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Siemens: **Energy Farm**

Teachers' notes

The aim of these materials is to provide an overview of the purpose, structure and deployment of the Siemens Farm interactive resource to enable a teacher to make essential planning decisions quickly and efficiently.

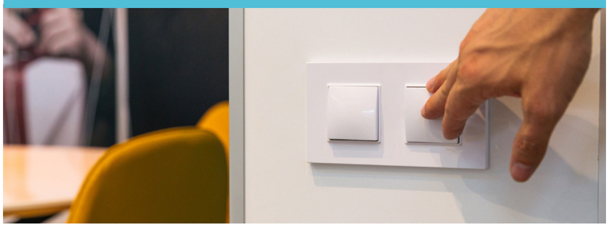
Purpose of the resources

Aiding understanding, energy supply and demand and the challenges and opportunities of effectively managing a small-scale power system.

The energy distribution system in the UK (and many other countries) is changing. Until recently, large utility companies would produce electricity using a generating plant that was large, expensive and economical through scale. The generators might be powered by fossil fuels, nuclear power or off-shore wind farms, for example; these companies would feed the electricity into a national distribution system and consumers would purchase it.

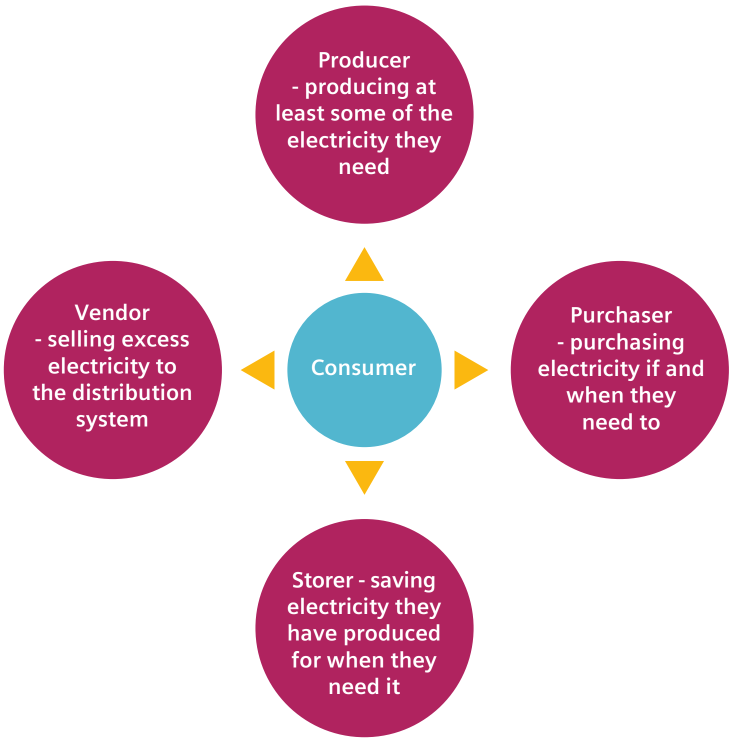
Producer, using large generators and distribution network

Consumer, purchasing electricity from network



Although this model still holds in some cases, it is changing for a variety of reasons. It is now easier for consumers to produce at least some of the electricity they need - solar cells are probably the most obvious example of this but in rural areas especially, there are other technologies that can be used as well. In this case, the consumer can also be a producer, although this doesn't necessarily mean that they produce all of the electricity they need. If they are making extensive use of solar and wind power, there may be times of the day when they are producing more electricity than they need but at other times their requirements/demands may outstrip their capacity/supply.

This model still presumes the existence of large utility companies so the consumer can purchase electricity. However, this demand may be less than in the past and, furthermore, electricity may be generated by the customer and sold back to the utility company.



Objectives of the resource

The overall purpose is to put the user in the role of the consumer and introduce them to the challenges and opportunities of effectively managing a small-scale power system. More specifically the objectives are to get students to understand how:

- Different technologies can be used to provide energy for people and their work
- These different technologies have different pros and cons
- To set up a system to supply enough energy to meet demand whilst keeping costs down and minimising negative impact on the environment

Meeting a variety of curriculum requirements, including:

A renewable energy resource is one that is being (or can be) replenished as it is used. The uses of energy resources include transport, electricity generation and heating. Students should be able to describe the main energy sources available, distinguish between energy resources that are renewable and energy resources that are non-renewable, compare ways that different energy resources are used, the uses to include transport, electricity generation and heating, understand why some energy resources are more reliable than others, describe the environmental impact arising from the use of different energy resources and explain patterns and trends in the use of energy resources.

Students should be able to consider the environmental issues that may arise from the use of different energy resources and show that science has the ability to identify environmental issues arising from the use of energy resources but not always the power to deal with the issues because of political, social, ethical or economic considerations.

AQA GCSE Combined Science specification.

In addition to specific concepts, it can also be used for a number of aspects of Working Scientifically, including:

1.3 Appreciate the power and limitations of science and consider any ethical issues which may arise.

1.4 Explain every-day and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments.

3.5 Interpreting observations and other data (presented in verbal, diagrammatic, graphical, symbolic or numerical form), including identifying patterns and trends, making inferences and drawing conclusions.

GCSE criteria for Working Scientifically

The scenario and success criteria

The context is one of a farm. This has been selected as it is realistic for a farm to be able to use a number of technologies to produce electricity and its demand is such that potential savings are significant. However, there will be some technologies that would be too large, complex and expensive to set up on a farm.

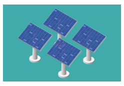
There are three distinct success criteria that students' efforts will be judged against:

- Running a system which supplies the farm with a continuous supply of electricity. This is to support the needs of residents and also to run operational aspects of the farm, such as the milking parlour and lighting for farm buildings.
- Keeping the system financially effective. Costs need to be kept down for the farm to be viable.
- Reducing negative impact on the environment. By using some technologies rather than others a much greater contribution can be made to conserving the natural environment.

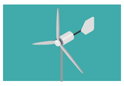
The scenario and success criteria (cont’d/...)

The first stage of using the resource is to **design the system**. The user has 20 tokens and can spend these in various ways. They fall into three groups:

1. Onsite generation
There are several ways in which energy can be produced for use on the farm:



Solar cells. Once installed they are free to operate but are obviously dependent upon the sun shining. They still work on a hazy day, but not as well.



Wind power. Again, these are free once installed but depend upon the wind blowing.

Biogas generator. Farms have plenty of material that can power such equipment – and it’s free. However, the gas produced can only be used for certain applications, such as heating.

Petrol generator. Unlike the other three this isn’t renewable and it’s not free; the petrol has to be purchased. It’s also polluting. Its advantage is that it’s available as a fallback if other sources fail.

2. Grid purchase
The farm can also be powered from the National Grid. A link to the National Grid can be purchased; once in place electricity can be purchased from the network. It’s charged for although is cheaper than the petrol generator. It is more polluting than the renewable sources but less so than the petrol generator.

3. Stored capacity
The farm can also store electricity; storage batteries can be purchased. They automatically store any electricity produced that is in excess of the immediate needs and save it for when demand is in excess of supply. The batteries only have a certain capacity; once full any excess electricity is automatically sold back to the National Grid and the value subtracted from the mains electricity bill.

Most facilities can be repeat purchased; the exceptions are the National Grid link and the petrol generator.

Testing the system design:

Once the system has been set up, it can then be tested over a seven day period. This runs automatically and produces a graphical display of the performance of the system.

Conditions vary day by day as the weather changes; this affects both the demand of the farm and the output of the solar and wind installations.

Notice that the system is controlled automatically; there is no need for the user to select which generator is being used. If there are solar, wind or biogas facilities these are used first. If they are sufficient to meet the requirements of the farm and if battery storage has been selected then excess electricity is stored. If the battery (or batteries) are full then excess is sold back to the National Grid.

However, if the renewables are incapable of meeting the energy demands of the farm (and if any battery storage has been drained) then electricity is purchased from the National Grid (assuming the link has been purchased). If there is no link to the National Grid then the petrol generator is fired up (assuming one has been purchased). Failing that, the lights go out.

Note that a key feature of the system is the way that the consumer is also a producer. The more (renewable) generating capacity that is purchased and deployed, not only are the requirements of the farm going to be met but also additional revenue can be gained from selling excess electricity to the National Grid.

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Feedback:

For each of the seven days there is a display showing supply and demand, the selling back of electricity to the National Grid and the weather. This is explained on the student briefing presentation by means of these two slides:

Daily performance

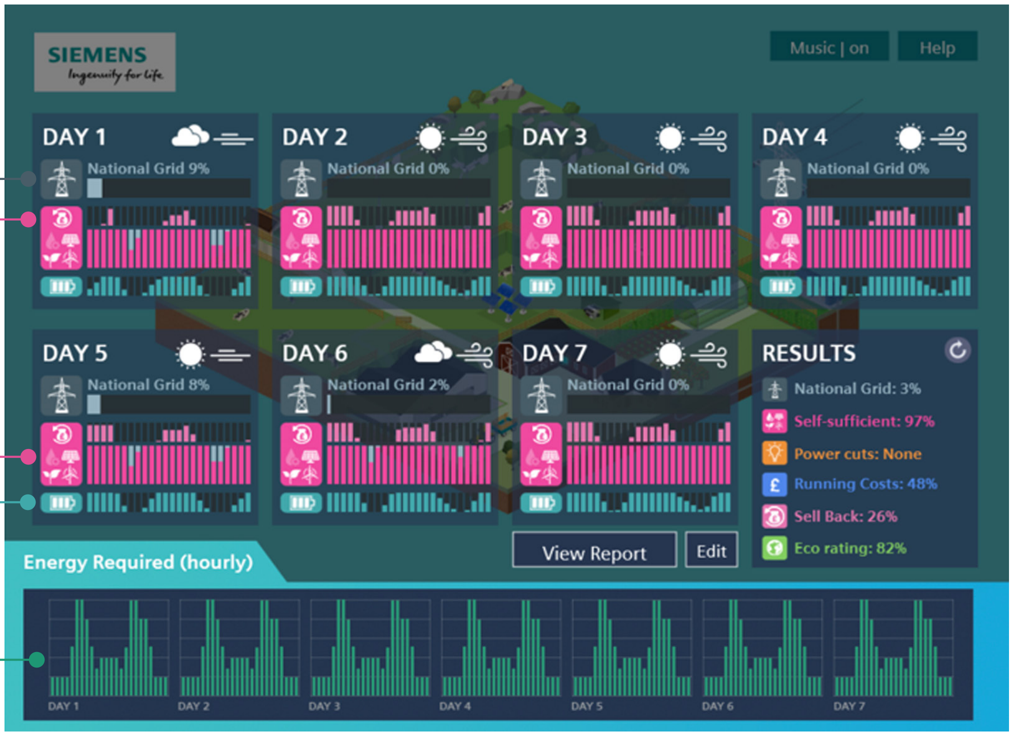
This shows the percentage of the farm's energy that came from the National Grid

This shows how much electricity was sold back to the National Grid.

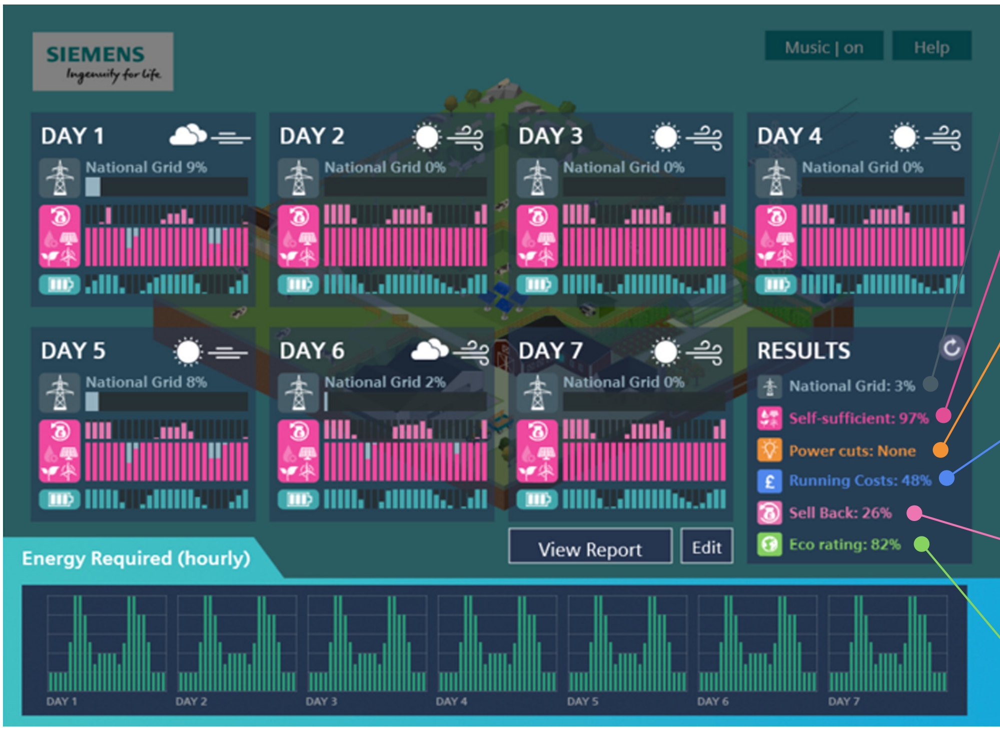
This shows the percentage of the farm's energy was generated on site. You can see where it had to be topped up from the National Grid.

This shows how much charge was in the batteries. When they are full, extra electricity is sold back to the National Grid.

This shows how much energy the farm needed each hour of each day.



Weekly performance



This shows the percentage of the farm's energy that week that came from the National Grid

This shows the percentage of the farm's energy that week that was generated on site.

This shows how many times that week the farm ran out of energy.

This shows the cost of supplying energy for the week.

This shows how much electricity was sold back to the National Grid.

This shows the eco-rating. The higher this is, the lower the negative impact on the environment.

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Refining the system:

The intention is that users refine the system in an attempt to improve its performance. Facilities can be sold back and others purchased. The revised system can then be tested to see if the indicators show better scores. There is no limit as to how many times the system can be changed and retested.

Ideas for using the resources:

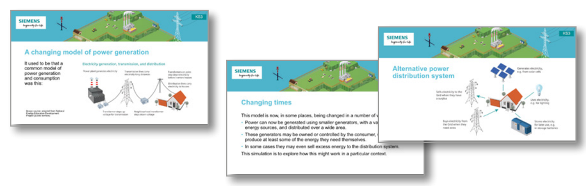
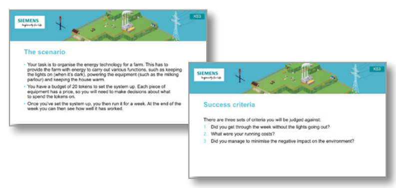
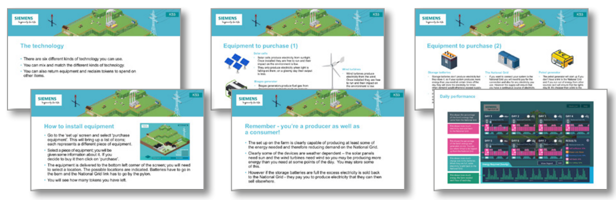
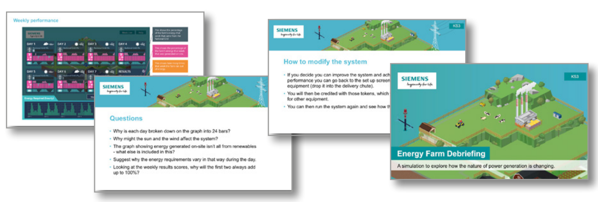
Whilst the resource can be used in a variety of ways, a recommended route is identified below:

1. Introduce the objectives, the nature of the challenge and the working of the resource.
2. Use the resource. The idea is that users will set up a system, test it, see how well it performs and then modify it. They can do this several times to see if they can get a good performance on all three indicators.
3. Draw out key learning points. It is important for students to not only get a good score but also for them to explain how that has been done. Furthermore, there is value in looking at some of the constituent skills such as interpreting graphs.

This resource can be used in a variety of places in a sequence of lessons. It could be used at the start to introduce the concept of energy being provided in various different ways, part way through to draw together key points that have been made or at the end to draw together a number of ideas. It could also be used as a revision lesson so that students revisit ideas in a different context.

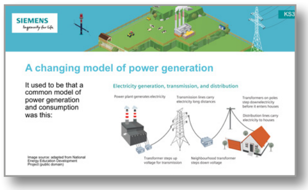
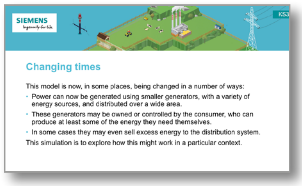
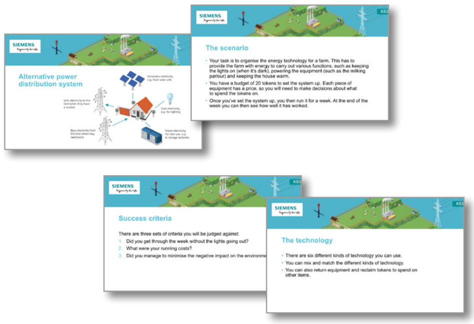
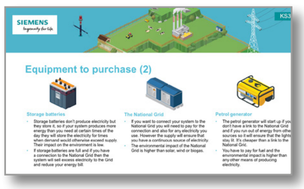
Supporting resources PPT support deck:

Part 1 - Briefing slides:

Slides 3-5 summarise the background to changing energy supply systems.	
Slides 6-7 introduce the resource in broad terms.	
Slides 8-13 then go through how to run the system	
Slides 14-17 explain how to interpret the feedback screen to improve the system; this includes some questions to test understanding of this.	

Although some briefing is important to avoid students not understanding what they are doing, it is also important to avoid 'over briefing'. Knowing how to set up a system can be usefully covered but students should be allowed to discover the more effective combinations of equipment. The learning will be less effective if students simply replicate on screen what they've been told will work well.

Part 2 - De-briefing slides:

Slide 3 is an invitation for students to consider how well they did with reference to the key performance indicators. This could be displayed towards the end of the students setting up and trying systems; the important this is that they have a record of their best performance that they can then use as a comparison. It might be better to avoid too great an emphasis upon who got the best score as this depends upon factors such as the weather as well as upon system design. Nevertheless, it is possible to devise a system that performs well on all three fronts.	
Slide 4 then asks students to consider how they achieved this; it uses the context of giving advice to another user. Encourage them to be analytical and gather key points made.	
Slides 5-8 then shows students the graphs from three other users and asks them to comment on what each shows, whether that system is working well and how it could be improved. This is partly to underline the importance of being able to interpret such evidence but also reinforces analytical skills. Some students may have happened upon a successful combination without knowing why it is effective. (System 1 shows a system that consists entirely of solar and wind power technology, System 2 has a few wind turbines with a petrol generator as back up and System 3 has a large wind farm and a National Grid connection).	
Slide 9 draws out some more general points about the use of alternative energy sources.	
Slide 10 puts the challenge into a broader context, getting students to think about how settings other than a farm can also use these ideas.	

It is worthwhile drawing out throughout this activity that it's not simply a case of understanding that farms can use wind and solar power. The bigger shift is in users also being producers. This trend is only likely to continue further over the next decade or so; it is important that students see how this perspective is likely to affect them.