European Agency for Safety and Health at Work

Green Jobs, new risks?
New and emerging risks to occupational safety and health in the electricity sector

Workshop for European Sectoral Social Dialogue Committee 'Electricity'

European Risk Observatory

European Agency for Safety and Health at Work

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More information on the European Union is available on the Internet (http://europa.eu).

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1 Introduction

In early 2010 the European Agency for Safety and Health at Work (EU-OSHA) commissioned a study "Foresight on New and Emerging Risks Associated with New Technologies in Green Jobs by 2020" (the 'EU-OSHA Foresight project'). The study, which ran for two years, was carried out by a consortium of the United Kingdom Health and Safety Laboratory (HSL), SAMI Consulting and Technopolis Group. It used the scenario building method to explore the development of a range of technologies in green jobs and their associated occupational safety and health (OSH) risks in three possible futures for Europe.

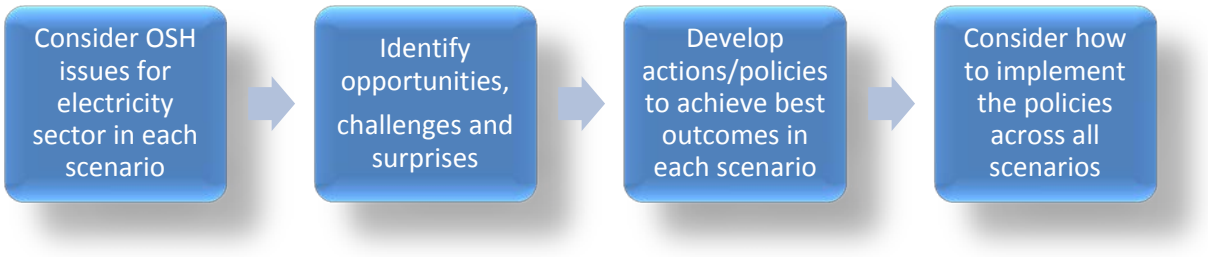
Scenario building is an established method for exploring the future in a way that allows a range of drivers of change to be taken into account. They are not predictions, but descriptions of possible futures that provide a structure for strategic thinking to inform planning. The future is likely to contain elements of all these scenarios, so envisaging them helps to anticipate the future.

The scenarios produced are intended to inform EU policy makers, Member States' governments, trade unions and employers, so that they can take decisions to shape the future of OSH in green jobs towards safer and healthier workplaces.

This report describes a workshop, based on the Green Jobs project, held in Brussels on 20 March 2014 for the European Sectoral Social Dialogue Committee (SSDC) Electricity. The objectives were:

- To engage in a discussion on new and emerging risks in the electricity sector with the members of the SSDC Electricity building on the EU-OSHA Foresight project;
- To stimulate their interest in the findings of the project relevant to their sector; and
- To demonstrate how scenarios can be used to anticipate new and emerging risks and to explore policy options to address these.

The development of strategies or policies is a complex process that often does not adequately consider the future environment in which the policies will need to be successful. The use of scenarios to support this process was demonstrated at the workshop, using the following steps:



The SSDC Electricity members discussed the future of the electricity sector in each scenario and were taken through the process of identifying potential future OSH threats and opportunities in each scenario and formulating policies or actions to respond to the most important of these. In a final exercise, they used a process known as 'wind-tunnelling' to compare the impact of those policies or actions in the different scenarios.

It is important to note that the policy development and testing exercises were undertaken to generate new ideas and demonstrate the contributions that scenarios can make to this process. They were not intended to be decision making exercises, as this would be a considerably longer process requiring further analysis.

The workshop concluded with a panel discussion between the social partners.

2 The workshop for the SSDC Electricity

The workshop was held over one day. Fifteen delegates from the SSDC Electricity, a participant from the United Kingdom Health and Safety Executive and two EU-OSHA staff attended. The event was facilitated by representatives of the HSL and SAMI Consulting, who had carried out the EU-OSHA Foresight project. Three scribes took notes of the discussions.

The Agenda for the workshop is at Annex 1 and a list of attendees is at Annex 2.

2.1.1 Welcome and Introduction

Tim Van Rie (European Commission, DG Empl B.1, Sectoral Social Dialogue) welcomed participants to the workshop and Xabier Irastorza (EU-OSHA) gave a brief introduction to EU-OSHA's foresight activities, the relevance of anticipating new and emerging OSH risks from new technologies in green jobs to the European Community Strategy for Health and Safety at Work 2007-2012, and the role of scenarios as a useful tool to:

- Anticipate possible new and emerging risks;
- Mainstream OSH into other disciplines;
- Encourage people to 'think outside the box' in a neutral context (the future) removed from the constraints of the present in order to generate new insights; and
- Test policies against different assumptions to develop future-proofed, surprise-resistant policies.

2.1.2 Session 1 - Workshop Introduction - How foresight and scenarios can support policy-making and introduction to the EU-OSHA scenarios

John Reynolds (SAMI Consulting) gave an introduction to the workshop proceedings. He also introduced the roles of foresight and scenarios and presented the three scenarios from the Green Jobs project.

Anticipating the future, or foresight, is important as Europe and the broader world are experiencing a period of probably unprecedented uncertainty. It is also important to gain an understanding of the forces driving accelerating rates of change and innovations. Foresight challenges predetermined views, allows a wider range of options to be considered and should lead to more robust and lower risk policies. It should also help to identify opportunities to influence the future and early warning signs of potential developments.

The Green Jobs project comprised three phases:

- Phase 1: Identification of key contextual drivers of change shaping green jobs;
- Phase 2: Identification of key technologies that could create new and emerging OSH risks in green jobs;
- Phase 3: Development and validation of scenarios describing the development of the key technologies selected and the new and emerging OSH risks to which they could lead, and demonstration of their potential value in policy making.

In Phase 1 a literature study, a series of 25 interviews with key people, a web-based survey and a voting exercise were used to identify the 16 drivers of change.

In Phase 2 a literature study, a series of 26 interviews with technical and OSH experts, a web-based survey and a workshop were used to identify 8 technologies and technology areas. These were:

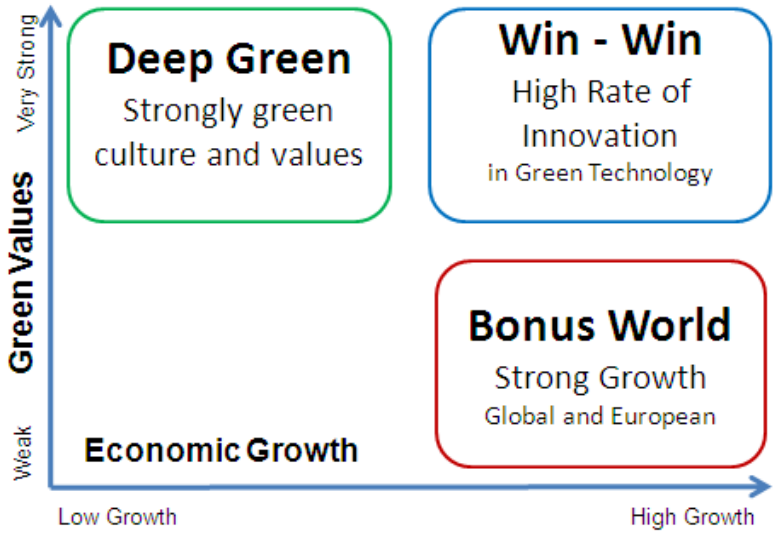
• Wind energy (industrial scale)	• Green transport
• Green construction technologies (buildings)	• Green manufacturing technologies and processes, including robotics and automation
• Bioenergy and the energy applications of biotechnology	• Electricity transmission, distribution and storage, and domestic and small-scale renewable energy
• Waste processing	• Nanotechnologies and nanomaterials

In Phase 3 the drivers from Phase 1 were reviewed and three broad clusters were identified, which were selected as the axes around which the scenarios would be built. These were:

- Economic Growth
- Green Values
- Rate of Innovation in Green Technologies

The three broad drivers of future change, identified above, were used as axes to generate three possible scenarios for 2020. The positions of the scenarios relative to two of the axes are shown below in Figure 1.

Figure 1: Economic growth and green values axes



The third axis is shown below in Figure 2 and shows the relative progress of green innovation, as distinct from other innovation, in each of the three scenarios. The three axes for the scenarios are brought together in a tabular form in Table 1.

Figure 2: Innovation Axis

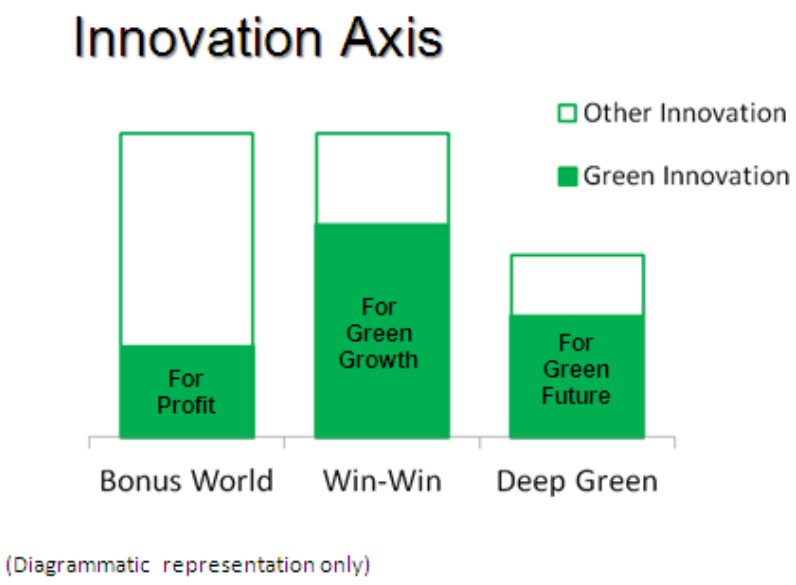


Table 1: Scenario axes

Scenario	Win – Win	Bonus World	Deep Green
Economic Growth	High	High	Low
Green Values	Strong	Weak	Strong
Rate of Innovation in Green Technologies	High	Medium -	Medium +

A brief overview of OSH conditions in each scenario is given in Table 2.

Table 2: Summary of OSH Conditions in each scenario

	In **Win-Win**, a buoyant economy, funds are available for investment in safety, but the innovation proceeds at a high pace. The rapid roll-out of new technologies and new products, and the creation of new jobs requiring new skills means that a wider population faces new risks over shorter timescales. It is, therefore, important that OSH assessments are undertaken early in the development cycle of a technology or product so that the pace of development doesn't leave OSH behind.
	In **Bonus World**, a healthy economy, funds are available to invest in OSH and make infrastructure and business processes safe, but OSH is of relatively low importance to most governments. Employers see OSH as important in terms of its impact on profits. New jobs and new products may bring new hazards and the rapid roll-out of new technologies means that a wide population is exposed to these with short timescales for determining their possible health and safety impacts. OSH by regulation is more effective than OSH by education. As in Win-Win, there are skills shortages associated with the high pace of innovation. This leads to a polarisation of the workforce with regard to skills, with less-skilled workers more readily found in jobs with poorer, more hazardous working conditions.
	In **Deep Green**, low economic growth has tempted employers to cut corners, making investment in safer and healthier infrastructure more difficult. A tendency towards decentralised, more local and smaller enterprises (in particular microenterprises and self-employment) makes it more difficult to reach workplaces to disseminate good OSH practices and to control OSH conditions. With emphasis on reduced consumption of energy and physical goods, most new jobs are in the service sector. Many new small businesses, often with skills deficits, are set up to meet these needs. A make-do-and-mend approach leads to refurbishment rather than replacement, so there are risks associated with the use of old equipment. In this scenario, there are more difficult 'dirty' manual jobs (in repair, maintenance, waste sorting etc.) than in the other scenarios with more innovation and automation. But the relatively slow roll-out of some new technologies and products gives more time to assimilate new hazards and risks. There are many new green processes and enterprises, all of which require new OSH procedures and training.

Full details of the scenarios and the scenario building process are given in the Green Jobs project report ([1]).

- **Exercise 1 – A sector in flux**

This exercise was designed to give delegates some familiarity with the scenario with which they would be working. The delegates, in three groups – one for each scenario – were invited to read a short summary of their scenario (see Annex 3) and to discuss what Europe in 2025([2]) would be like for the

[1] EU-OSHA — European Agency for Safety and Health at Work, *Green jobs and occupational safety and health: Foresight on new and emerging risks associated with new technologies by 2020*, 2013 http://osha.europa.eu/en/publications/reports/green-jobs-foresight-new-emerging-risks-technologies/view

[2] In scenario work it can be helpful to look a few years beyond the target date so that changes happening after 2020 are considered.

electricity sector in their scenario. How would it differ from today and what would the main issues be? The conclusions of each group are summarised in Table 3.

Table 3: Exercise 1 – Key issues

	*Win-Win*
High growth in this scenario could lead to higher demand for energy and as a result increased carbon emissions overall. There would have to be incentives to reduce consumption, although higher energy prices in this scenario would go some way towards lowering demand. A move towards green technologies could have a negative effect on overall employment levels in this scenario owing to a shortage of skills caused by the high pace of innovation and roll out of new technologies. In this scenario, there will still be reliance on nuclear and fossil fuel energy in some areas. There would have to be cross-European cooperation. For example, Germany has wind energy in the north and solar energy in the south, but needs access to 'back up' as part of its energy mix for days when there is little wind or sun. Back-up could be expensive if power stations are not fully utilised and only operate at times of need.	
	*Bonus World*
This feels like the world we are experiencing now. Economic growth is a priority, whereas green is 'nice to have', i.e. a secondary priority. Governments have a short-term vision, responding to complaints (e.g. about noise or pollution) rather than getting to the root of the problem and taking leadership in the green agenda. Europe has achieved economic growth but missed the EU's 2020 targets relating to greenhouse gas emissions cuts and energy efficiency. More efficient technologies have been introduced because of the increased price of energy resources and most people think that technologies will solve the problems over time. Looking back at 2020, the European Commission thinks that it has achieved growth but not as green or inclusive as it wanted. Businesses are pointing to all the extra costs that the European Commission is burdening them with. The unemployment rate is at a medium level and we missed the chance to create green jobs. Now that the economy is better, there is an opportunity to invest in green jobs. There is a pressure to move towards the Win-Win scenario because the recession has largely been forgotten. As employees move from old coal plants to new renewables plants, they do not have the required skills. There is a need to increase training, made more difficult by the high level lot of short-term jobs. The constant changes in technologies and a shortage of skills are combined with a tendency to ask people from less developed countries to do the work. There is poor integration of migrant workers into society and increasing inequality. There are low levels of cooperation between countries as each country is focused on its own profits. This makes it hard to streamline international standards. There is also a low level of energy security because of the lack of investment in reserve capacity.	

	*Deep Green*
If there is no money, you have a risk of low investment. This is rather like the position today. There is a risk that there will be unemployment and that short-termism will prevail. In such a scenario there would be a real imbalance between the green values of the citizens and what they want for their homes, so there would be little investment in green energy production. Workers accept long hours and more dangerous conditions. Workers don't want the unions to look into unsafe conditions because they are frightened of losing their jobs. There is competition between workers from different countries who seek to undercut each other. Maybe this is not a very comfortable world to be in, with a lower quality of life in the short term. There will be no 'one-size-fits-all' solution. Energy production will be adapted to the local context, with a range of solutions adapted to different countries and situations, for example, solar in southern Europe and wind in windy countries. Will nuclear energy be significant?	

2.1.3 Session 2 - Technological change in the electricity sector

Peter Ellwood (HSL) then gave a short presentation on technologies relevant to the electricity sector. The supply system is changing from a centralised system in which large power stations produce electricity which is transmitted to end users, to one where generation is increasingly distributed and smaller generating sites serve their local areas and sell surplus electricity to national grids. So we are moving from a system in which the flow of electricity is almost entirely in one direction, to one where there is increasingly a two-way flow. Renewable sources such as biomass, wind and solar energy are a key component of the distributed network. Important developments that will be needed to make this work will be energy storage technologies to help smooth out the fluctuations in supply that result from intermittent sources, and development of a 'smart' and modernised grid to facilitate the operation of the two-way flow of electricity.

- **Exercise 2**

In this exercise delegates, again working in three groups, were asked to read a brief summary of the technology developments described in the presentation (Annex 4). They were then asked to consider: (1) the likely energy mix in their scenario in 2025, (2) which key technology developments were needed now and (3) what the associated operational issues might be. Each group was then asked to present its findings to a plenary session. These are summarised in Table 4.

Table 4: Technology developments

	*Win-Win*
The scenario envisages a Supersmart grid (SSG), so this needs to be developed. But who will pay? There are issues over politics, competence and resilience of the grid, amongst others. Battery technology needs to catch up with needs. At present it lags behind. Safety issues with lithium ion batteries are a concern.	

Competence and control of the after-market for electric vehicles are problem areas.
Old technology. Decommissioning of old power stations, or in some case re-lifing will need to be done
All technologies – workforce capability. There will be increased automation and only a small number of highly-skilled jobs. A large number of operators could push risks down to inexperienced employees.
A suggested energy mix might be: renewables 40%; fossil fuels 20%, nuclear energy 20%; 20% reduced demand due to energy efficiency.

Bonus World

Wind energy - The biggest turbines will not be developed and companies will rely on streamlining well known and proven technologies. Companies will increase the life expectancy of wind turbines and invest in smarter maintenance solutions rather than new equipment. The price of electricity will go up because everyone is competing for resources making wind energy more competitive than it is now. Many wind farms are not connected to the grid but provide local demand. In Northern Germany, there has been a lot of public opposition to working on infrastructure for connections. There is a strong 'not in my backyard' mentality.

Wind turbines that have come to the end of their lifecycle are being left on site as the cost of recycling them is high.

Bioenergy - The sector is being driven by innovation and the increasing price of energy. More money is being invested in bioenergy than wind energy because this is a consumption society, producing more and more waste. Energy companies see the value in using waste as a feedstock as they can make money from it. There is opposition from local communities to building biomass plants (because of the externalities) – they want cheap electricity but 'not in my back yard'.

Biofuels could be the biggest sector for innovation. Technology development here could be driven by the need to support the car industry and not the idea of wanting a greener world. Genetic technology is being seen as more acceptable for use in developing biofuels than for food.

Small-scale renewable energy - The government has decided to cut subsidies here. That is bad for people wanting to install photovoltaic panels on their roof. Despite the cuts in subsidies, the wealthier people in this scenario will continue to install domestic energy installations because they want their homes to be smarter and they like the idea of being energy producers.

There is a risk of growing inequalities. For companies, the poorer are seen as bad customers and it is not a problem if the company loses them. The poor are also not a priority for governments.

Theft of power could be a serious issue.

Batteries and storage - Energy security is a lower priority and power cuts are a bigger risk.

Energy distribution - There is little investment in smart grids as electricity production will be very concentrated in the hands of few big power plants. Nothing is pushing people to think about smart grids. In the short term it costs a lot more than one can get out of it.

Deep Green

All technologies – maintenance of existing technologies. Operational issues are less to do with the technologies themselves and more to do with societal aspects – acceptance of costs, political will, and economics.

OSH risks will be high – repairers in distributed work situations may be less well trained than those working for large companies.

Small scale energy production – increased uptake in this scenario. A Deep Green population would accept any disadvantages, for example smells from biogas production. There will be a need to improve energy storage and invest in transmission and distribution. Batteries can be dangerous.

All technologies - politics. Different priorities in different countries, so EU standards difficult to formulate. Companies need to adapt to cope with different standards and understand local priorities – a real challenge for big companies.

Energy efficiency – insulation may contain nanomaterials. More risks for householders and companies as people try to manage waste disposal in house.

Growth in hydroelectric power. It was recognised that most of the good sites have been used, so new sites will be far removed from the end users. Transmission and storage will therefore be a challenge.

2.1.4 Session 3 - Health and safety in the electricity sector

Peter Ellwood gave a presentation on a range of OSH issues with potential implications for the electricity sector. These included cross-cutting themes that had been identified during the green jobs project and issues that were specific to the electricity sector.

- *Decentralisation* of processes and workplaces into smaller, dispersed units and microenterprises, possibly with lower OSH awareness and culture, and fewer resources for OSH. There is likely to be difficulty in communicating and enforcing good OSH practice in dispersed workplaces. Renewable energy is a good example of this, with distributed, small-scale installations which, especially when installed by new, unskilled entrants in the sector, are likely to be non-standard installations, hazardous to maintenance workers.
- *New materials* – a wide range of new and modified known materials is becoming available. For many of these the risks are unknown. Examples from the energy sector include: nanomaterials in insulation material; new composites in wind turbine blade manufacture; a range of materials in batteries, for example graphene; toxic chemicals in solar panels. Risks may occur throughout the lifecycle of manufacture, installation, use and decommissioning and recycling. Harmful effects of new substances may not become apparent for years and it will be difficult to link disease to jobs if people have many jobs in a lifetime.
- *Conflict between green and OSH* – where measures taken to protect the environment may adversely affect OSH. For example, time pressures associated with environmental grants and subsidies, such as deadlines for feed-in-tariffs for renewable electricity, can lead to work done in a hurry, with the potential for new entrants to appear, without the necessary skills, and could contribute to OSH being overlooked.
- *Innovation and automation* – rapid progress in innovation could mean that OSH gets left behind, but increasing automation could also mean that workers are removed from dangerous work. Increasing complexity in processes and human machine interfaces, and over-reliance on computers, could introduce new risks.
- *Increasing reliance on electricity* – increasing use of electric or hybrid vehicles could bring new risks to maintenance workers and emergency services from high-voltage systems. Increasing use of electricity to heat buildings and connection to smart grids could bring risks to installers, maintenance workers and emergency services. As vehicle batteries that have reached the end of their life for vehicle service will be increasingly used to store electricity in buildings, as well as the "normal" fire and explosion risks associated with batteries, there may be the added complication of batteries that are degraded, decaying, unlabelled and of unknown provenance and design.

- *Other issues* - skills shortages, polarisation of the workforce – high skilled jobs versus precarious work, an ageing workforce, subcontracting, metal theft ([3]), gender issues, psychosocial issues.

- **Exercise 3 – What are the future OSH challenges and opportunities in each scenario?**

In this exercise, working in their groups, delegates were asked to consider the OSH presentation and to discuss the OSH issues for the electricity sector in 2025 in their scenario. These could be existing OSH risks found in new combinations, involving different possibly unskilled workers' groups, or that could be considerably changed, or be completely new.

They were then asked to select and agree the following:

- The most challenging OSH issue in their scenario;
- The greatest opportunity to reduce OSH risks in their scenario; and
- The most surprising OSH issue (positive or negative) or the issue, in their scenario, of which they have least understanding.

The challenges and opportunities identified in each scenario by the groups are shown in Tables 5-7 below.

Table 5: Challenges and opportunities – Win-Win

Opportunities and challenges – Win-Win 	
Challenge	Ensuring the competence of workers. With technological developments being made so quickly, risks may not be fully understood and OSH research is lagging behind. In addition to the pace of change, skills shortages and loss of skilled staff as an ageing workforce reaches retirement, will contribute to lack of competence. The problems will be worse for decentralised/smaller units. Public opinion and political will are important drivers for improved competence.
Opportunity	Risk awareness should be improved at all levels, from producers through to end users – setting standards, up-skilling workers. This needs investment and a long term view. Business and workers have to be convinced that it's for their benefit. But up-skilling can cause stress, so stress management needs to be taught as well.
Surprising	The pace of change in continuous and unrelenting, which is going to lead to a vast range of applications and a range of health and safety issues. There are European Commission Directives for basic OSH standards and these should be implemented across Member States – a level playing field. Don't wait for accidents to happen.

[3] Metal theft could result in power cuts, leading to risks as industrial processes are interrupted. Theft could also leave live cables exposed, presenting risks to maintenance workers and others.

Table 6: Challenges and opportunities – Bonus World

Opportunities and challenges – Bonus World 	
Challenge	The high rate of innovation and technological rollout may lead to workers not feeling trained enough, which could lead to stress and their inability to cope with the pressure of work. The increasing demands on workers to produce more and to work longer will also lead to more stress and psychosocial risks. There will be limited efforts to detect and trace occupational incidents/injuries because the main focus is on profits. The trend may be for migrant workers to work for a low salary and accept the risk (i.e. the mentality is that 'if I don't do it, the company will find someone else').There may also be a risk of a growing gap between superficial commitments by top management and the reality.
Opportunity	Social media coverage of OSH, coupled with legislation, could create opportunities to strengthen or weaken a company's reputation and market value. This would help to create a business case for OSH from the increased value of the company and reduced cost from staff turnover and absenteeism. It can also generate a more transparent working environment and encourage Corporate Social Responsibility (CSR) reporting by companies.
Surprising	There is likely to be a high risk of crime, which will have impacts on workers and the working environment. Theft of metals and electricity from electricity distribution lines could be a problem. This could occur in remote locations that are difficult to protect. This can cause risks for operations and maintenance staff. Delivery staff could also need additional physical protection.

Table 7: Challenges and opportunities – Deep Green

Opportunities and challenges – Deep Green 	
Challenge	The lack of awareness of risk. Risks are forgotten, are not taken into account during planning and then reappear again and again. We need foresight to include prevention in the planning phase – this was not done in Deep Green. There was an EU Framework Directive back in 1989 but it was not implemented on an equal footing throughout Europe. Why not? There are problems translating knowledge and solutions so that micro-enterprises can understand.
Opportunity	The slow pace of technological change in this scenario should give us more time in which to respond, so technology should not leave OSH behind.

	However, it could also be argued that with a lower level of activity problems take longer to appear. There is time for research to produce results, but the counter to this is the lack of funding. Do we use money to research or to keep things running?
Surprising	The quality of spare parts for old equipment, especially if bought on the Internet or second-hand. This could affect do-it-yourself maintainers of equipment, or maintenance workers who install spare parts whose provenance is not known. This risk is likely to be higher in Deep Green because of the emphasis on maintaining equipment.

- **Exercise 4 – Policy response to risks. How can we shape the future towards better OSH in each scenario?**

In this exercise, again working in their groups, delegates were asked to review the OSH issues they had identified in Exercise 3 and then to develop potential actions or policies to deal with:

- The most challenging OSH issue;
- The greatest opportunity to reduce risks; and
- The most surprising issue (positive or negative) or the issue of which they have least understanding.

The discussion should also consider the health and safety benefits of the actions/policies and how they might be implemented. The actions and policies identified for each scenario are shown in Tables 8-10 below.

Table 8: Policies and actions – Win-Win

Policies and actions – Win-Win 	
OSH Challenge: Competencies of workers for new technologies	**Policy WW1: Voluntary mapping of job profiles/job descriptions** *Expected H&S Benefits:* ▪ Identify skills gaps and point the way to further training where necessary. ▪ Improved competence would result in improved levels of OSH. ▪ Help define standards for safety and competence. ▪ Establish the limitations of competence. *Implementation:* ▪ Bottom-up approach (but with leadership from the top). ▪ Constant reviews of competence levels. ▪ The deciding factor in recruitment is actual competence – the ability to do the job safety – not just a certificate on the wall.

	▪ The ability to do the job safely must be the No.1 consideration when appointing a new staff member. ▪ Employers, unions and social partners together would be the organisations to take this forward.
OSH Opportunity: To raise risk awareness	**Policy WW2: Retraining of staff based on personalised risk assessment** *Expected H&S Benefits:* ▪ Companies would recognise when employees are no longer able to do certain tasks. ▪ Analysing near misses (incidences of accidents narrowly averted) helps further understand risks, and thereby reduce them. ▪ Advice could be offered on how to seek help and where to find it. (e.g. avoid the problem of always being online and thus never shutting off from work). ▪ Improved OSH, especially with regard to stress-related conditions and improved general wellbeing. *Implementation:* ▪ Use an online risk assessment tool (OiRA [4] is currently available, but it's mostly for SMEs). ▪ Email questionnaires to assess stress (this has improved the reporting of stress-related problems). ▪ Combat any culture of silence. ▪ More reporting (e.g. of near misses) essential. ▪ Coaching upwards from shop-level to management. (This is just as important as coaching down for improving H&S.) *Anticipated problems with implementation:* • Problems are more difficult to tackle in smaller companies that don't have the funds to address them – and lack of awareness is more of an issue among them.
OSH Surprising Issue: Pace of change	**Policy WW3: Research to identify new OSH risks** *Expected H&S Benefits:* Better awareness and preparedness for dealing with new risks. *Implementation:* Require that research into new technologies includes research into OSH issues. The risks identified would feed into competency frameworks, especially for multi-skilled workers.

[4] OiRA – Online interactive Risk Assessment – is an EU-OSHA web platform that enables the creation of sectoral risk assessment tools in any language with in an easy and standardised way.

Table 9: Policies and actions – Bonus World

Policies and actions – Bonus World 	
OSH Challenge: High rate of innovation	**Policy BW1: Regulation plus company education/training** Summary: The policy is to regulate to have workers and employers engage in developing an OSH policy; and to make a business case to companies for this approach. *Expected H&S Benefits:* OSH policy promoted with the involvement of workers. The hope is that management commitment combined with worker engagement will result in reducing stress on workers and will increase awareness of OSH issues and reduce absenteeism and staff turnover (which is the main consequence of all the additional pressure on workers). *Background:* In Bonus World, large and powerful companies are key players and people are focussing mostly on maximising profits. There are high rates of innovation and not so much of a shift to a greener world. This leads to more pressure on workers. *Implementation:* ▪ To implement this policy, we need government to push for a regulatory framework as we recognise that companies will not do it by themselves. ▪ As companies are key players, governments need to convince companies that it will be profitable to move in this direction. ▪ We need to support education and training programmes, with the commitment of the workers. ▪ We need workers to be involved to implement the policy.
OSH Opportunity: Use of social media	**Policy BW2: Support the use of both social media and litigation to highlight health and safety issues** The policy boils down to better awareness of health and safety issues through the use of social media, backed up by legislation. *Expected H&S Benefits:* This will contribute to: ▪ improving working conditions. ▪ creating a more transparent working environment; ▪ pressure on companies to voluntarily commit to a certain safety culture.

	▪ More transparent Corporate Social Responsibility (CSR) reporting by companies. ▪ A more preventive approach to health and safety (i.e. not waiting for problems to develop). *Implementation:* Create a legislative framework for individuals/trade unions to take legal action where harm is done in the workplace. ▪ This could then improve worker conditions and encourage a preventive approach. ▪ The legislation has to be in the right format. With a legislative framework on litigation in place, workers and trade unions and civil society can use social media to point to health and safety issues. ▪ Social media can create pressure to discuss health and safety problems that workers have. ▪ Social media could be used by companies to report good practice and report good things. ▪ Employers could use social media to promote their brand (their health and safety policies) to the workforce. Employers with good standards in place might want to join a coalition to ensure that the policies they have in place are adopted by others so that there is a level playing field in terms of health and safety policies.
OSH Surprising Issue: High risk of crime	**Policy BW3: Legislation to protect the infrastructure and workers in the electricity sector.** *Expected H&S Benefits:* Workers would feel more secure and face less danger from damaged equipment or physical attacks. *Implementation:* Strengthening the law to punish crimes in this area is unlikely to be effective on its own. The legislation would need to be supported by investment in technology to protect the infrastructure and detect criminal activity. There would also need to be greater collaboration between companies and law enforcement agencies. There would need to be specific measures to protect against cyber-crime.

Table 10: Policies and actions – Deep Green

Policies and actions – Deep Green 	
OSH Challenge: Lack of awareness of risk	**Policy DG1: Develop tools for better training alongside a system to capture new risks** *Expected H&S Benefits:* Fewer accidents and reduced exposures to harmful conditions. *Implementation:* To be implemented within a framework agreed between managers, social partners and employees. ▪ Generate action plans to implement a training policy at the state level. ▪ Define a framework at a group level. ▪ Work between all levels – European, national, local but also management and employees in order to define action plans. ▪ Identify tools that need to be developed at the local level in the correct context. ▪ Observe the work (at the local level) and define best practice. ▪ Ensure operators to have a better understanding of the risk they face at various points. ▪ Training is not only in the classroom, but also on the job.
OSH Opportunity: Take advantage of the slow pace of change	**Policy DG2: Develop a system to capture emerging risks and a platform to share learning** *Expected H&S Benefits:* • Sharing of rare occurrences, which are going to be first • Encountered at the grassroots level. • Risks are recognised and acted upon. *Implementation:* ▪ Needs to be implemented using people with hands-on experience. ▪ We should experiment with learning by doing and doing by learning. ▪ Implementation plans should involve all groups (big companies and contractors). ▪ Requires a multi-level platform to be implemented at both European and national level (including both employers and workers in both cases). ▪ States would prefer industry to create the platform.

OSH Surprising Issue: Quality of spare parts	**Policy DG3: Devise a system to ensure spares are genuine** *Expected H&S Benefits:* ▪ Spare parts will be of required quality. ▪ Fewer accidents resulting from equipment failure. *Implementation:* Options such as a smart system which would allow equipment to recognise parts, or one in which manufacturers are required to produce spares for a minimum period, as in the car industry, were considered. However, in further discussion the group agreed this issue was not likely to be a problem in reality.

Wind Tunnelling - Testing the ideas/actions/policies from Exercise 3 across the scenarios

Testing policies against a range of the scenarios is important, as the future is likely to contain elements of each scenario in a combination that cannot be anticipated. Such testing can help to identify which policies are robust enough to work in a range of different futures as opposed to those that will work in only one. In this way policies can be future-proofed. This process is often called 'wind – tunnelling'.

This exercise was carried out in plenary session, but it can also be conducted through group exercises or a separate review by a policy team. Whatever the approach, care is needed to safeguard against preconceived views on both policies and the future. An open-minded approach will allow decision makers to consider the widest range of possibilities.

Each group was asked to report on two of the actions or policies considered for their scenario. Each group reviewed the policies generated in the other two scenarios, considering the following for their scenario:

- **Relevance** - is the policy addressing an issue that will be significant in their scenario?
- **Benefits** - is the policy effective given the conditions in their scenario? and
- **Implementation** - if a policy is potentially successful in their scenarios, would it be implemented in the same way?

On the basis of these criteria, the two policies from each scenario were tested across the three scenarios and scored between +5 and -5. Due to time constraints it was not possible to discuss a second policy from the Deep Green scenario.

The results of this exercise are as shown in Table 11:

Table 11: Wind-tunnelling of policies and actions

Policy (in order of presentation)	***Score in Win-Win***	***Score in Bonus World***	***Score in Deep Green***
1. Policy BW1 (***Regulation plus company education/training***) (proposed by the Bonus World group).	+1	+5	+3

2. Policy WW1 (***Voluntary mapping of job profiles/descriptions***) (proposed by the Win-Win group).	+5	+2	+4
3. Policy DG1 (**Tools for better training**) (proposed by the Deep Green group).	+1	-1	+5
4. Policy BW2 (**use social media to point out H&S risks**) (proposed by the Bonus World group).	+5	+5	0
5. Policy WW2 (**Retraining of staff based on personalised risk assessment**) (proposed by the Win-Win group).	+5	+1	+3

It is important that decisions taken are not simply based on a scoring of policies against the scenarios. A low score does not necessarily mean that a policy should be discarded. A policy that initially appears to be scenario dependent might be valid in other scenarios if implemented in a different manner, or modified in some way. The process is used to facilitate cross scenario consideration of policies and if stakeholders are engaged in the process it can provide a good framework for facilitating a strategic discussion. During the plenary discussion the following conclusions were drawn on the six policies that were tested:

Policy 1. Regulation plus company education/training (proposed by the Bonus World group).

This policy found some favour in the Deep Green scenario, but in Deep Green there would be more emphasis on acquiring agreements between workers and employers. It was less suited to Win-Win, because regulation in Win-Win is not seen as the best strategy to solving the issues.

This is an example of how a policy that works well in one scenario would need very different implementation to succeed in another.

Policy 2. Voluntary mapping of job profiles/descriptions (proposed by the Win-Win group).

This policy was assessed as not being viable in Bonus World, where companies are already focused on addressing the skills shortage. The Deep Green scenario was much more supportive of this policy, but to succeed in Deep Green the policy framework for introducing such profiling would need to be defined at company level.

This is an example of how a policy that works well in one scenario might not be viable in another

Policy 3. Tools for better training (proposed by the Deep Green group).

This policy would be ineffective in Bonus World as it is unlikely the framework required to implement it could be agreed between managers, social partners and employees.

The policy is also questionable in Win-Win, and may be unfeasible if the policy is imposed. Regulation can't keep up with the rapidly changing world of Win-Win, where more flexibility is required with more emphasis on partnership.

This is an example of how a policy that is a priority in one scenario can have a negative impact in another.

Policy 4. Use social media to point out H&S risks (proposed by the Bonus World group).

In Win-Win, this policy would be a good response to fast-developing technologies, and social media could also be used to raise awareness of existing legislation; but in Deep Green companies would already know what they should be doing and it shouldn't require external pressure from social media.

This is an example of a policy that would work well in some scenarios, but may not even be needed in another.

Policy 5. Retraining of staff based on personalised risk assessment (proposed by the Win-Win group).

Bonus World also has problems relating to job stress, but it is questionable whether this policy can be implemented in Bonus World. The policy is more favoured in Deep Green, but the use of e-learning and the formalisation of systems could be problematic.

By contrast to policy 4, this is a policy that addresses areas of need in each scenario, but the details of the implementation are highly scenario dependent.

2.1.5 Session 4 – Social Dialogue

Tim Van Rie briefly introduced the session and then the social partners gave a description of the activities of the SSDC Electricity. Workers are represented by industriAll, a union covering a wide range of industries, including the generation and distribution of electric power, and the European Federation of Public Service Unions (EPSU), which represents over 265 unions. The industry is represented by the Union of the Electricity Industry (EURELECTRIC). The session was moderated by Christian Nikel, Chair of the SSDC Electricity. Corinna Zierold represented industriAll and Adelaïde Boodts EURELECTRIC.

One of the current focus areas of the SSDC Electricity is the social dimension of the transition to a low-carbon economy, e.g. the strong impact on the sector and on employment shifts between sectors.

In 2011 the SSDC Electricity published a study of the move to a low carbon economy. The change is not having much impact on the total number of jobs, but demographic change is leading to a lot of investment in skills and reskilling.

Social dialogue at national, sectoral and company level is necessary to ensure a 'Just Transition' to low carbon.

This workshop is a sidestep from the normal activities of the SSDC Electricity. OSH issues concern both employers and employees and the event has helped highlight some national examples of areas of concern.

The aim is to report back to the next meeting of the SSDC Electricity, which will reflect on the points raised and further thoughts and take these up in subsequent meetings with the representatives of the European Parliament and the social partners.

Thanks are due to EU-OSHA for organising this event and to the consultants who facilitated the proceeding.

2.1.6 Conclusions

The scenarios from the Green Jobs project were used by the SSDC Electricity to identify potential future OSH issues and formulate policies and actions to deal with them. Some of these policies were tested across the scenarios ('wind tunnelling') to demonstrate how they perform in different potential futures. The workshop demonstrated the scenario process but did not allow sufficient time to undertake a thorough policy identification process. Much more time would be needed to investigate the issues in more detail.

Scenarios are a potentially powerful tool, which can be used to assist in the development and testing of policies, and while they do not remove the uncertainty of the future, they should lead to the consideration of a broader range of policies and a better understanding of the respective risks.

The workshop helped to demonstrate some of the uncertainties on the future of OSH in the electricity sector. The scenarios are not predictions of the future, as the actual future is likely to contain elements of each of the scenarios in a combination that cannot be forecast. They are tool to support strategic discussion about the future and the potential opportunities and challenges.

The Green Jobs project demonstrated the value of scenarios in facilitating a constructive discussion between social partners. The greatest value from the workshop is likely to have come from the strategic discussions held in each of the groups and the insights gained on an area of shared concern. The participants looked forward to continuing these discussions in the SSDC Electricity.

Annex 1 - Programme

GREEN JOBS, NEW RISKS?

Workshop on new and emerging occupational health and safety risks in the electricity sector

Hotel Thon Brussels – Rue de la Loi 75 – B-1040 Brussels

Programme 20 March 2014

09:00-09:10	**Welcome and introduction** Tim Van Rie (European Commission) and Xabier Irastorza (EU-OSHA)
09:10-10:45	**A sector in flux** Economic growth, green values, decentralisation *Presentations by John Reynolds (SAMI Consulting)* *Group exercise: scenario building (i) – the future of the electricity sector*
10:45-11:05	Coffee break
11:05-12:30	**Technological change** Energy generation, storage and distribution *Presentation by Peter Ellwood (Health and Safety Laboratory, HSL)* *Group exercise: scenario building (ii) – the future of energy technologies*
12:30-13:30	Lunch
13:30-14:50	**Health and safety** New and emerging risks, physical, chemical, biological and psycho-social *Presentation by Peter Ellwood (HSL)* *Group discussion, based on scenarios*
14:50-15:10	Coffee break
15:10-16:50	**Policy response** Exploring prevention, risk assessment, education and training options *Group discussion followed by plenary debate*
16:50-17:20	**Social dialogue** The role of social partners in managing risks, prospects for joint actions *Panel debate by social partners*
17:20-17:30	**Concluding remarks**

Annex 2: Workshop attendees

Name	Organisation	Country
Bill Bates	Health and Safety Executive	United Kingdom
Adélaïde BOODTS	EURELECTRIC	Belgium
Sam BRADBROOK	Health and Safety Laboratory	United Kingdom (Contractor)
Martin DUCKWORTH	Sami Consulting Ltd	United Kingdom (Contractor)
Peter ELLWOOD	Health and Safety Laboratory	United Kingdom (Contractor)
Xabier IRASTORZA	European Agency for Safety and Health at Work	EU-OSHA
Egle KAMINSKAITE	UAB "Vilniaus energija"	Lithuania
Ina KLEVA	Latvenergo AS	Latvia
Antonio Francisco LEÓN GARRIDO	FITAG-UGT	Spain
Stuart McGHIE	Unite the Union	United Kingdom
Jean-Pierre MONDUCCI	FEDERATION OF MINES ENERGIE CGT	France
Christian NIKEL	EDF / EURELECTRIC Chair of SSDC Electricity	France
Palle ØRBÆK	Danish Working Environment Authority	Denmark
Emanuela PREITI	ENEL	Italy
John REYNOLDS	Sami Consulting Ltd	United Kingdom (Contractor)
Katalin SAS	European Agency for Safety and Health at Work	EU-OSHA
Norbert SCHÖBEL	European Commission EMPL.B1	Belgium (European Commission)
Jérôme SCIARD	EDF	France
Peter VANAUTRIJVE	ABVV-ACOD-Gazelco	Belgium
Tim VAN RIE	European Commission EMPL.B1	Belgium (European Commission)
Corinna ZIEROLD	industriAll European Trade Union	Germany

Annex 3 Scenario Summaries

Scenario summary – win-win

High economic growth

Looking back from 2025, after a slow start in 2012, growth across the EU and OECD returned to the levels prior to the economic crash of 2008. Developing countries also experienced high growth similar to the first decade of the century.

High green values

Advances in climate science started to show how vulnerable we are becoming to climate change. Growing public concerns encouraged governments to introduce green policies, including ones leading to deep and progressive cuts in carbon emissions.

There was strong approval for green behaviour by corporations and individuals. This was reinforced by concerns over resource shortages (food, commodities, minerals, water and energy).

High innovation in green technologies

Green growth has increasingly been seen as vital for a sustainable future. Corporate profits and access to finance have supported high levels of investment in new business opportunities and infrastructure. The rate of technological developments has accelerated with high levels of innovation. A high proportion of the innovation has been aimed at achieving a green outcome and generating future profits.

Society and work

Most people in the EU now feel prosperous and place a higher value on the preservation of the environment, human life and well-being. The strong economy allows governments to address the increasing demands for welfare and to invest in education.

There is high employment and many new jobs and new products are now being created over ever-shorter timescales, which can lead to new hazards and risks if not designed taking OSH into consideration.

Scenario summary – bonus world

High economic growth

Looking back from 2025, after a slow start in 2012, growth across the EU and OECD returned to the levels prior to the economic crash of 2008. Developing countries also experienced high growth similar to that of the first decade of the century. High growth has led to high prices for natural resources, including energy.

Weak green values

After 2012, economic growth was the priority and some environmental degradation was considered to be an unavoidable consequence of strengthening EU economies. When faced with the costs, people have not valued greenness sufficiently for governments or business to have an incentive to deliver it. Government support for green practices is limited to charging for the visible externalities of production (such as noise, pollution, landfill and traffic congestion).

Medium innovation in green technologies (directed towards profits)

Most consumers and businesses choose green products and services only if they are better or cheaper than the alternatives. Innovations in green technologies are limited to those areas that show a positive financial return.

High total innovation

There are continuing advances in technology that get adopted into new products and processes. High levels of capital investment mean that capital-intensive technologies can be rolled out quickly. Corporate profitability and access to finance have supported high investment in infrastructure. The environmental consequences of increased use of resources are seen as acceptable and necessary.

Energy sciences continue to deliver improvements in efficiency and low-carbon energy, but it is now clear that serious and unacceptable compromises would be needed to achieve a zero-carbon future.

Scenario summary – deep green

Low economic growth

Since 2012, there has been little economic growth within the EU and some countries are still facing sovereign debt problems. The BRIC countries have not returned to the former high-growth rates and are currently growing at about 5 % per annum (2) . Other developing counties are growing at a rate broadly in line with their population growths.

Strongly green values

Green values have strengthened over the last decade and there is widespread and strong approval for green behaviour by corporations and individuals. This has given governments a mandate to legislate for deep and progressive cuts in carbon emissions. Reduced growth is seen as a price worth paying for a green future.

Advances in climate science have shown just how vulnerable the human race will be to climate change. There are growing public concerns about the loss of ecosystems and resource shortages.

Medium innovation in green technologies (directed toward greenness)

The concerns about a green future have driven progress on improvements in efficiency and the target of a zero-carbon future. There are continuing advances in technology, but restricted levels of capital investment mean that capital intensive technologies have been slow to be rolled out. Commercial success depends on having appropriate green products and services.

There have been significant local small-scale innovations to address green issues, many directed toward self-reliance.

Energy sciences continue to deliver improvements in efficiency and low-carbon energy but it is clear that serious compromises will need to be made to achieve a zero-carbon future.

Medium total innovation

The priority has been to direct innovation towards achieving a green future.

Society and work

Over the last decade, the key priority has been to move towards a green future, at the expense of growth and other social objectives. As a result, there is now higher unemployment and lower corporate profits. The reduced tax base has restricted the ability of EU governments to pay for increasing welfare demands.

The greening of the economy and society has introduced many new processes and enterprises, creating new green jobs. Businesses are focused on survival and reducing costs, and workers are concerned about joining the significant number of unemployed.

Innovation continues to deliver improvements in efficiency and reduced carbon outputs, but it is clear that serious compromises need to be made to achieve a zero-carbon future. Despite the difficulties, a green future is generally seen as worth the sacrifices.

Annex 4: Scenario Technology Summaries

Scenario technology summary – win-win

Wind energy

The target of 230 gigawatts (GW) of installed capacity in 2020 (EWEA, 2012) was met. Now in 2025, good progress is being made towards the target for 2030 of 400 GW of installed capacity.

Improved manufacturing techniques and new monitoring and control processes have helped to contribute to safer operations.

There are now large turbines of up to 20 megawatts (MW). Large turbines have been designed specifically for the marine environment, including for installation in deeper offshore locations.

The foundations in shallower water have improved and the innovations in deeper water have included floating installations. Accommodation platforms have also started to appear in wind farms further offshore.

Bioenergy

Legislation has been passed to support the objective of a zero waste economy.

Biogas production has developed over the last decade and 20 % of the gas in the mains is now biogas.

Most agricultural waste is biodigested anaerobically to produce methane. Waste water is used for its nutrient content to fertilise biogas production.

Bioenergy is produced in large facilities (of 400 MW) and small combined heat and power (CHP) plants in towns.

In most cases, biomass is heat treated to dry it and increase its energy density before transport. The energy embedded in municipal waste and manufacturing processes is now recovered.

Second-generation biofuels, produced with GM bacteria, are now common in transport. And third-generation fuels have been developed.

Domestic and small-scale renewable energy

Companies and individuals have invested heavily in alternative energy technologies in response to high energy prices. Government incentives have also encouraged these investments.

Smart meters are now installed in all homes and small business premises. They are used to monitor and manage smart appliances and electricity demand in response to the requirements of the grid and the price of electricity.

Companies with roof space for PV and yard space for turbines generate energy as a secondary business. Farms and companies working with organic materials (such as leather and foodstuffs) generate wind, solar, biogas and biodiesel.

Domestic buildings and offices have solar panels and highly efficient fuel-cell combined heat and power systems. Many also have small ground-sourced and air-sourced heat pumps. New buildings are being built with a high thermal mass to store heat to give, typically, five days of hot water.

Batteries and energy storage

The increase in renewable energy generation has led to the need for high-capacity energy storage. For transmission networks, several bulk energy-storage solutions have proved practical, and are being progressively implemented, such as large-scale molten salt storage systems (sodium sulphur batteries, 50 MW). Other battery technologies for energy storage include fluorine and vanadium flow batteries. Experiments are continuing with deep-sea energy storage.

Connections across Europe and upgrades to capacity mean that European hydroelectric systems are able to supply all of the European electricity demand for several days at a time.

On the smaller distribution network scale, micro-compressed air energy storage, battery storage, compact thermochemical storage and flywheels are used.

Domestic-scale battery energy storage is also now common as 'retired' electric vehicle batteries are used as static energy stores.

Energy transmission and distribution

Following all the changes to energy generation and managing demand at transmission and distribution levels, energy supply is now highly complex. There are two-way grid architectures with flexible tariffs, incentives to use storage, and smart meters to control it all.

A SuperSmart Grid (SSG) using high-voltage direct current (HVDC) technology is now transmitting renewably generated electricity over vast distances between points in North Africa, the Mediterranean and northern Europe.

Scenario technology summary - bonus world

Wind energy

High economic growth and resource scarcity have pushed up energy prices to the point that in favourable locations wind energy can generate electricity at a cost that is comparable with other sources of supply.

Most new wind farms are onshore and many are located nearer to the areas of highest demand. Planning rules and environmental impact assessments have been relaxed permitting more wind farm locations in built-up areas.

There are no subsidies or green tariffs to support the development of more expensive wind farms. When this support was withdrawn, there was a rush to develop wind farms before the deadline. Old wind farms are decommissioned, as repowering would not be economically viable.

Turbine design has focused on cost-efficiency, including low-cost maintenance. The very largest turbines envisaged in 2012 were never built, and the industry is now mainly installing turbines of between 5 MW and 7 MW. Standard designs based on common design platforms (like some models of car) and innovative maintenance regimes have helped to reduce costs.

Bioenergy

There is plenty of waste to harvest for its energy content, and it is incinerated where it is profitable.

Biomass sources (forest and agriculture, and agricultural waste) get used by means of the most cost-efficient route. Coal, natural gas and oil power stations persist, supplemented by lots of small-scale localised biofuel and biomass CHP generating plants.

Second-generation biofuels (liquid fuels and chemical feed stocks from lignin and cellulose) became common, aided by rapid innovations in genetic modification and synthetic biology.

High energy prices encourage third-generation biofuels, including technology transferred from medical biotechnology.

Methane digesters and pyrolysis are used to generate biogas.

Domestic and small-scale renewable energy

After 2012, there was increasing public opposition to the costs of renewable energy. Feed-in tariffs were cut back, so there has been limited investment in domestic and small-scale energy over the last decade. 'Horror stories' of poor people being forced to upgrade their domestic wiring after the electricity meter has been taken out, also led to strong reactions against smart meters. With increasing energy costs, insulation has become increasingly important.

Network operators encourage some distributed generation, but only in particular areas as a means of saving on the costs of upgrading the network.

Batteries and energy storage

The grid has maintained its substantially one-way architecture, with most electricity still provided by large generators. Due to the limited level of intermittent and distributed generation, there has been limited investment in bulk energy storage on the transmission networks. The exception has been pumped hydro facilities for load balancing, to avoid the cost of upgrading the networks.

Storage applications on the distribution networks are specialised and limited. Some energy storage (such as flywheels, ultra capacitors, batteries, compressed air and hydro) is used in the network for load balancing and to avoid the cost of upgrading the network. There are also flywheels and supercapacitors for specialised public transport applications.

Power cuts are a greater risk due to limited investments in smart grids and storage facilities. Small capacity storage, such as banks of former EV batteries, are therefore of increasing interest. Domestic PV systems are also designed to provide some electricity if there is a power cut.

Vehicle development has favoured hybrids, so their energy storage requirements are limited.

Energy transmission and distribution

There continues to be significant growth in the demand for energy. There has been under-investment in the transmission and distribution networks and a smart grid infrastructure. The need for investment is now a major issue.

There have been investments in interconnectors where there is a strong business case.

Since 2012, copper prices have doubled and the use of aluminium cables has increased. Metal theft has become an important concern in the energy sector, and more broadly.

Scenario technology summary – deep green

Wind energy

Despite the strong green values and political support, the lack of capital has constrained the development of wind energy. The total installed base in the EU has recently passed 100 GW. Few of the deeper offshore sites that were envisaged in 2012 have been built.

Over the last decade, projects have tended to be smaller, with infill developments. Most turbines are relatively small: between 3MW and 5MW. The latest designs have converged on direct-drive generators and transformers in the nacelle.

The priority of the remaining big wind energy players is to drive down costs and minimise the investment needed to deliver wind energy. 'Make-do-and-mend' attitudes have encouraged owners to refurbish older wind farms rather than rebuild them. Also, as technology has improved, 1 MW turbines have been replaced by 3 MW installations on the same towers.

Bioenergy

There have been big changes in the ways of sourcing energy and managing waste. The energy content is recovered from all local waste that is not recycled.

Local procurement is important with local biogas from landfill. There is increased use of local community biofuels and biodiesel. Animal fats and food waste are used as heavy fuel oils.

Biomass production and its associated land use have increased over the last decade. There has been little spillover from high-value biotechnology but green biotech has cut costs and increased the energy intensity of crops. Some former coal power stations have been converted to burn biomass.

Domestic and small-scale renewable energy

Over the last decade there has been a significant increase in local small-scale energy generation. These have been made cost competitive by increased taxes on large nuclear and fossil fuel generators.

There is significant use of biogenerated energy resources. There is also a wide mix of technologies: biogas digesters; local hydro-electricity; waste incineration; and domestic combined heat and power.

There has been a trend for both businesses and local communities to generate energy, often using non-standard 'do-it-yourself' systems, built with parts from various sources.

Batteries and energy storage

The surge in biogas and biomass energy production has led to high levels of storage of harvested biomass as an energy reserve.

Battery developments have been constrained by concerns about the use of toxic materials and the need for them to be recycled. The growth of electric vehicles has also been slower than anticipated in 2012. Vehicle batteries are used for static storage after their peak performance has degraded.

In times of energy surplus, electricity is used to generate gas (methane and hydrogen) as a store of energy and as a medium to transport energy through the existing gas network.

There is 'virtual storage' through measures being taken to match energy supply and demands.

However, this has been made difficult by the diverse, localised energy providers and the relatively slow roll-out of smart meters.

Energy transmission and distribution

There has been a lack of funds for investment in the electricity transmission network, which has become less reliable.

There has been greater emphasis on distribution systems. The complex network of localised energy production has led to increased bidirectional flows. The diverse range of energy suppliers at multiple levels has made control of the network increasingly difficult.

As a result of restricted levels of investment and increasing levels of localised energy product, the reliability of the electricity supply has been reduced.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