Desertec

Save the world with power

plants in the desert!

Quelle: http://www.compass-project.eu/resources_detail.php?UG_hodnota_id=8

The generation of energy with solar power plants in the desert is a highly controversial issue. Which arguments put forward?
To what extent do solar power plants have the potential to contribute to meeting Europe´s energy needs?
What are the advantages and disadvantages of differnet means of energy producition?

Worksheets for task 1

GLOBAL MISSION

OUR GLOBAL MISSION

Mankind is confronted with enormous challenges: Global energy demand is climbing rapidly due to population growth and progressing industrialization. At the same time, global CO_2 emissions have to be drastically reduced within the next few years in order to prevent a disastrous climate change.

This is where the DESERTEC Concept offers a solution which can be implemented worldwide: Sufficient clean power can be generated in the world's deserts to supply mankind with enough electricity on a sustainable basis. DESERTEC is an integrated concept which includes energy security and climate protection as well as drinking water production, socio-economic development, security policy and international cooperation.

Retrieved from www.desertec.org, 30/05/2011

According to a TRANS-CSP study, 17% of Europe's energy requirements may be met by solar imports by 2050. This would involve 2,500 km² of desert surface for the solar power plants and 3,500 km² for the high-voltage direct current transmission lines throughout the entire EU-MENA region (Europe – Middle East – North Africa).
Retrieved from www.desertec.org/en/concept/questions-answers, 30/05/2011

Green electricity from the Sahara - "Solar energy will pay"

Nuclear or solar, coal or wind? For Greenpeace Manager Roland Hipp, Germany is going to have to choose a system. In an interview for MIRROR ONLINE, he calls for a clear 'no' to coal, following the example of the phasing out of nuclear power and of state aid for solar energy from the Sahara.

mirror-Online: 09.07.2009 (http://www.mirror.de/wirtschaft/0,1518,634892,00.html)

Desertec Project - Expert doubt the desert energy miracle

It is one of the largest energy projects ever. Thanks to the Desertec Initiative, in the future Europe is to get its green electricity from the Sahara. But politicians and experts are sceptical: the plans are too expensive, the technology too complicated and implementation takes too long.

mirror-Online: 13.07.2009 (http://www.mirror.de/wirtschaft/0,1518,635811,00.html)

"Desertec was just hype"

One year ago saw **the start of the desert energy project Desertec, which is backed by major German corporations such as Siemens and the MünchenerRück. Solar power stations in the deserts of North Africa should soon revolutionize Europe's energy supply. But now a more realistic note has replaced the initial euphoria.**

By Marc Dugge, ARD radio station in northwest Africa

A bridge of electricity from north to south, a new dimension to power supplies, an historic project – from the very beginning, talk of Desertec meant being generous with the superlatives. […] After all, 400 billion Euros makes quite an impression.

However, it soon became clear that so far the 'investment' has been little more than playing around with ideas; businesses are for the moment waiting to see if and how they might be a part of desert energy.

In other words, Desertec is basically just engaging in lobbying for a great idea. The aim of the initiative is to bring possible partners together. No more and no less. […]

Many uncertainties

One thing that is sure is that many people are still very unsure. Europe can't decide whether or not it really wants the desert energy. It is also not clear who is to bear the huge costs of this massive investment. In addition, there are technical issues to contend with. For example, between Spain and France there are not enough power lines to transmit the power from the south to Central and Northern Europe.

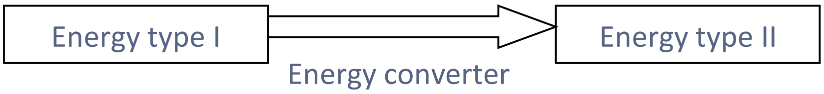
Which is why Manfred Konukiewitz from the OECD recommends not rushing into anything: "It is important for the time being that we don't encourage any short term hopes but remain open and honest, making it clear that such enormous visions need time." At the moment the work is on pilot and reference projects.

Tagesschau: 21.7.2010: http://www.tagesschau.de/wirtschaft/Desertec116.html

Worksheets for task 2

Worksheet 2.1: Energy conversion – Part 1

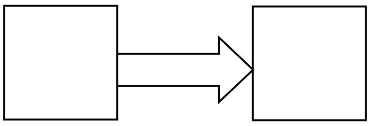
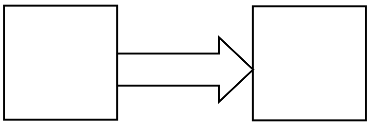
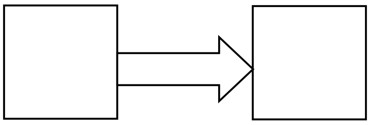
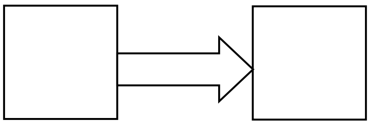
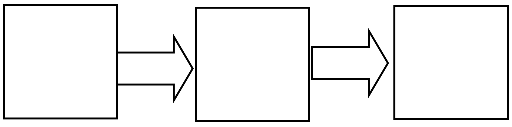
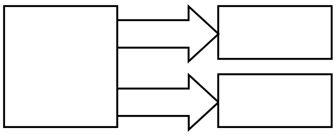
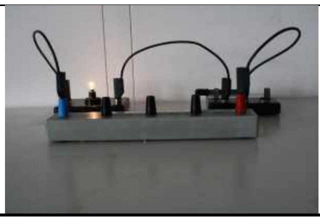
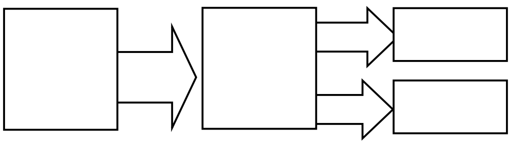
The conversion of different kinds of energy into one another can be observed in many processes in the natural world and in technology. According to the principle of conservation of energy, no energy is lost in the process. Energy conversion can be represented with an energy flow diagram. Basically, an energy *flow diagram* should look like this:



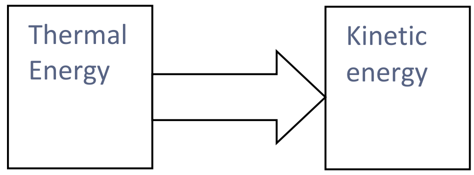
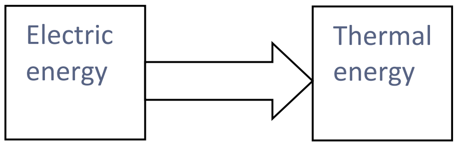
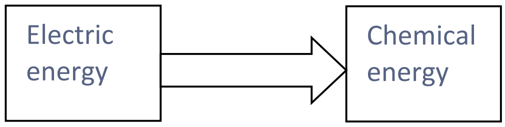
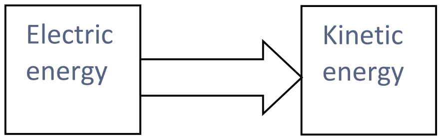
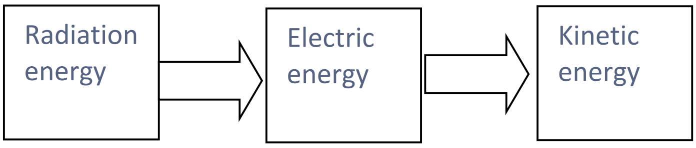
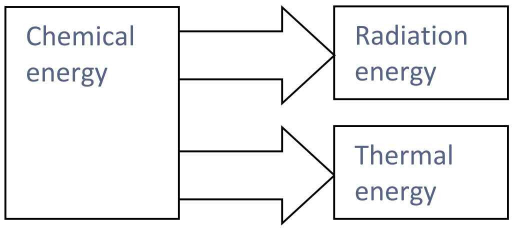
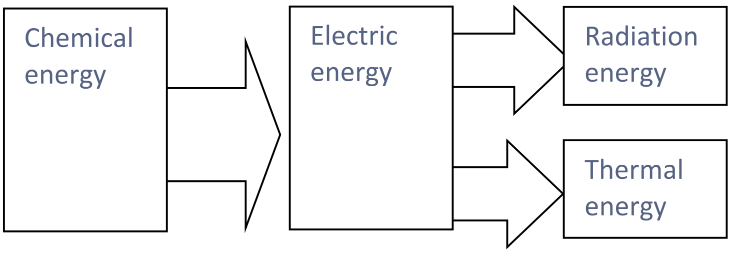
Conduct the following experiments in which different forms of energy are converted into another.

For each step, create an energy flow diagram by filling in the right-hand column of the table.

Worksheet 2.1: Energy conversion – Part 2

Experiments		Energy flow diagrams
1) A coin (2 Euros) is balanced on the neck of a bottle, which is placed in a bowl of warm water. The coin begins to move.		
2) An immersion heater heats water in a flask.		
3) Batteries are charged by plugging the charging device into a socket.		
4) An electric motor lifts a load.		
5) A solar cell is connected to the model of a cyclist. This moves when exposed to light.		
6) A candle burns.		
7) A circuit contains a battery and a bulb. The bulbs light up.		

Solutions for worksheet 2.2

Experiments	Energy flow diagrams
1) A coin (2 Euro) is balanced on the neck of a bottle, which is placed in a bowl of warm water. The coin begins to move.	
2) An immersion heater heats water in a flask.	
3) Batteries are charged by plugging the charging device into a socket.	
4) An electric motor lifts a load.	
5) A solar cell is connected to the model of a cyclist. This moves when exposed to light.	
6) A candle burns.	
7) A circuit contains a battery and a bulb. The bulbs light up.	

Information sheet 2.2 Solar power plants

Solar power plants with curved mirror troughs. Unlike gas power plants, these power plants use renewable energy resources; in this case it is the sun's energy. Large mirrors focus the sunlight on a pipe carrying a heat transfer fluid, or 'working fluid', which is located along the focal line of the trough. The working fluid is heated in the pipe to approx. 400°C. The collector is made up of the mirror and the pipe. The individual collectors are connected by a manifold (linking all the fluid pipes).

Figure 1: Curved mirror troughs to collect solar energy/radiation(retrieved from Wikimedia Commons, http://commons.wikimedia.org/wiki/File:Parabolic_trough_solar_thermal_electric_power_plant_1.jpg, 02.08.2010, image by kjkolb).

The heated working fluid is routed to a heat exchanger in which steam is produced (see Fig. 2). The steam flows via pipes and is used to drive a steam turbine. The turbine is connected to a condenser, in which a large part of the steam's thermal energy is transferred to the cooling water, thereby condensing, and to a generator, which is driven by the movement of the steam turbine.

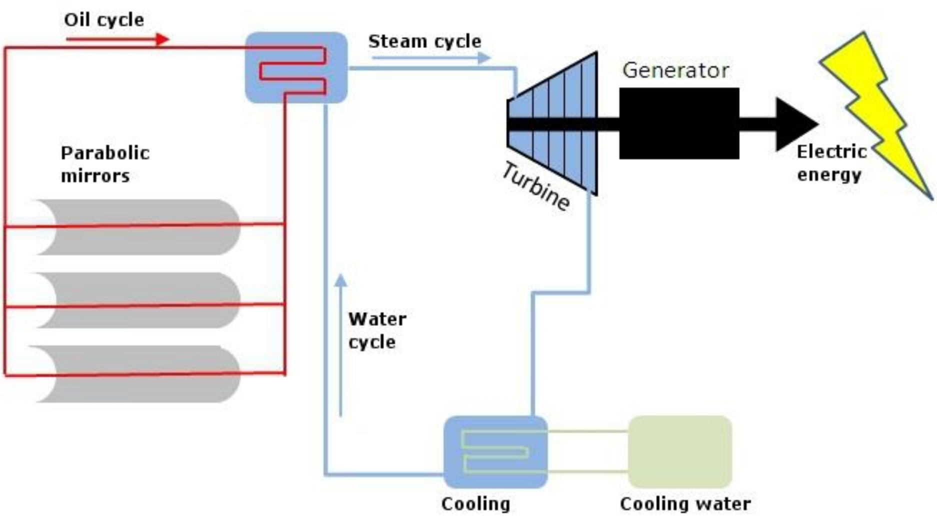


Figure 2: Solar power plant

Information sheet 2.3 – Gas power stations

Gas power stations. Gas or oil is burnt in a combustion chamber (Fig. 3). This produces a hot jet of gas which drives the paddle wheels of the turbine. The temperature of the gas before reaching the turbine is 800°C or higher; the outlet gas temperature is about 500°C. Like in the solar thermal power plant, the turbine converts thermal energy into mechanical energy. The turbine is connected to a generator, which is driven by the movement of the steam turbine, and mechanical energy is converted into electric energy.

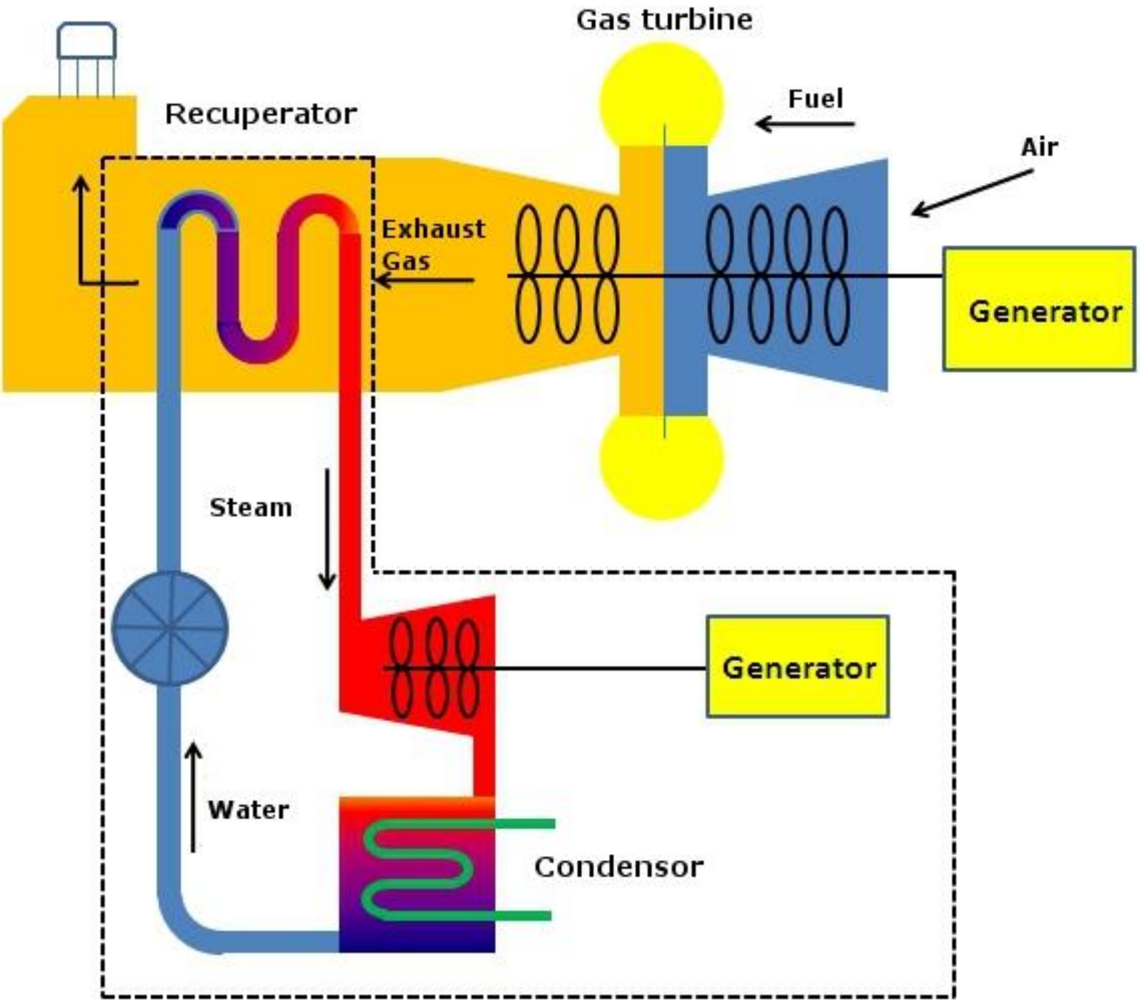
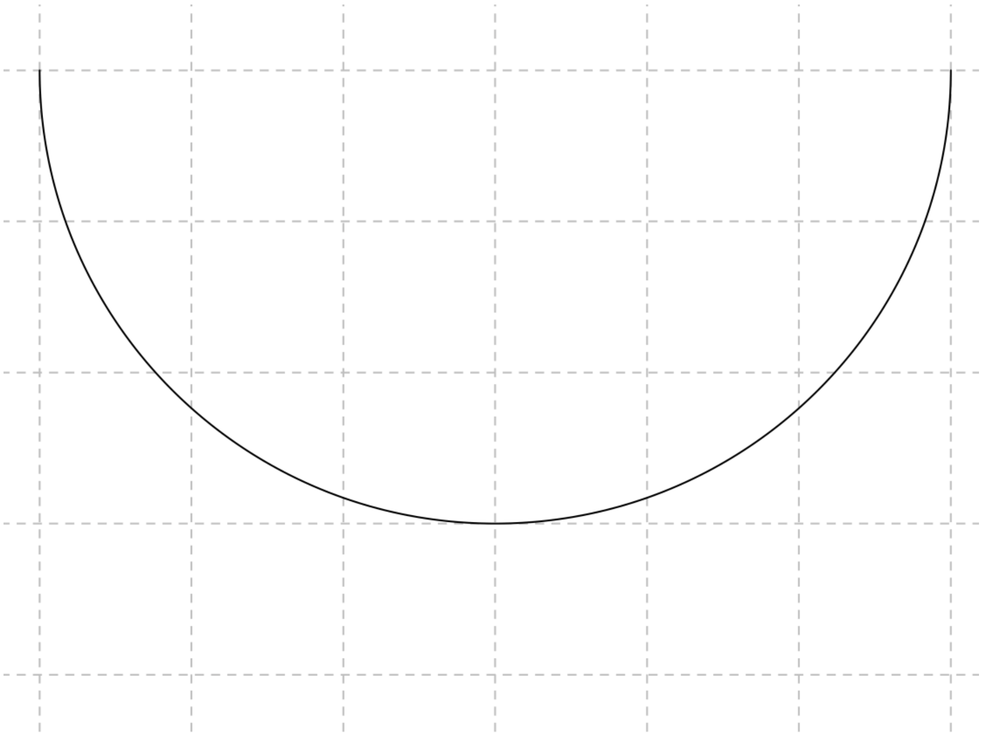


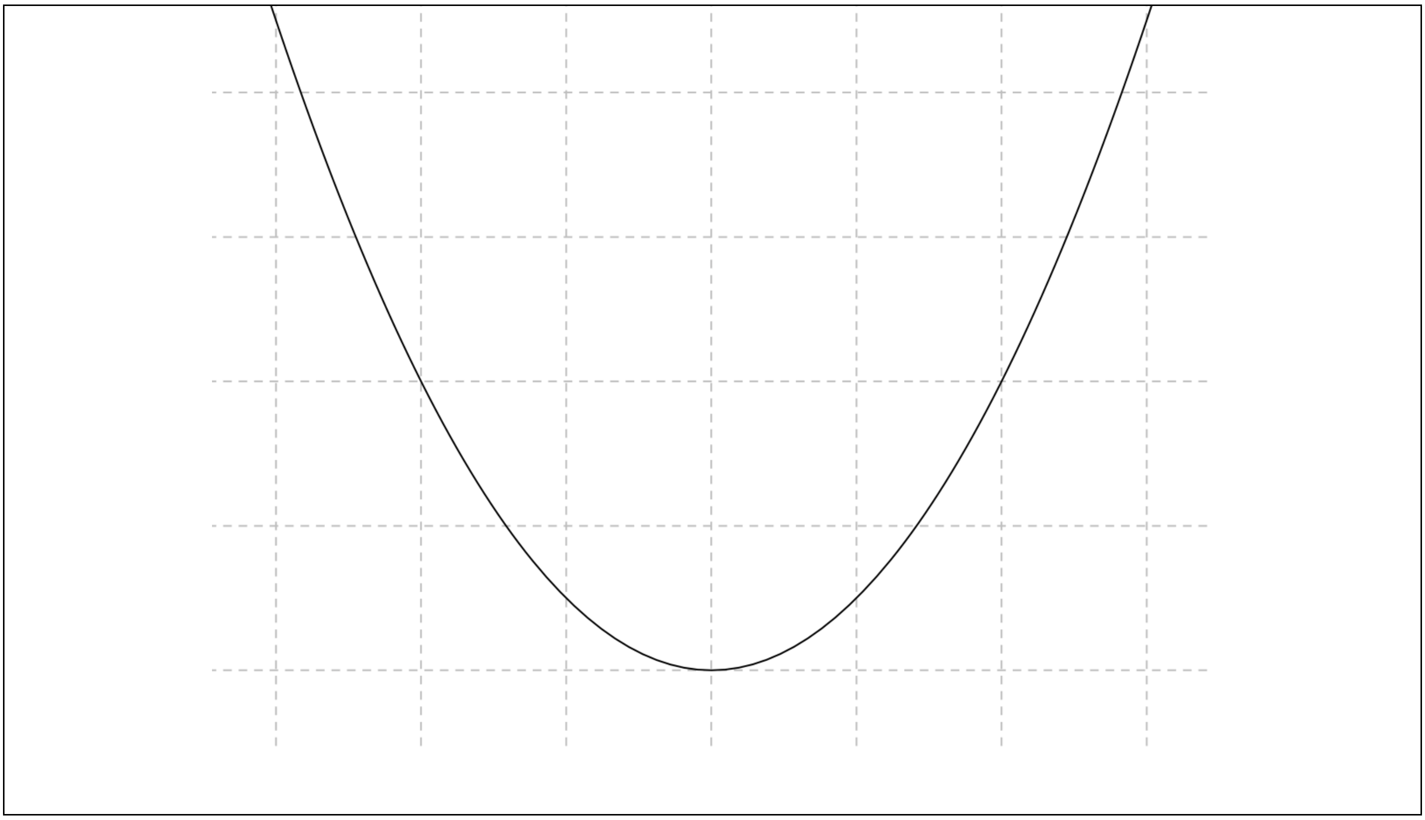
Figure 3: Gas power plant

Unlike other steam power plants, gas turbine power stations can be ready for use within minutes. They need neither cooling towers nor complicated facilities for exhaust gas cleaning, they can be erected relatively quickly and are cheaper than other steam power plants of similar output, such as coal-fired power stations. However, the power generating costs are higher than with other steam power plants. Therefore, they are usually not used as base load plants but to cover demand peaks.

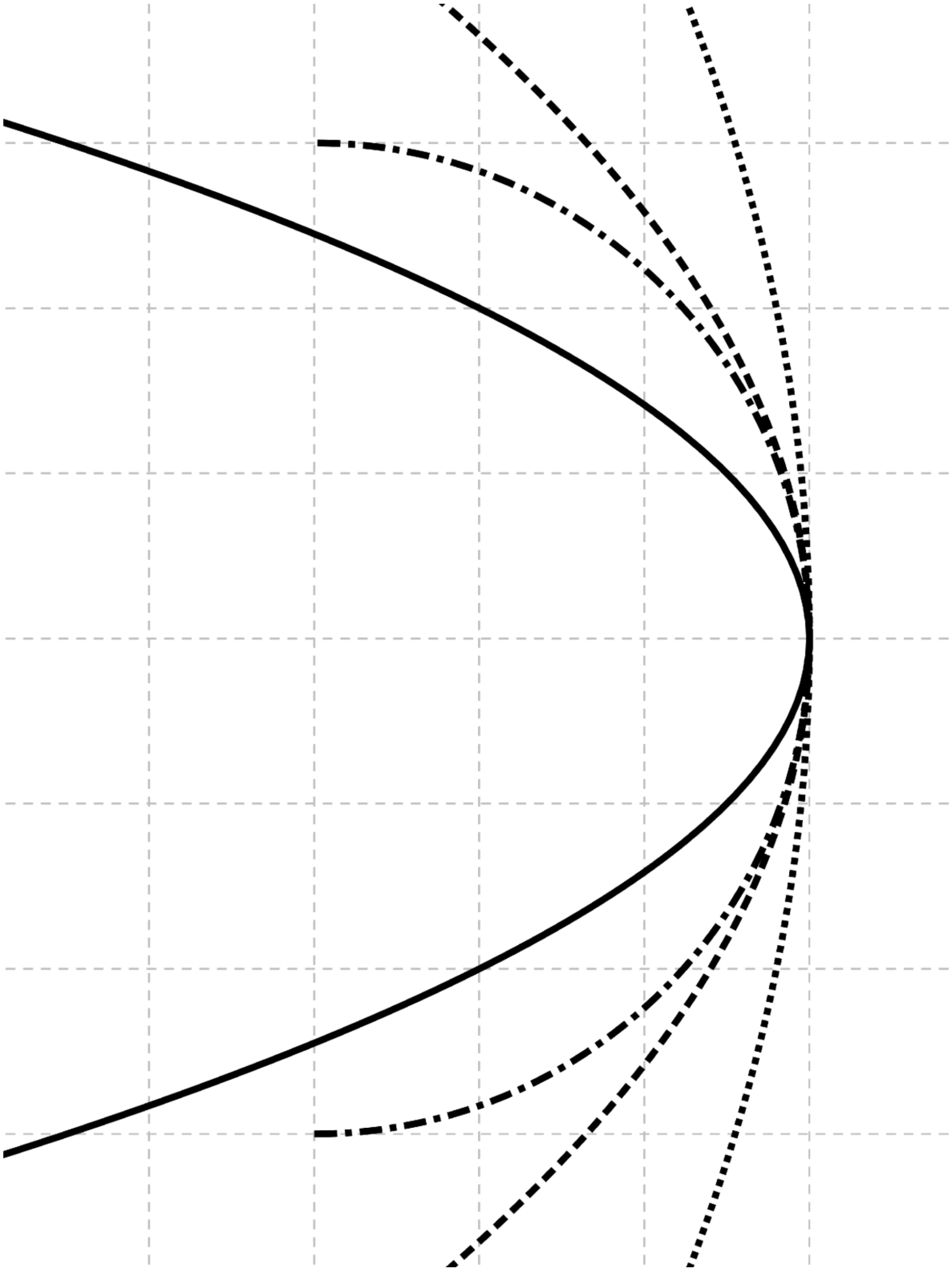
Worksheets for task 3

Worksheet 3.1: Figure of a circle and a parabola



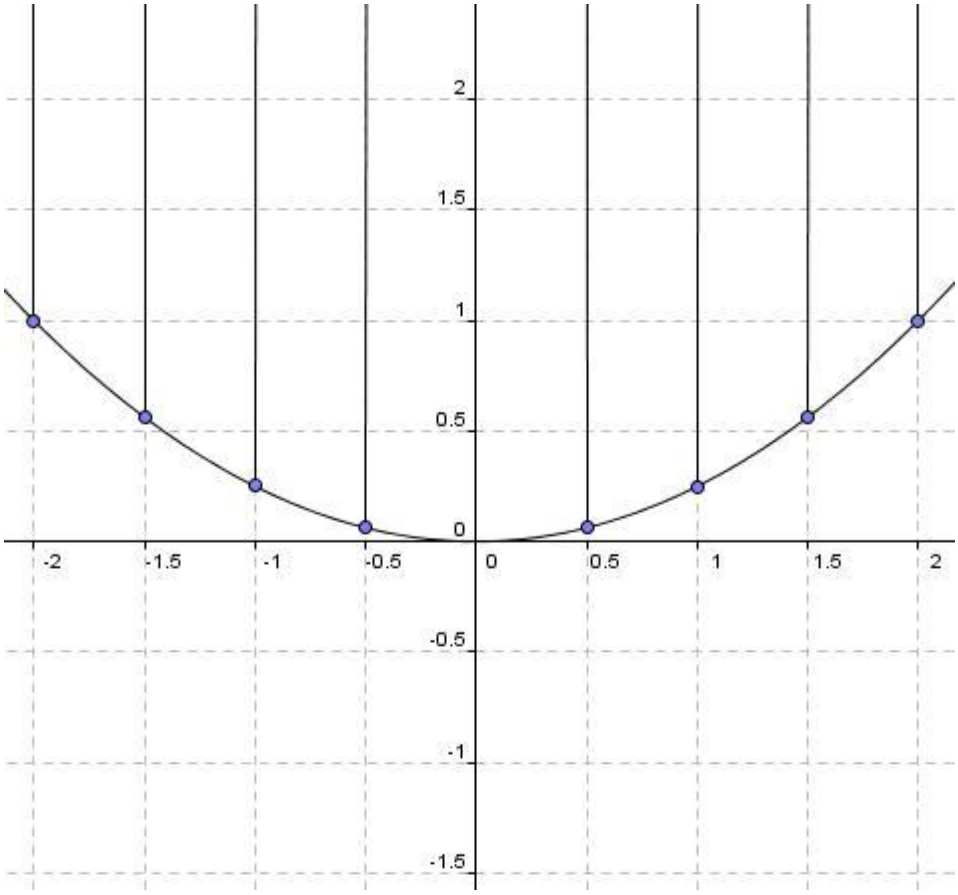


Worksheet 3.2: Figure of a parabola for construction purposes



$$f(x) = \frac{x^2}{4}$$

$$f'(x) = \_\_\_\_\_\_\_$$



a) For $x_0=1$ and $x_1=-1.5$ calculate and draw the tangents with the tangent equation. Then reflect incoming rays from the sun on these tangents.

For reflecting the light, you needed to draw the normal to the connection points. Look at the functions that describe these normal and compare them with the functions of the corresponding tangents. Describe the relation between the two. Compare your results with your neighbour.

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b) Calculate and draw the normal for two further points on the parabola mascil

Worksheets for task 5

Worksheet 5.1: Energy consumption – newspaper article

Energy from the desert

The world's largest solar project taking shape

By 2050, roughly 15 percent of Europe's energy needs are to be met in an environmentally friendly way with the help of the desert sun. The costs are currently estimated at around 400 billion Euros. However, a starting date to begin constructing the planned solar power stations and wind parks has not yet been set. Most of the energy is to be generated in solar thermal power stations, which use mirrors to concentrate the sunlight. The concentrated sun's energy heats the working fluid which is inside the pipes running through the focal point of parabolic mirrors. A special oil or fusible salt is generally used. The hot liquid flows to a heat exchanger in which water is made to evaporate. The ensuing pressurised steam drives the turbines which produce the power. The efficiency of this system is estimated to be between 16 and 25 percent, which is higher than with photovoltaic systems.

FAZ, 13.9.2009 (retrieved from http://www.faz.net/s/RubD16E1F55D21144C4AE3F9DDF52B6E1D9/Doc~E09310A89B87D4A8CB3CA3154A4DE2B60~ATpl~Ecommon~Sspezial.html)

Energy consumption expected to double by 2050

Global energy consumption is expected to grow considerably over the next few decades. Experts predict an increase of up to 100 percent.

According to a study conducted by the World Energy Council (WEC), which was presented on Monday at the World Energy Congress in Rome, the global demand for energy will increase by 70 to 100 percent by 2050; in other words, it is expected to more or less double. As a result, the prices for all kinds of energy – oil, gas, coal, electricity, wind, water and nuclear energy – will also increase considerably.

Focus: 12.11.2007 (retrieved from http://www.focus.de/immobilien/energiesparen/energyverbrauch_aid_138934.html, 03.08.2010)

Extract from a report conducted by an energy economics research society:

Conclusions and perspectives

The sharp decline in energy consumption, as calculated in scenarios 2 and 3, is by no means the result of a natural 'business-as-usual' development. Both the introduction of technologies with higher energy efficiency and changes to the needs determinants (compared to scenario 1) are the result of a huge effort which the population is only willing to carry out if provided with extensive legal provisions. A reduction in energy and CO2 emissions, however, is only possible if everyone behaves in an environmentally friendly way.

(Retrieved from http://www.ffe.de/taetigkeitsfelder/energybedarfsprognosen-struktur-and-marktanalysen/257, 3.8.2010)

Worksheet 5.2: Energy needs – technical information

Technical details for the Andasol power stations (details per power station)	
Position	
Project name	Andasol 1, Andasol 2, Andasol 3
Site	10km east of Guadix in the municipality of Aldeire and La Calahorra, in the region of Marquesado del Zenete, province of Granada
Area of land	approx. 195 hectare (1,300 x 1,500 m), north-south facing
Access to overhead power lines	Connection to 400 kV power line at Hueneja (approx. 7km away)
Solar field	
Parabolic trough technology used	Skal-ET
Size of solar field	510,120m^2
No. of parabolic mirrors	209,664 mirrors
No. of receivers	22,464 4m-long pipes
No. of sun sensors	624 units
Annual direct normal irradiance (DIN)	2,136 kWh/m^{2}a
Solar field efficiency	approx. 70% peak efficiency, approx. 50% annual mean
Heat storage tank capacity	28,500t salt for 7.5 hours at full load
Power plant capacity	
Turbine output	49.9 MW
Annual operating hours	approx. 3,500 hours at full load
Estimated total amount of energy	approx. 180 GWh
Efficiency of whole plant	approx. 28% peak efficiency, approx. 15% annual mean
Estimated life expectancy	at least 40 years

http://www.solarmillennium.de/upload/Download/Technologie/Andasol1-3deutsch.pdf (19.01.11)

Worksheets for task 6

Information sheet 6.1 - The transportation of energy

Basic physics. As we have already discovered through our work on the different types of power stations, electrical energy is usually produced through synchronous generators. This means that a three-phase current is created. The frequency of these three-phase currents in Western Europe is50 Hz.

As the power stations are generally not located anywhere near the end user/customer, it is necessary to transport, or to transmit, the electric power over long distances.

The electric power (P) transmitted in a circuit is the product of electric potential (V) and current (I). So the formula is P=V*I, with the corresponding units 1W=1V*1A.

If for example P=100kW=100 000W has to be transmitted, there are two possible ways to do this:

Potential Vin V	Current I in A	Power P in W
250	400	100,000
10,000	10	100,000

The advantages and disadvantages of this transmission are:

- If power is to be transmitted at high voltage, then it is necessary to invest quite a lot in its isolation (e.g. several meters of "air" when transmitting the power over land).
- If power is to be transmitted with a high current, then it is necessary to have power lines with a large cross section, as high currents lead to an undesirably large line loss through resistance.

For large amounts of power (approx. 1,000 MW) transmitted in a financially viable wire diameter, currents under 2,500 A are necessary – in other words with a very high voltage of more than 400 kV. Therefore, in the case of the transmission of large amounts of electric power, high-voltage power lines are preferable for distances over several hundreds of kilometres.

Transmission via alternating current:

Power stations can generate such a high voltage in alternating current mode very efficiently by means of power transformers. At the end of the overhead line the high voltage is reduced in a step-down transformer to a lower AC voltage (110 kV) or medium voltages of 10 to 30 kV.

To keep losses low when using three-phase alternating current, connections with at least three conductor lines are required with a certain separation distance, in addition to an earth potential. Above ground this is managed using typical overland power lines. For underground cables, e.g., underwater cables, this is only possible with an enormous technological effort, and thus as a rule is limited to a maximum distance of 70 kilometres.

Transmission with direct current

Unlike AC voltage, the simple transformation of DC voltage is not possible. This means that technically complicated converters capable of carrying high voltages are needed in addition to transformers for AC voltage. However, direct current allows for transmission using only two or even one cable, which may be laid subterranean or undersea cable.