which applies to all work-related activity in the energy sector) can form the basis of a fit-for-purpose regulatory framework that provides clarity and consistency across both onshore and offshore health and safety regimes. If there is clear and compelling evidence that the scope of the Act is insufficient, however, it may ultimately prove appropriate, in some cases, to put in place additional regulations.

Overall, HSE will focus on harnessing tried and tested approaches wherever possible, and on establishing a framework flexible enough to respond to new and unforeseen developments in the years ahead. Moving forward, this will require HSE to keep hazards and risks – and industry's ability to control those hazards and risks – under close review.

Co-operation and collaboration

The Health and Safety at Work etc Act places the onus for controlling risk on those who create it. Employers are therefore obliged to ensure, so far as is reasonably practicable, the health and safety not just of their workforces but also of anyone else who may be affected by their work activities. Establishing an effective safety culture and ensuring competence in conducting risk assessments are just two examples of how an organisation's health and safety performance needs to be underpinned.

HSE recognises that co-operating and collaborating effectively, not only with employers but also with other relevant organisations, will be essential to ensuring that an appropriate level of health and safety is achieved in the field of emerging energy technologies. With this in mind, HSE will engage in a wide-ranging but complementary suite of activities and initiatives:

- Establishing a constructive, productive dialogue with dutyholders to alert them to potential hazards and risks, and to help them develop proportionate strategies to address these, is a key objective. One priority here is to encourage dutyholders to address health and safety considerations at an early stage in a project's life (eg as part of applications for planning consent or other early-stage permissions to undertake a particular activity on a particular site).
- HSE will continue to engage early and work closely in partnership with relevant industry/trade bodies and trade unions, encouraging them to take a lead where appropriate in setting standards and in defining, requiring and delivering best practice. For example, HSE is working with others to promote and encourage inclusion of health and safety within core technical and vocational training for workers in the energy sector both with and without previous experience of emerging energy technologies.

- HSE will also continue to work very closely with government departments and other regulators which have an interest in the energy economy (eg from an environmental protection perspective).
- HSE will encourage provision of advice tailored to the specific needs of small and medium-sized businesses.
- Cross-sector learning and communication will be encouraged and knowledge and experience will be shared with other countries. As well as ensuring that the UK is in a position to respond to international developments in the regulatory sphere, one of HSE's ongoing objectives is also to influence the safety debate in relevant international arenas and ensure that UK businesses can compete on a level playing field with their competitors in other countries.
- HSE is seeking to achieve leverage by influencing (and, where appropriate, initiating) research in emerging/new energy technologies that ensures they address health and safety from the outset, and by encouraging industry to develop new standards and guidance as necessary.

To sum up, as a health and safety 'champion', HSE is completely focused on helping the UK build up and develop its competence in the field of emerging energy technologies and on securing effective management and control of all relevant hazards and risks.

Conclusions

The new energy economy will undoubtedly present a range of health and safety challenges, foreseen and unforeseen, as it evolves and expands up to 2020 and beyond. Nevertheless, these challenges are essentially manageable and, if addressed promptly and appropriately, need not act as a brake on the rapid and widespread use of emerging energy technologies in the UK.

Pinpointing key hazards and risks, identifying broader issues and outlining the basis on which HSE proposes to move forward in this sphere, this report has sought to provide reassurance to all stakeholders that a secure platform for progress is in place. A new type of energy sector is attainable, where both workforces and public are safeguarded effectively – and where the very fact that these safeguards exist helps to enable the deployment of emerging energy technologies in a timely and effective way, in line with Government policy.

Addressing the challenge of major change positively and proactively, and encouraging ownership and leadership within the energy sector itself, HSE is fully committed to making a crucial and distinctive contribution to the establishment of a secure, safe, low-carbon, affordable energy system in this country.

Annex: A quick guide to the main hazards by technology

✓ = Potential hazard

Energy technology/ energy source	Major hazard potential	Occupational hazards										Potential hazards to the public
		Biological and chemical	Confined spaces	Construction-related (eg lifting, excavation)	Drilling activities	Electricity-related	Fire and explosion, explosive atmospheres	Machinery (eg entanglement)	Mechanical and structural failures	Pressure systems failure	Working at height	
Advanced coal and carbon abatement												
Coal bed methane	✓			✓	✓		✓		✓			
Co-firing of coal and biomass	✓	✓	✓				✓					
Integrated gasification combined cycle	✓	✓		✓			✓		✓	✓		
Supercritical coal power plant	✓	✓		✓					✓	✓		
Underground coal gasification	✓	✓		✓	✓		✓		✓	✓		
Carbon capture and storage	✓	✓	✓	✓	✓		✓			✓	✓	✓
Natural gas storage and liquefied natural gas (LNG) imports												
LNG import and regasification	✓						✓		✓	✓		✓
Underground gas storage (offshore)	✓				✓		✓			✓		
Underground gas storage (onshore)	✓				✓		✓			✓		
Renewable energy												
Biodiesel/bioethanol production (large)	✓	✓		✓		✓	✓			✓		
Biogas production (large)	✓	✓	✓	✓		✓	✓			✓		
Biogas production (small and medium)		✓	✓			✓	✓			✓		
Biomass (direct or advanced thermal treatment)		✓	✓	✓		✓	✓			✓		✓
Geothermal			✓		✓	✓				✓		

Energy technology/ energy source	Major hazard potential	Occupational hazards										Potential hazards to the public
		Biological and chemical	Confined spaces	Construction-related (eg lifting, excavation)	Drilling activities	Electricity-related	Fire and explosion, explosive atmospheres	Machinery (eg entanglement)	Mechanical and structural failures	Pressure systems failure	Working at height	
Solar/photovoltaic		✓				✓					✓	
Wave and tidal				✓		✓		✓	✓			
Wind (offshore)		✓	✓	✓		✓	✓	✓	✓		✓	
Wind (onshore – medium and large)		✓	✓	✓		✓		✓	✓		✓	✓
Wind (onshore – microgeneration)				✓		✓		✓	✓		✓	
Power and energy infrastructure/transmission												
Batteries and super-capacitors		✓				✓						
Electricity infrastructure, distribution and connectivity (regional/ local level)				✓		✓					✓	✓
Electricity transmission (national and international infrastructure)				✓		✓					✓	✓
Fuel cells		✓				✓						✓
Gas transmission networks						✓						✓
Non-conventional energy storage systems						✓		✓	✓			
SMART metering/ grids						✓						✓
Hydrogen												
Hydrogen generation, distribution, storage and use	✓	✓				✓	✓			✓		✓