



Umweltfreundliche Energieanlagen

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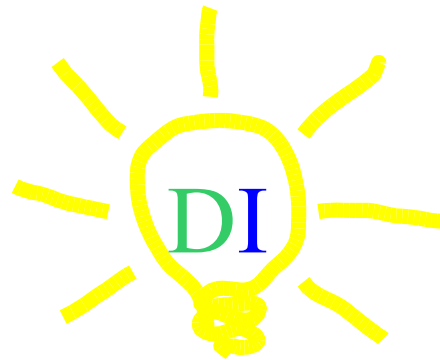
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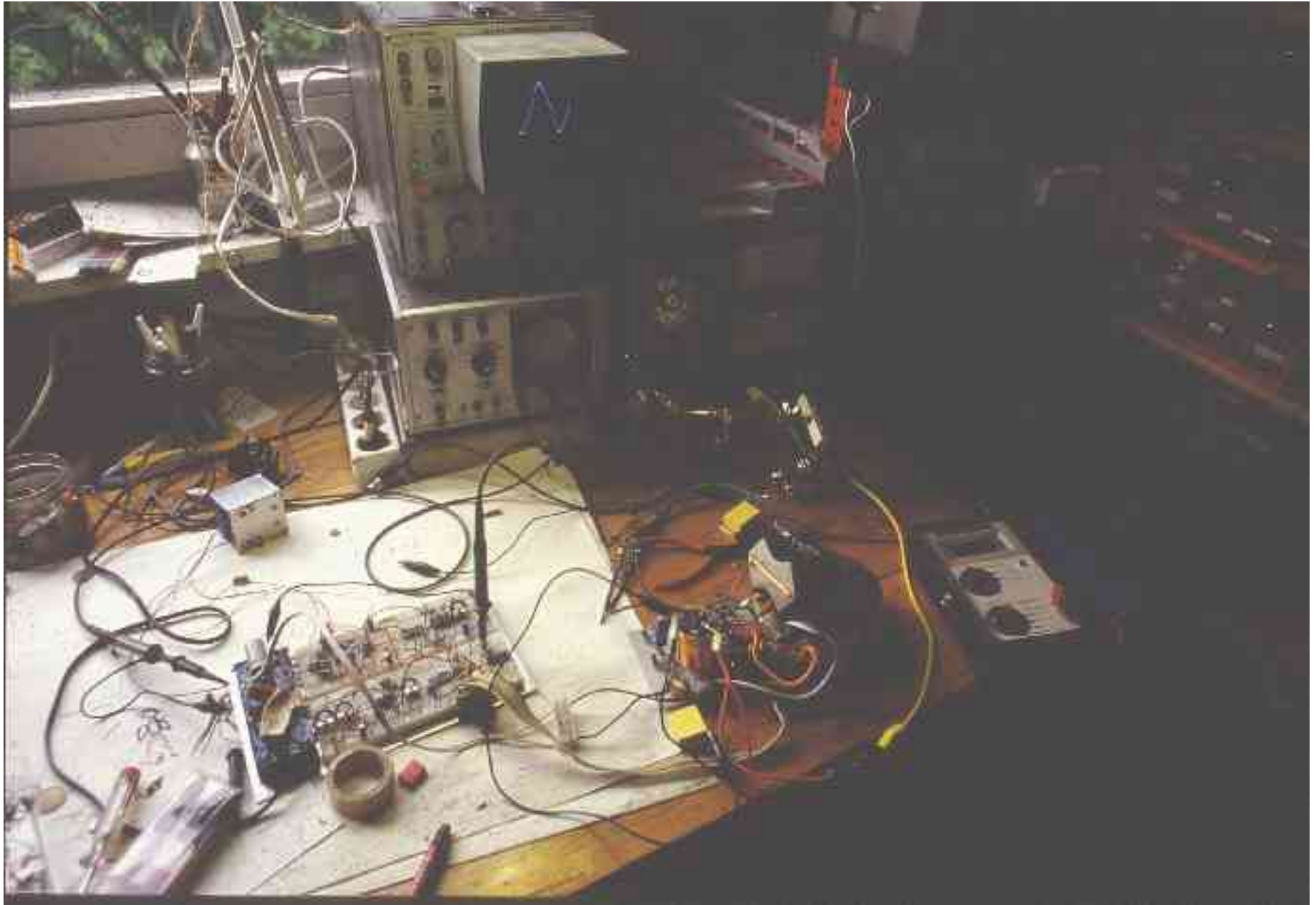


WORLD CLIMATE & ENERGY EVENT

February 14.-16. Rio de Janeiro



**distributed intelligence in power networks
one of the keys of a 100% renewable energy future**



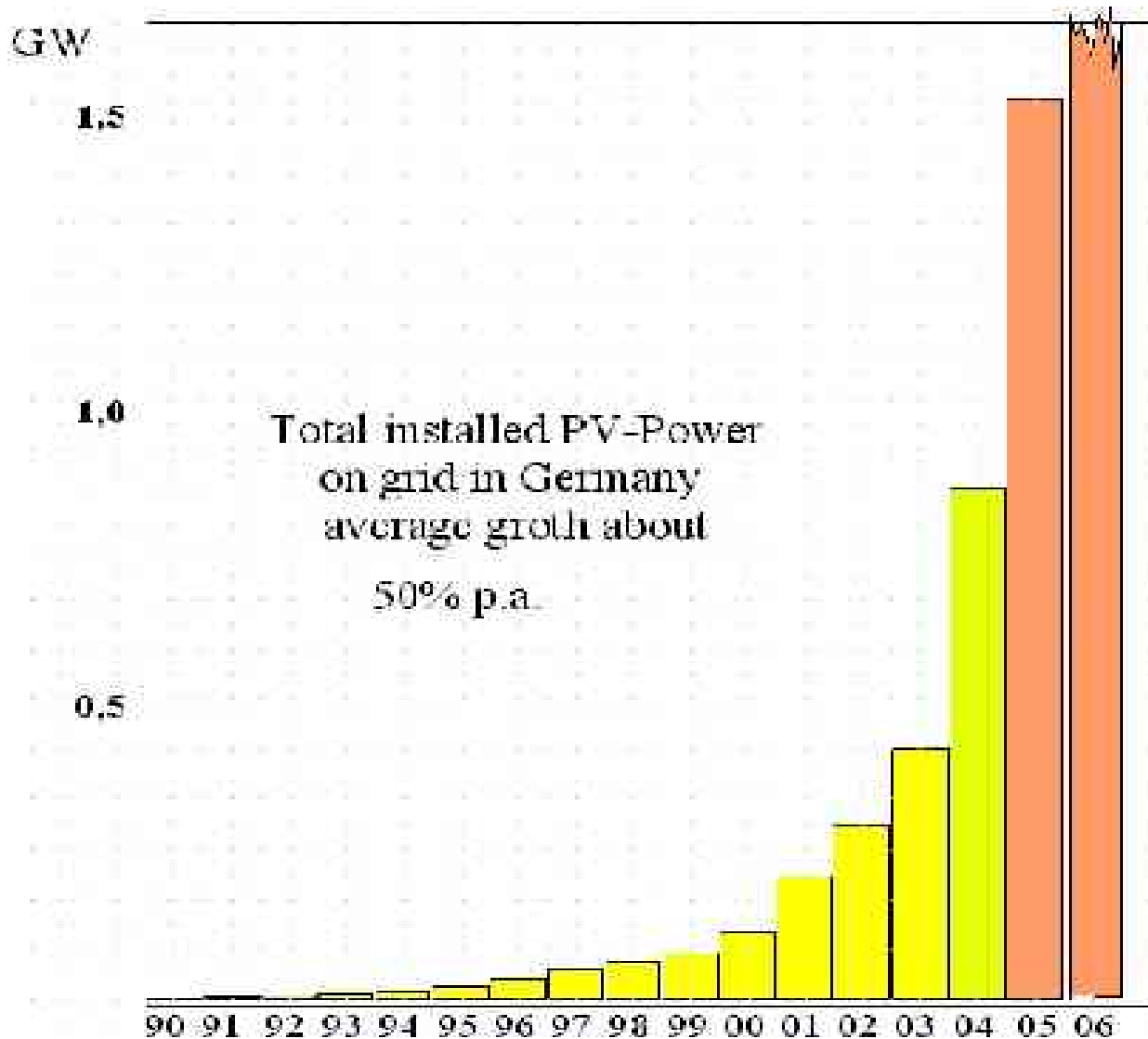
Testing grid connected PV Inverter circuits at UfE in 1987



Plug and play PV-Inverter of the late eighties.

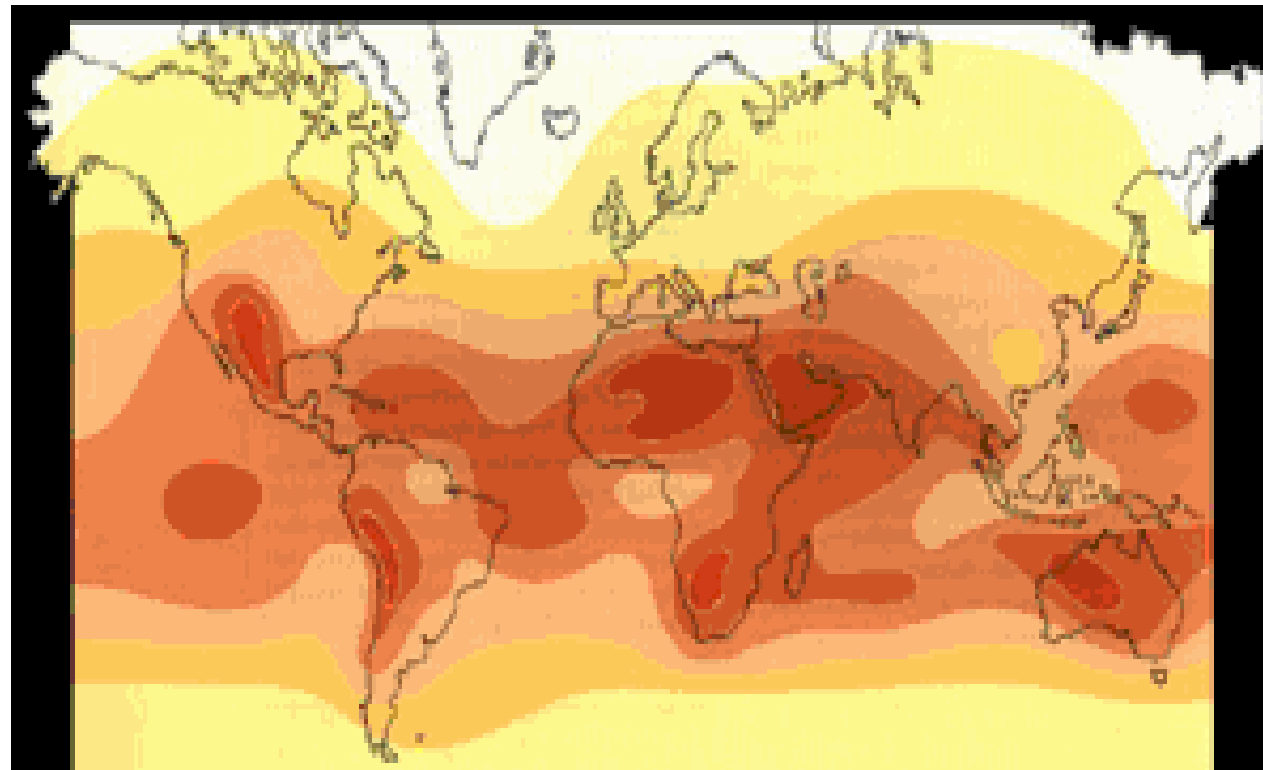


UfE ENS islanding control device using grid impedance step monitoring to detect uncontrolled islanding.





Grid connected photovoltaic systems on rooftops in **Germany!!!** can produce twice the electricity that is used in the house below.



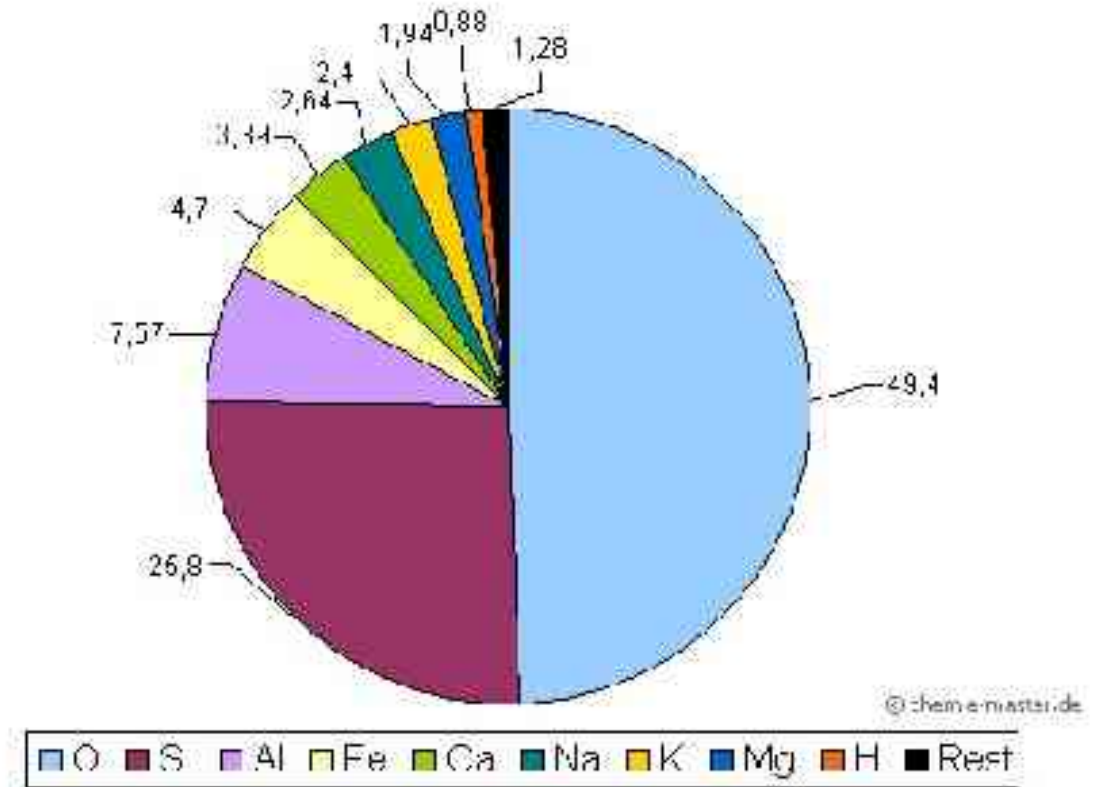
Durchschnittliche solare Einstrahlung/Jahr kWh/m²



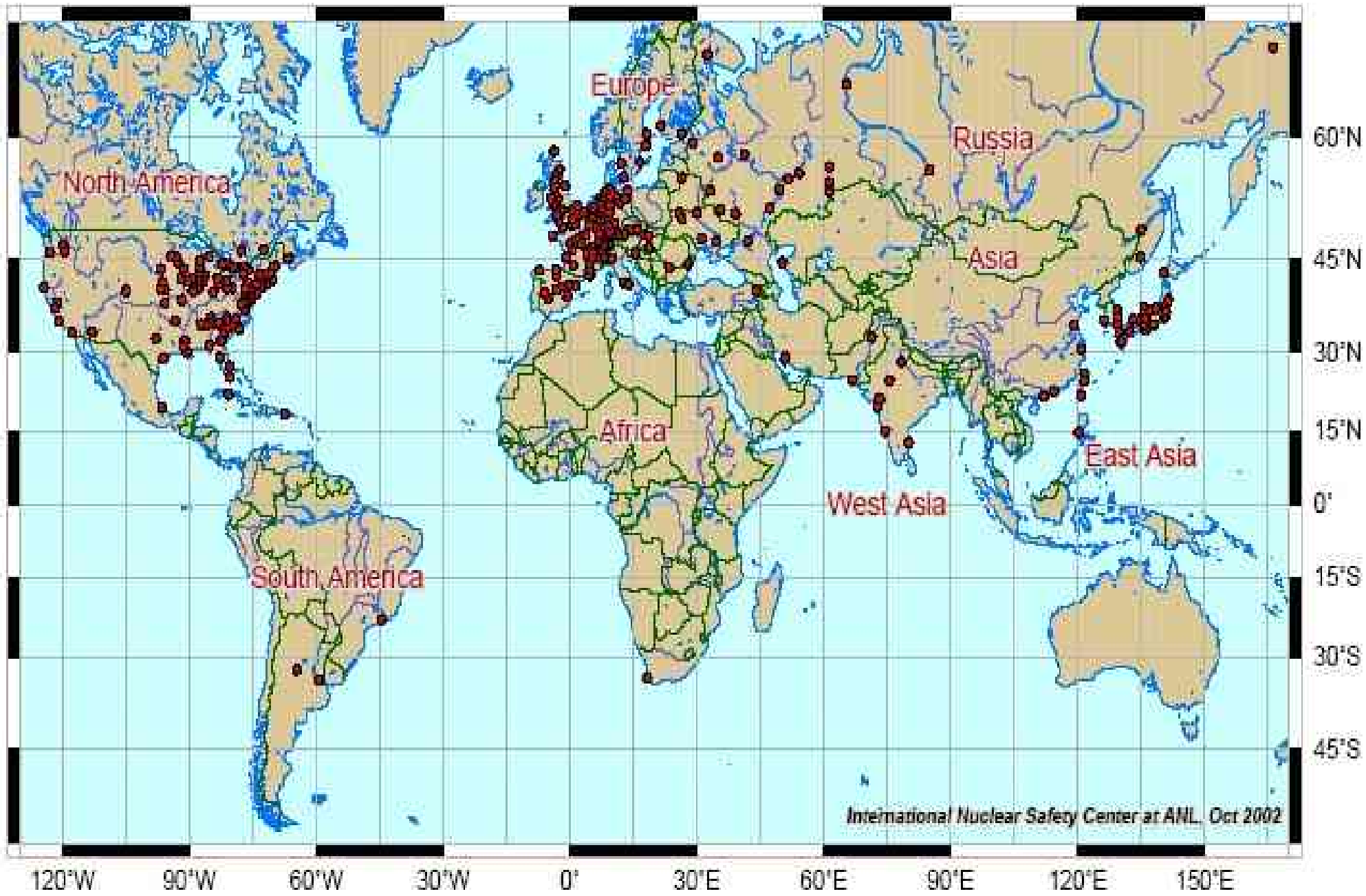
Silicon used for solar cells is one of the most common elements on earth. There is more silicon and aluminium as needed to cover the whole surface of the world a hundred times.

The high price of solar cells has nothing to do with the raw material. It is human labour and some energy costs. But energy is only about 3% of the whole costs. So 97% is left to human labour.

Prozentuale Anteile der häufigsten chemischen Elemente an der Zusammensetzung der Erdkruste



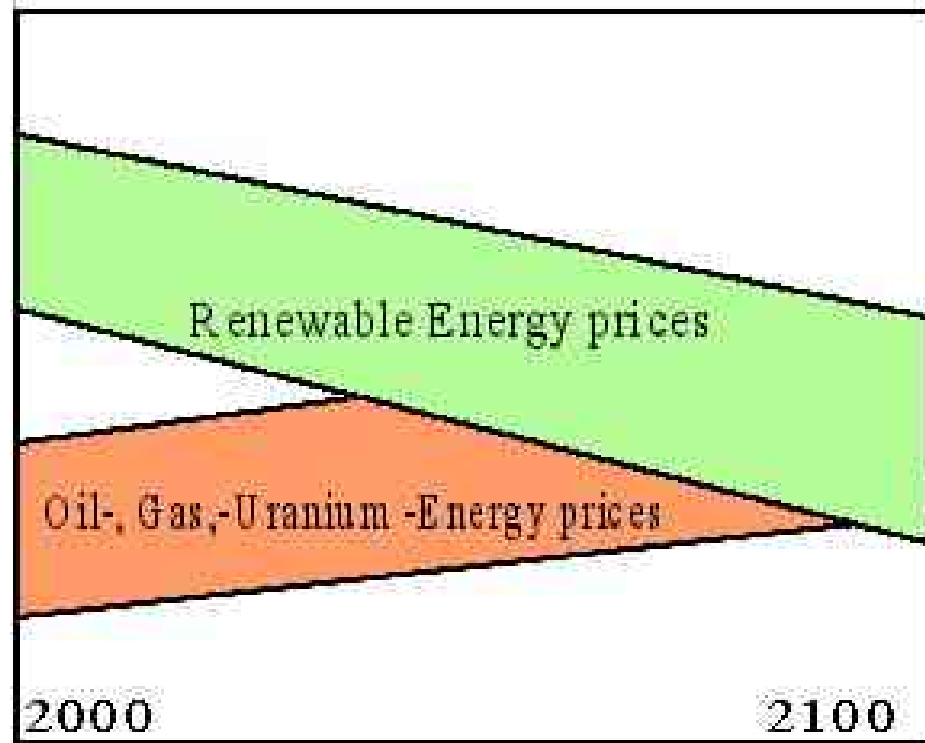
Solar energy is nothing than human labour and sustainable business!



International Nuclear Safety Center at ANL, Oct 2002

One of the very few reasons against Renewable Energies is the higher price. But the price of electricity from RE has been decreasing in the past, and this development will continue as sure as the price for energy based on fossil sources will increase - as long as it is legal to burn these resources just for energy.

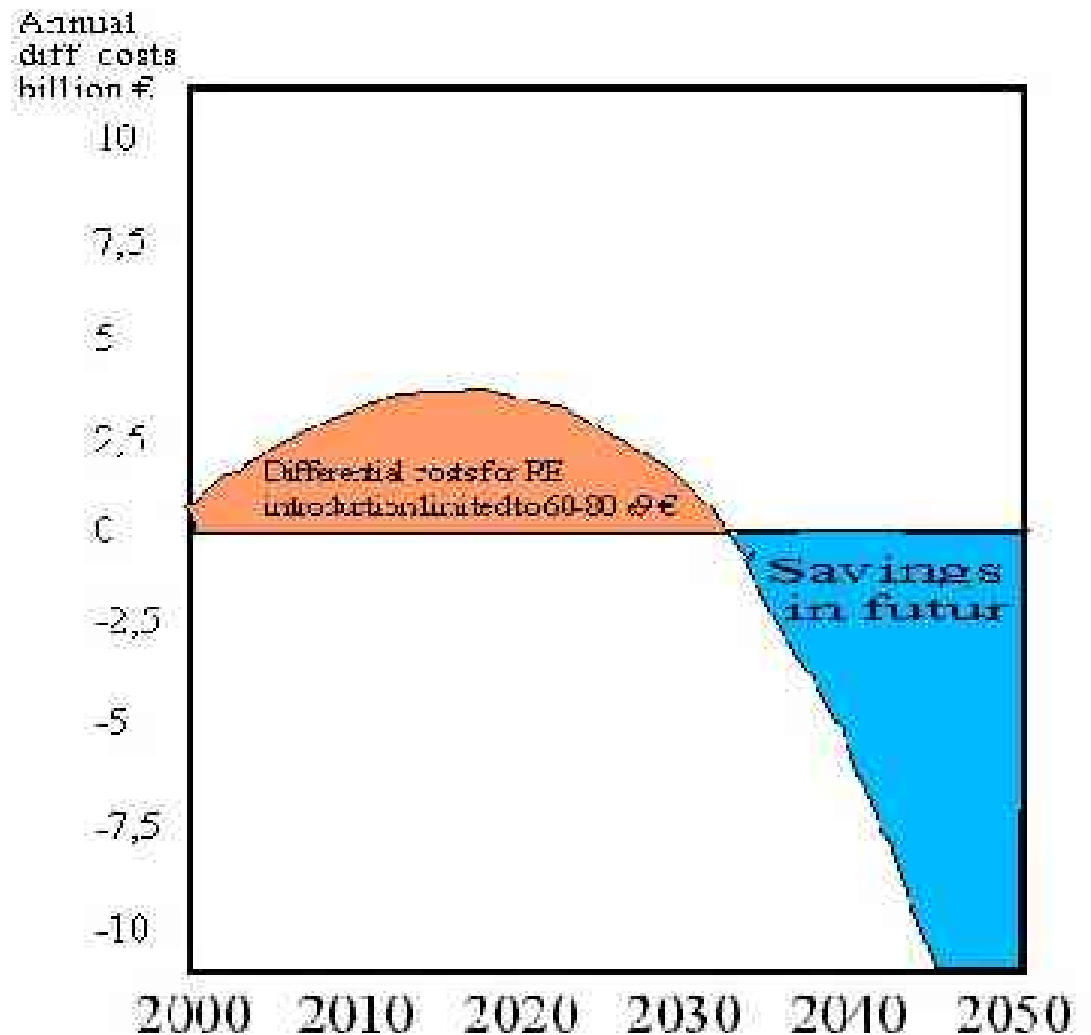
There is no doubt that this two lines will cross some day, it is only a question when this will be. This day will be the end of the fossil energy age.



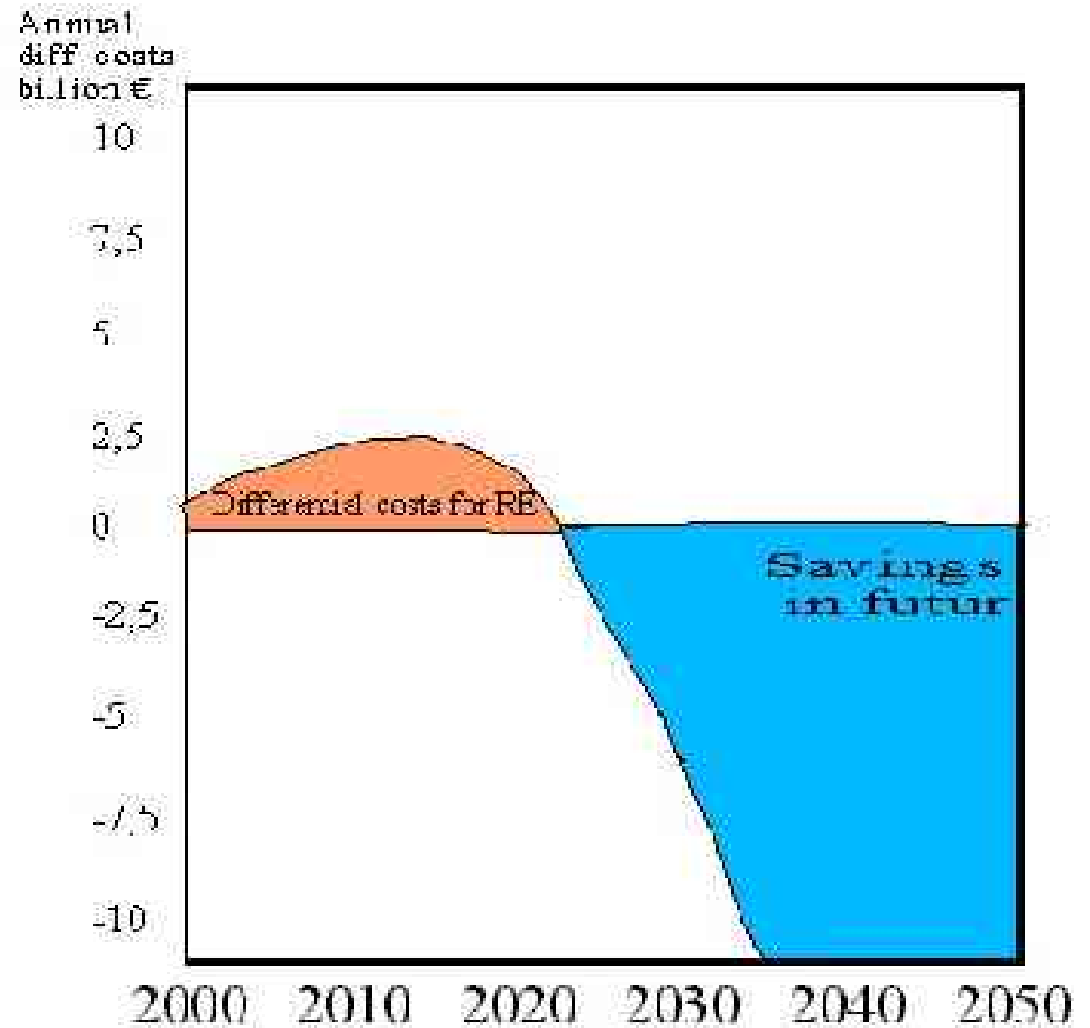
Introduction of RE in Germany is supported by the Renewable Energy Law.

The costs of RE introduction of about 2 billion Euro now could raise to a peak of 4 billion in 2015.

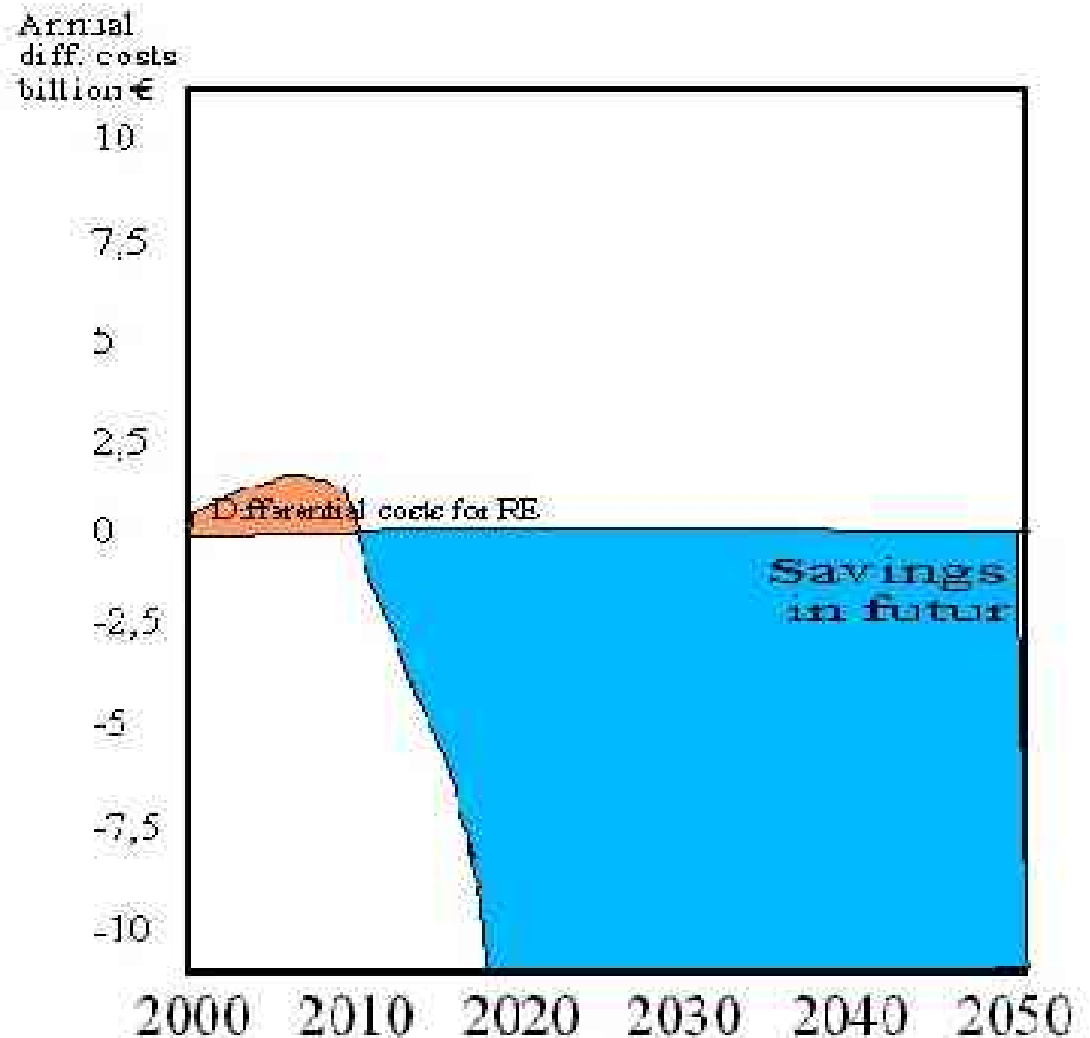
But it will decrease again and turn into profits in 2030.



In countries with stronger RE resources this differential costs will be lower and turn into profits more early.

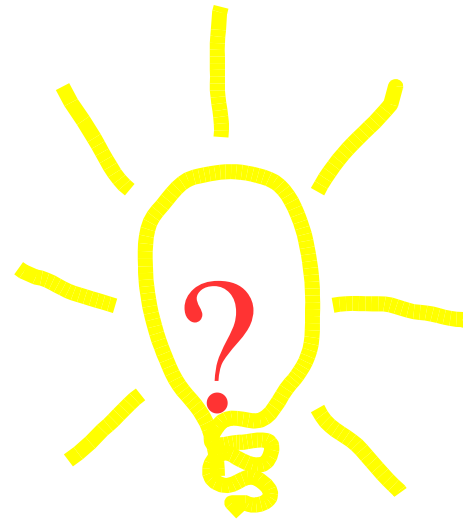


These figures are based on an assumption of annual growth of fossile energy prices of 2%.
Maybe this assumption would be much too low.
Then costs for RE introduction would turn into profits within an few years!



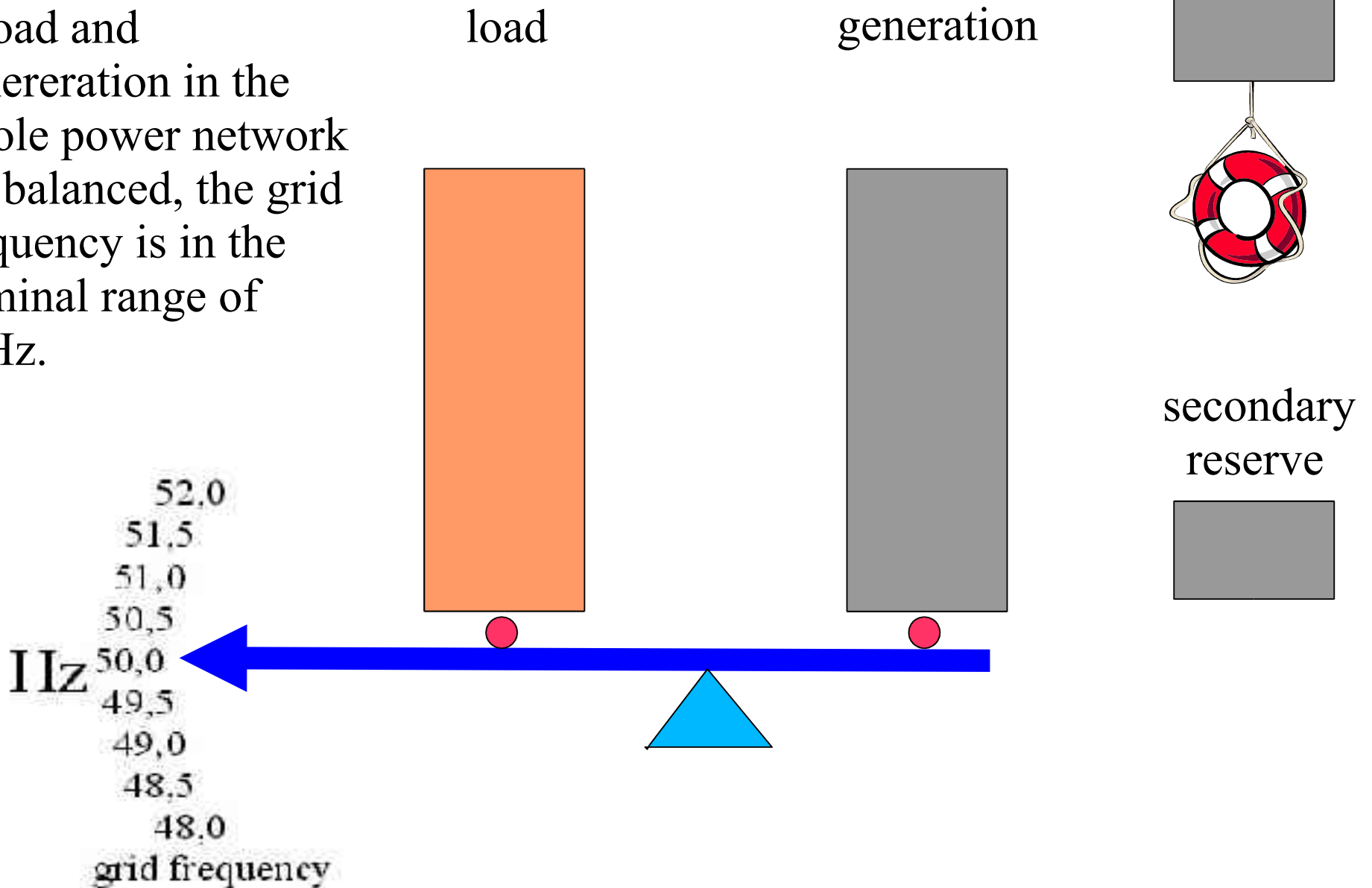
So we could have RE and there would be a lot of benefits from using them. But there are concerns about how this could work in the electric power networks with a bigger share of renewable and distributed energies.

I want to show you now that it would be possible to integrate even 100% of RE into the grid.



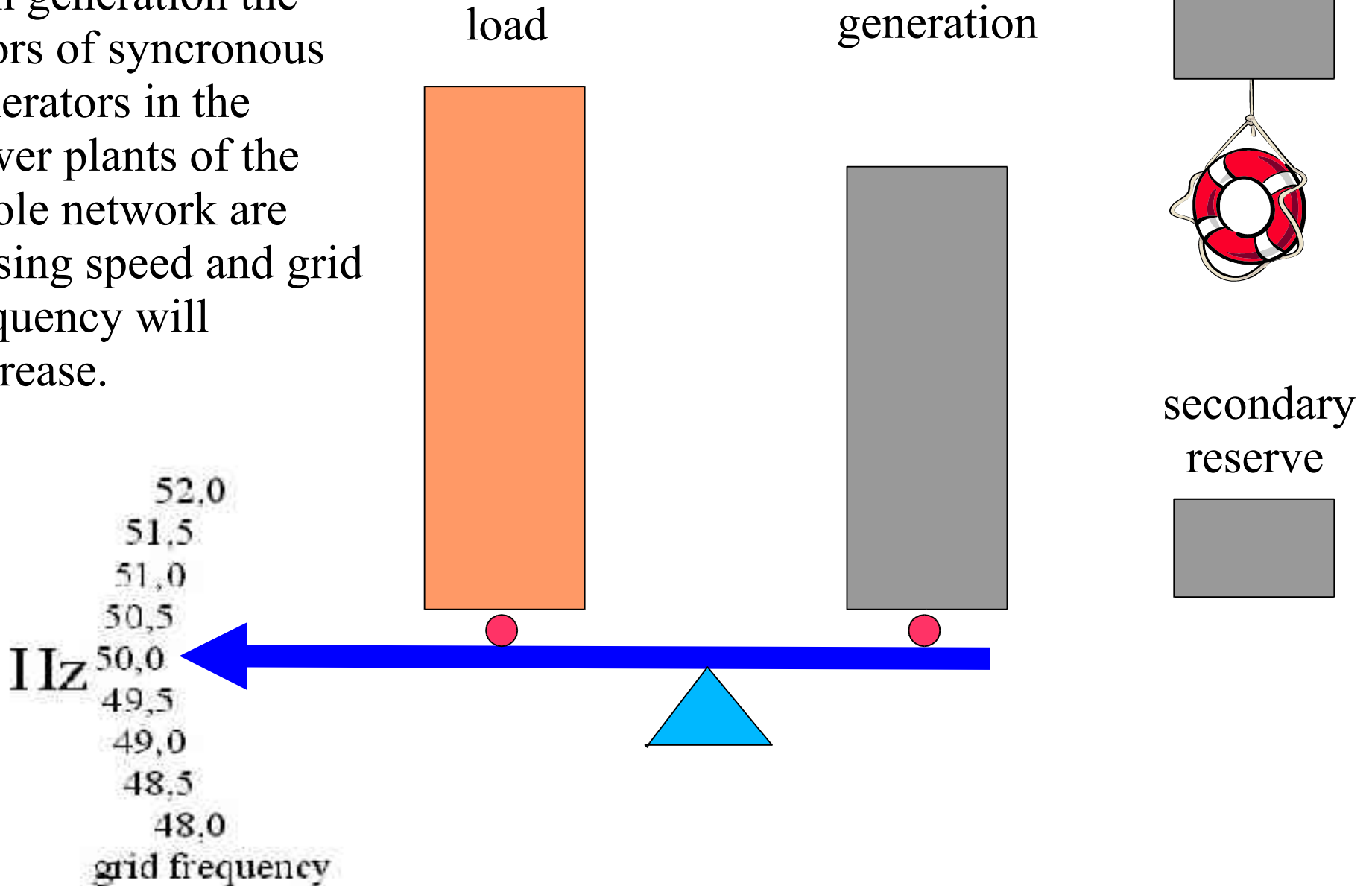
Grid Regulation

If load and generation in the whole power network are balanced, the grid frequency is in the nominal range of 50Hz.



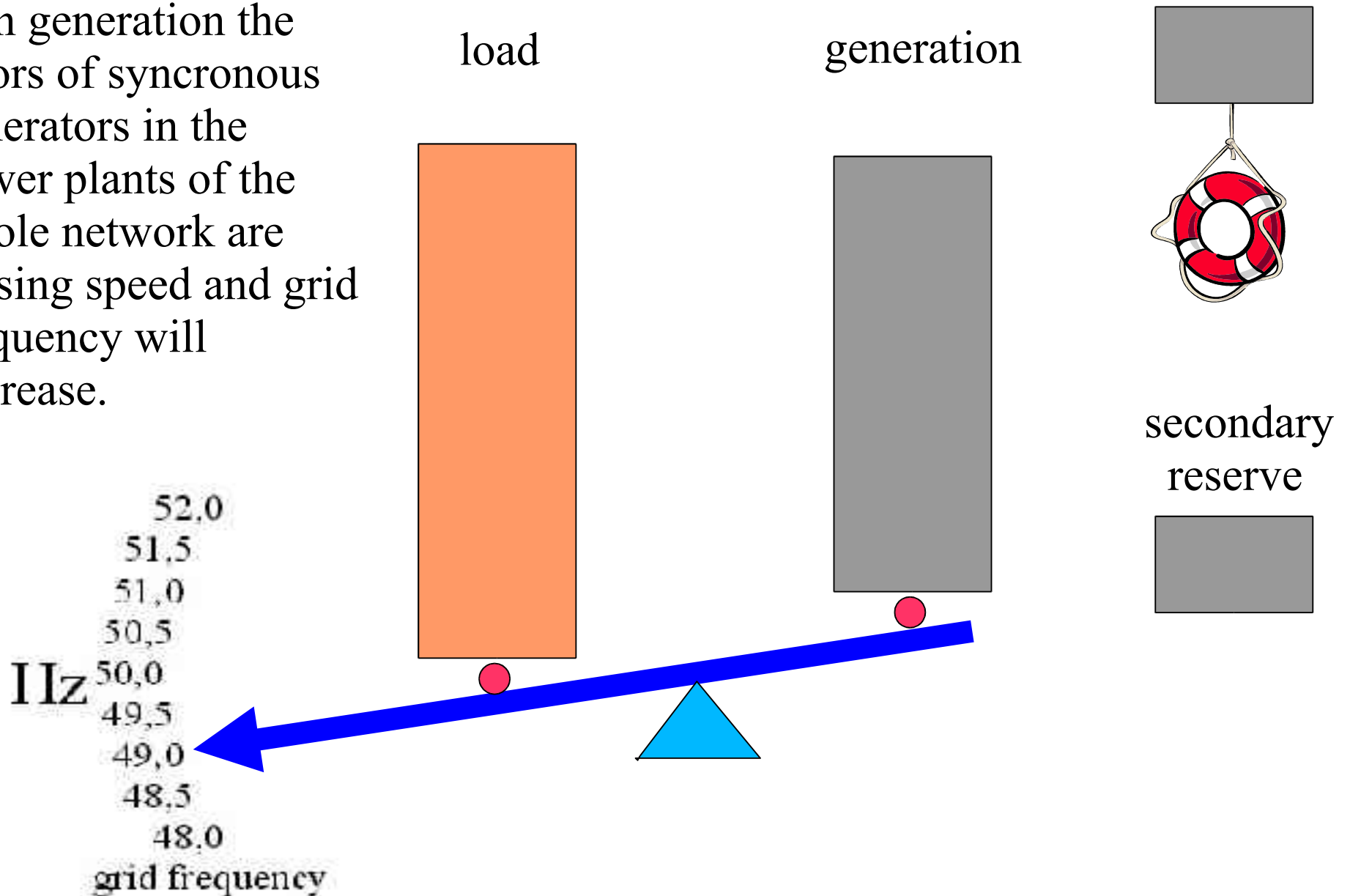
Grid Regulation

If there is more load than generation the rotors of synchronous generators in the power plants of the whole network are losing speed and grid frequency will decrease.



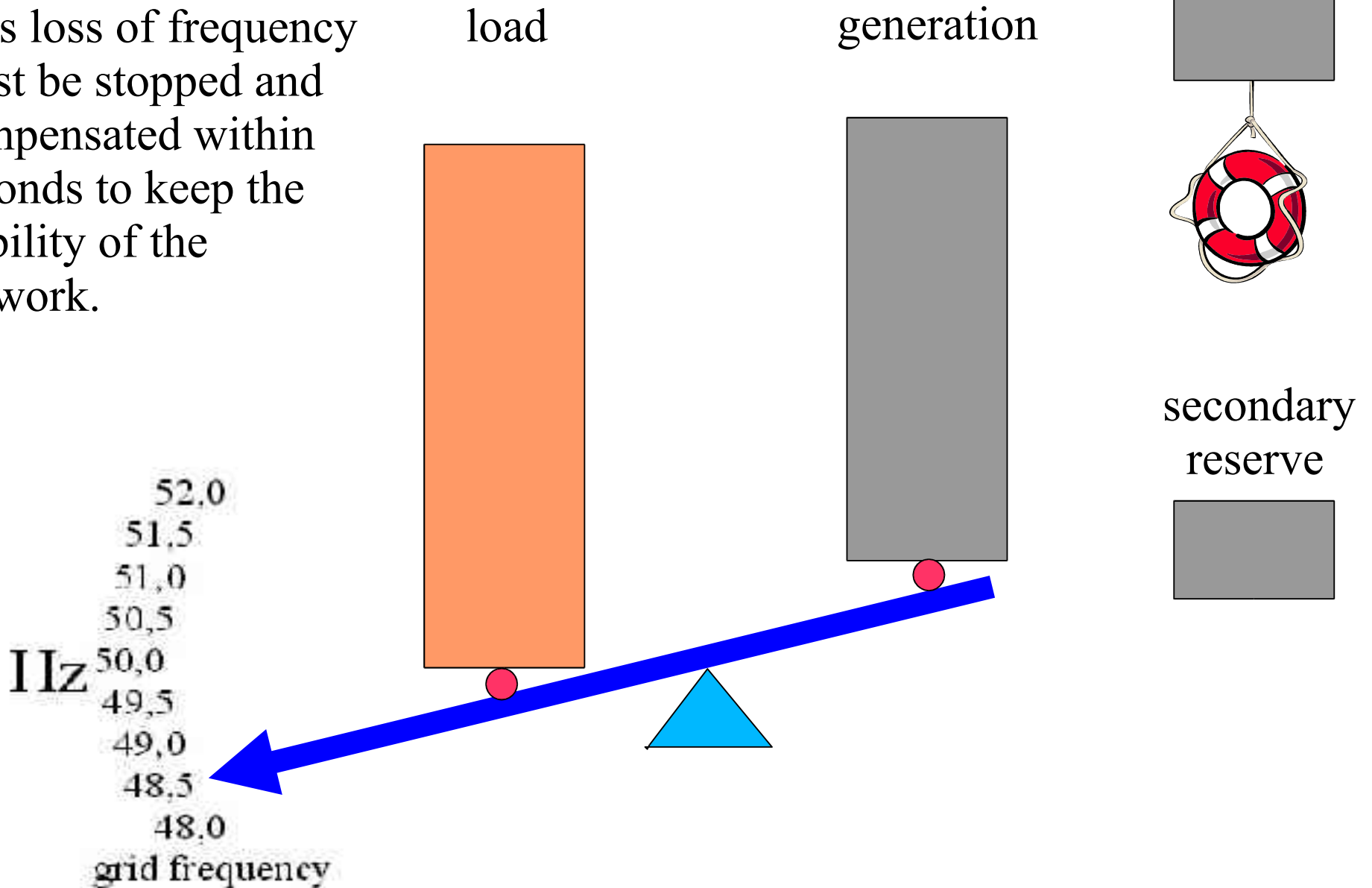
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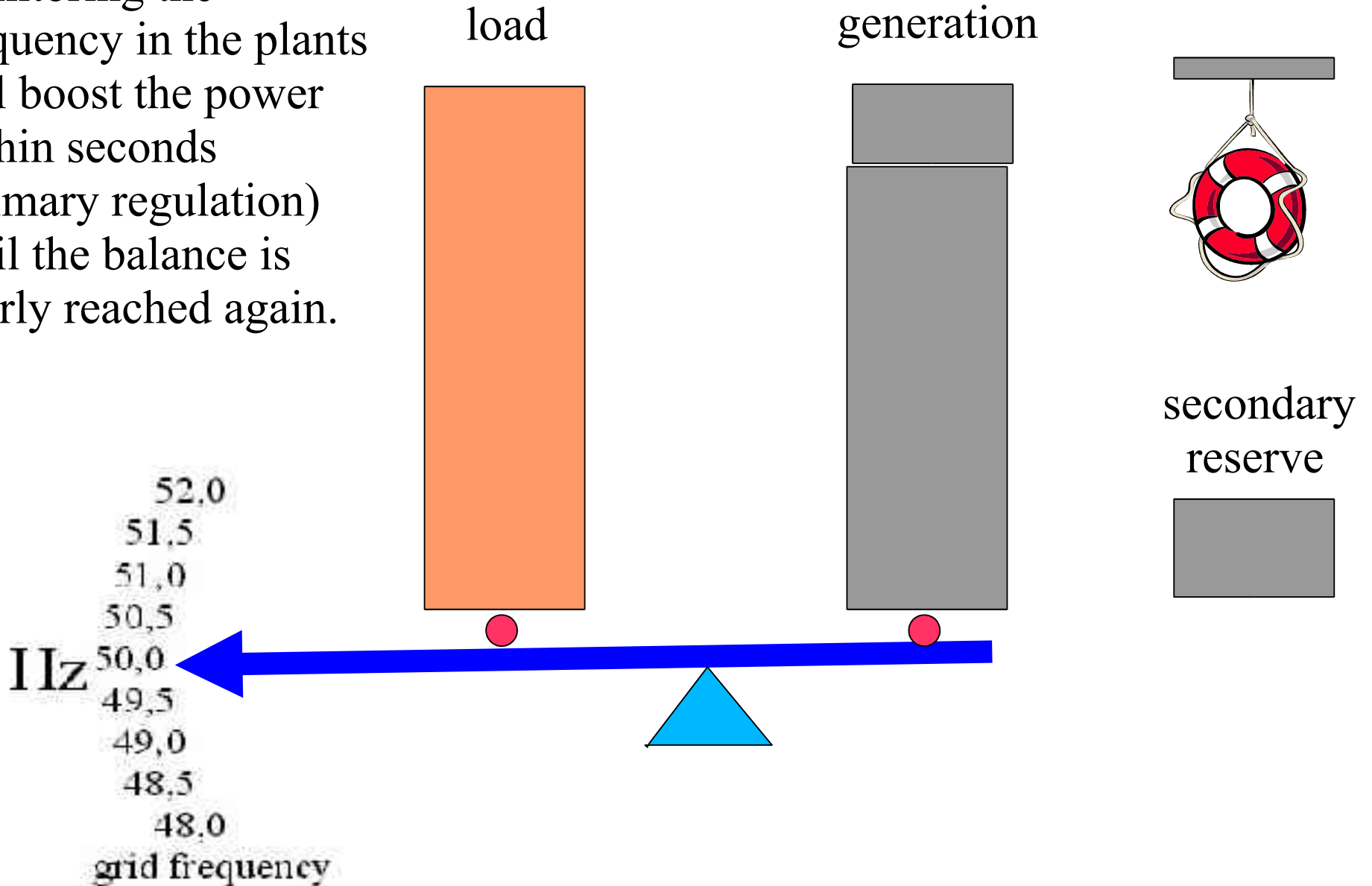
Grid Regulation

This loss of frequency must be stopped and compensated within seconds to keep the stability of the network.



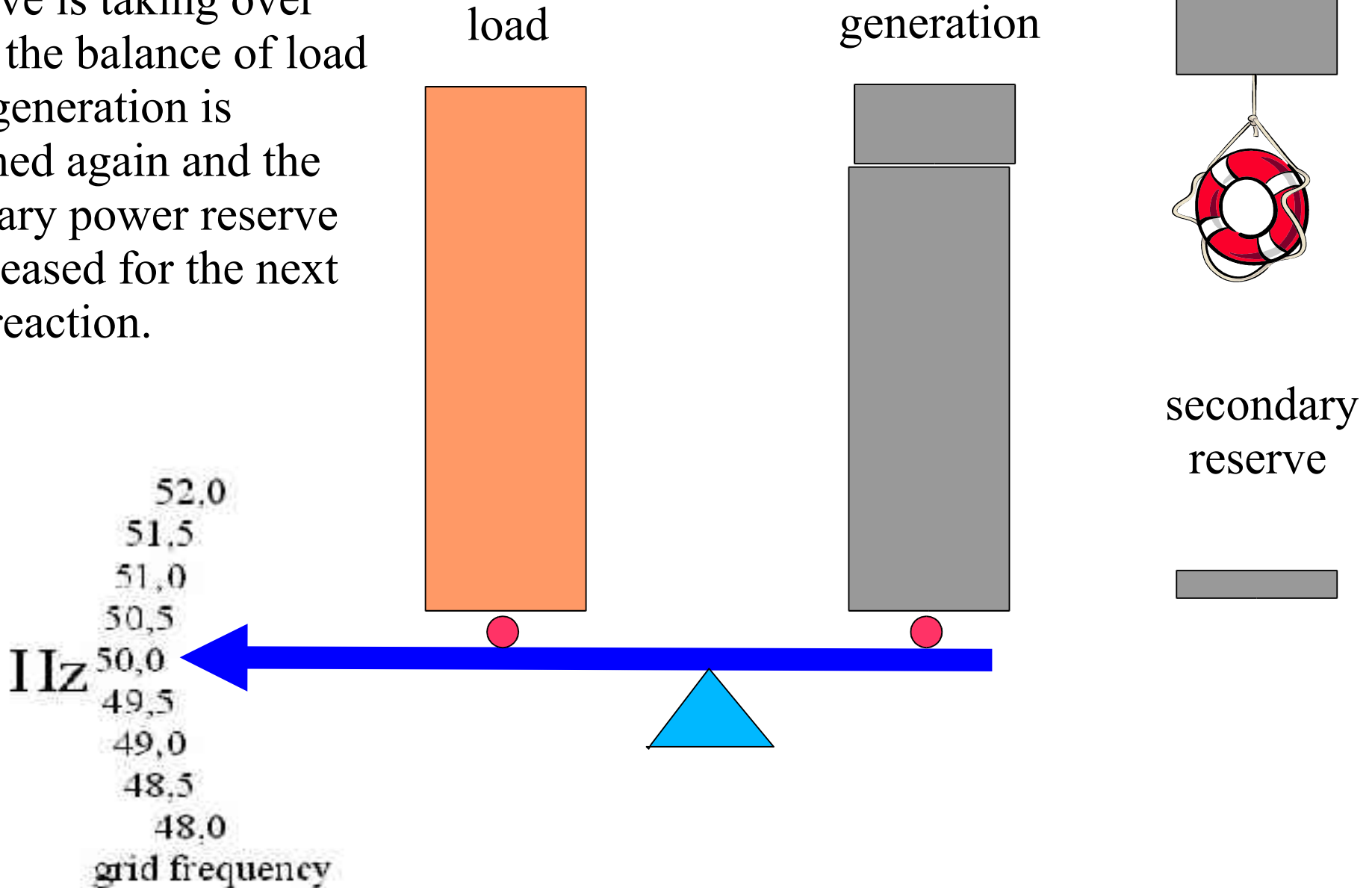
Grid Regulation

The regulators monitoring the frequency in the plants will boost the power within seconds (primary regulation) until the balance is nearly reached again.



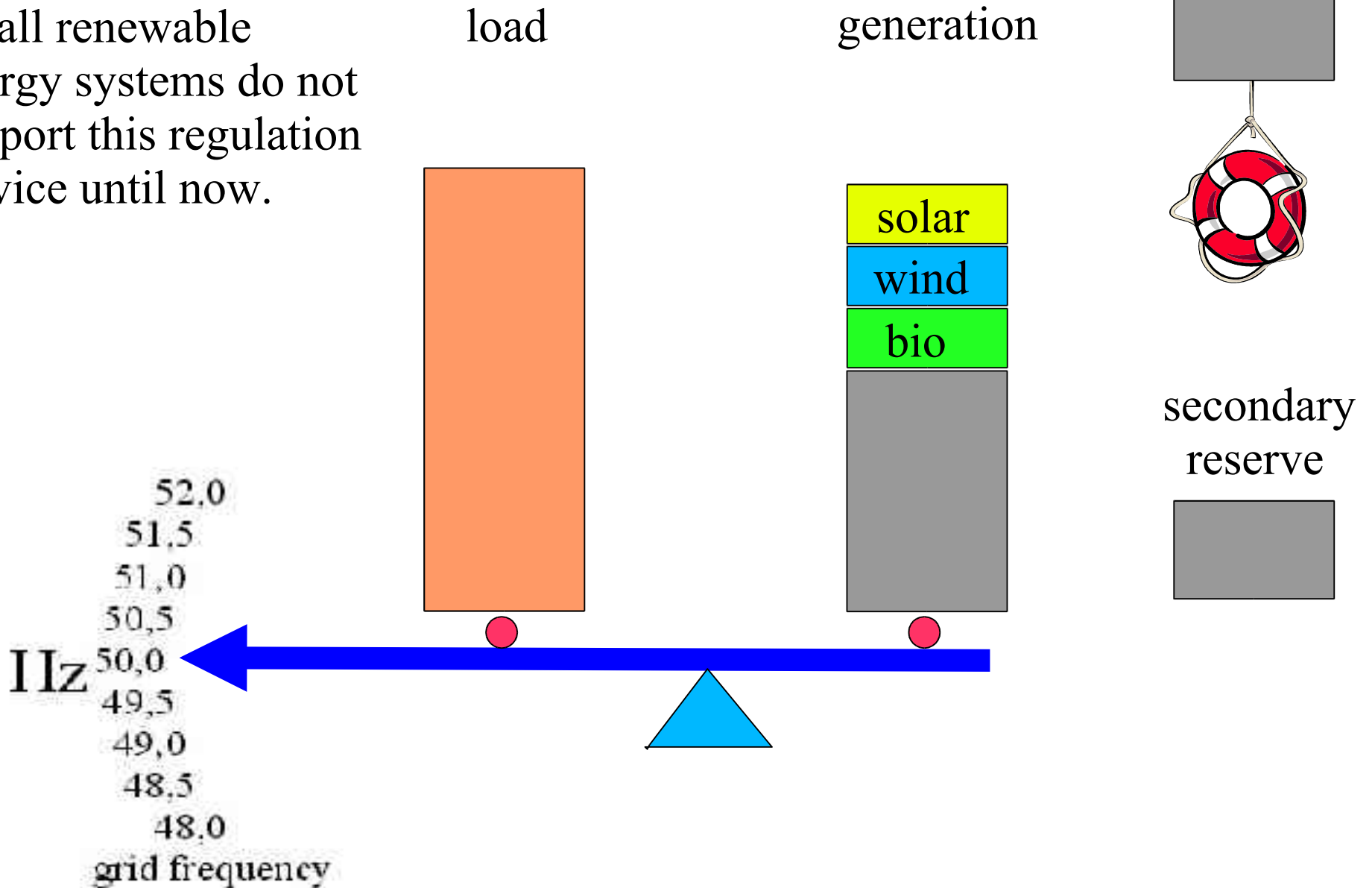
Grid Regulation

After a few minutes the secondary power reserve is taking over until the balance of load and generation is reached again and the primary power reserve is released for the next fast reaction.



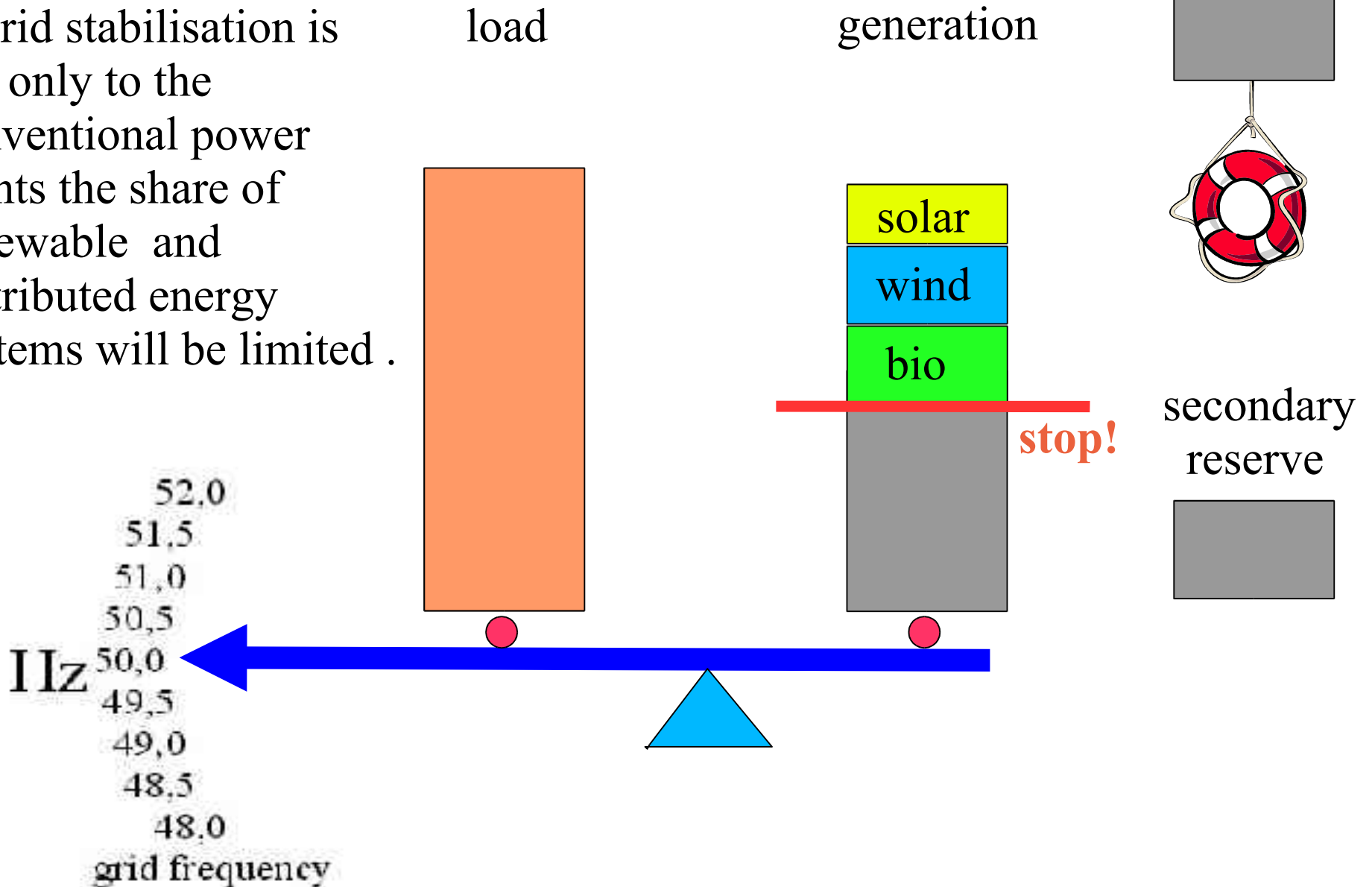
Grid Regulation

Small renewable energy systems do not support this regulation service until now.



Grid Regulation

If grid stabilisation is left only to the conventional power plants the share of renewable and distributed energy systems will be limited.



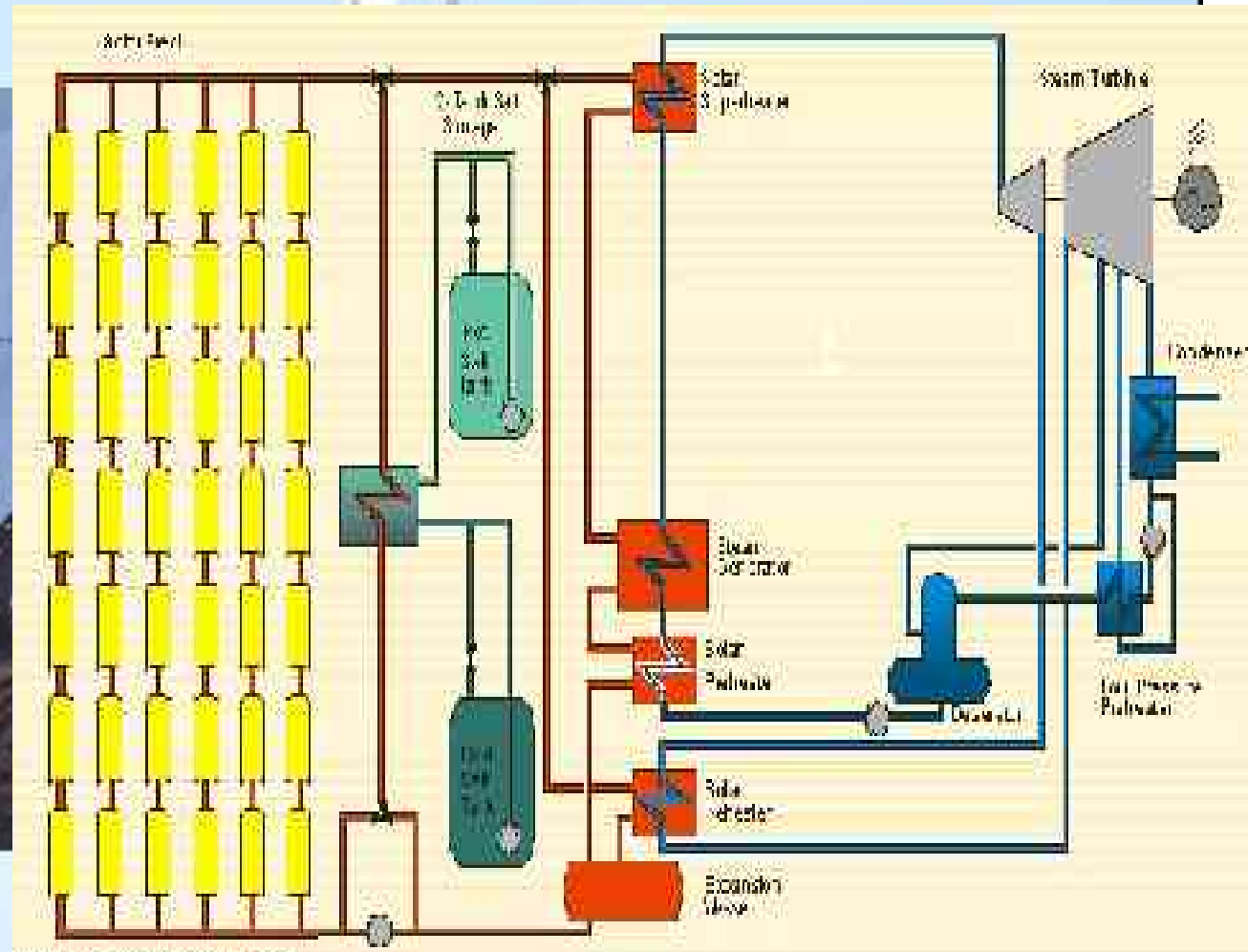
Projects in Spain: AndaSol I & II



- **Technology:** „Solar-only“ Parabolic Trough Power Plant
- **Installed Capacity:**
2 x 49,9 MW_{el}
- **Storage:** Two-tank molten salt storage for 7.7 full load hours
- **Project Site:** Plateau of Guadix, Province Granada
- **Net electricity production:**
2 x 179.1 GWh/a
- **EPC price:**
2 x 260 Million €

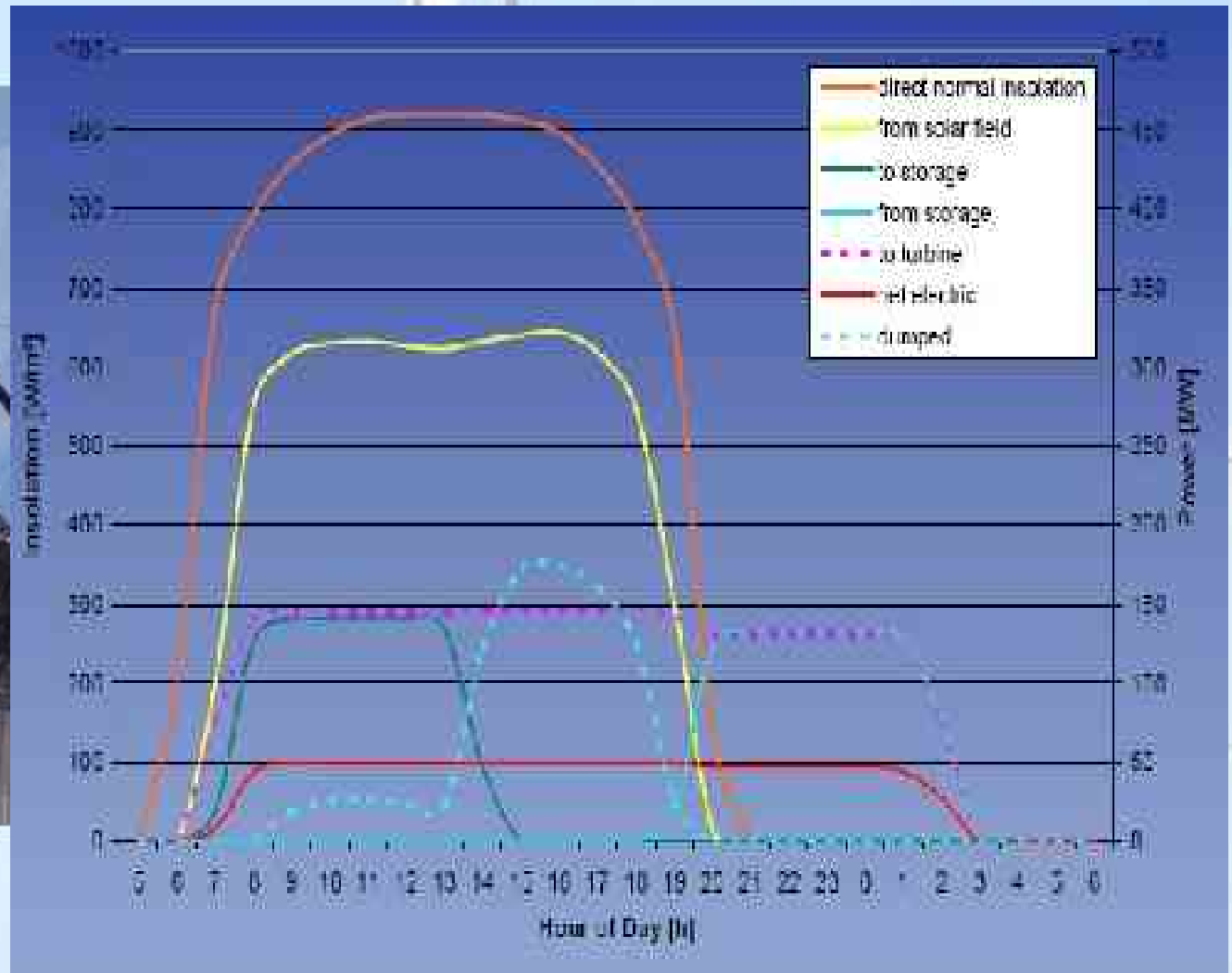
Solar power plants with storage capacity can be regulated.

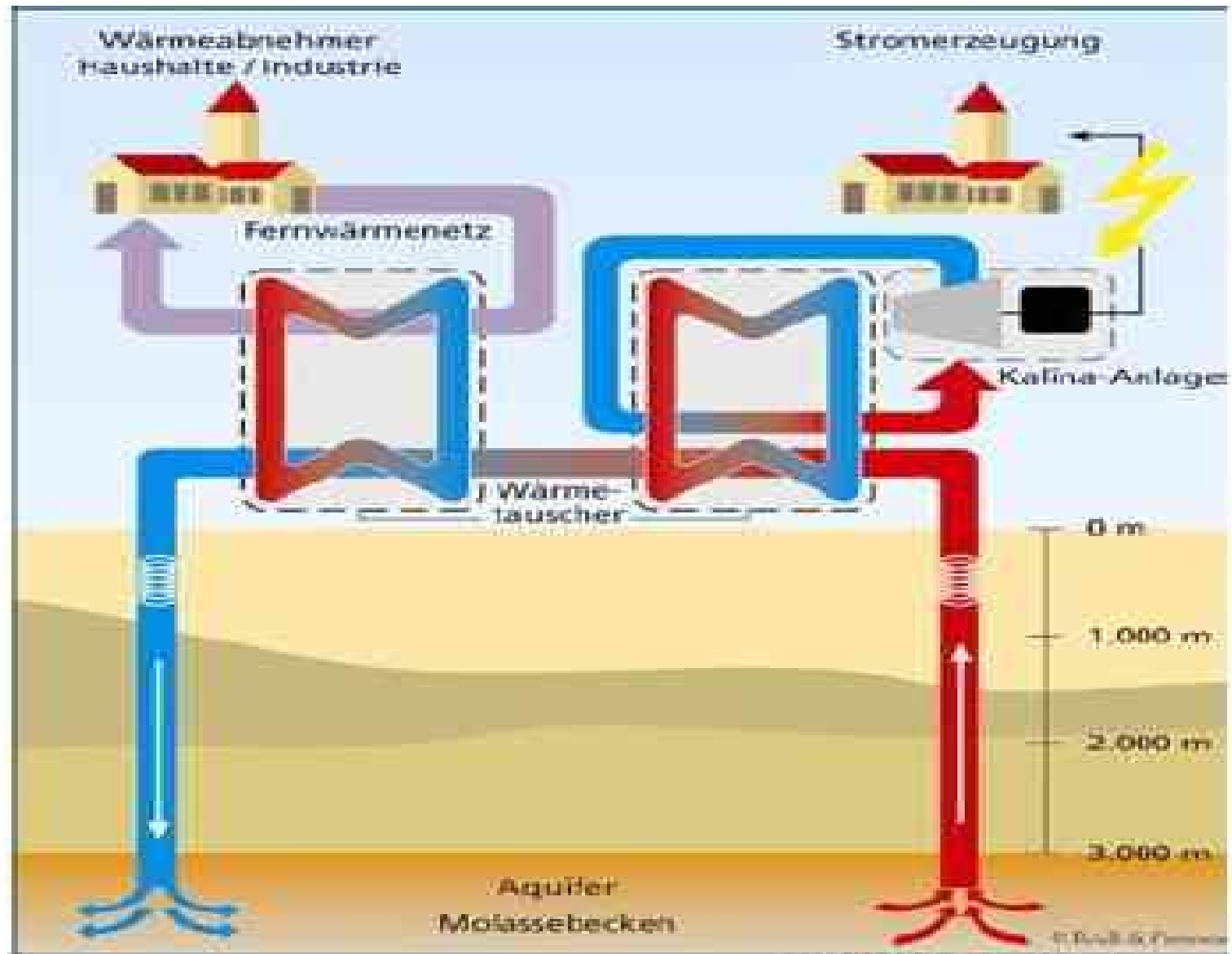
Projects in Spain: AndaSol I & II



rights by P. J. SOLIMAH 2005

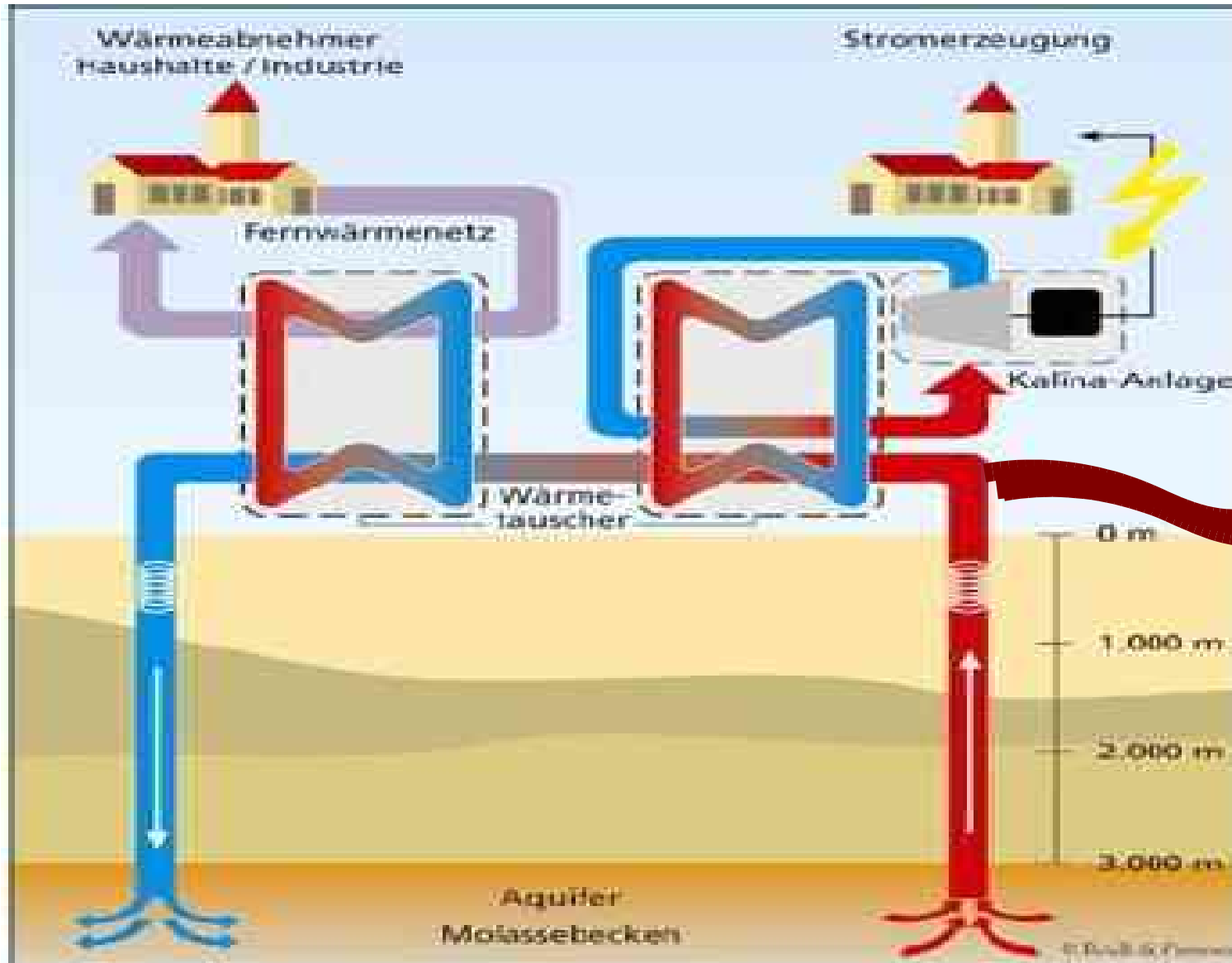
Projects in Spain: AndaSol I & II





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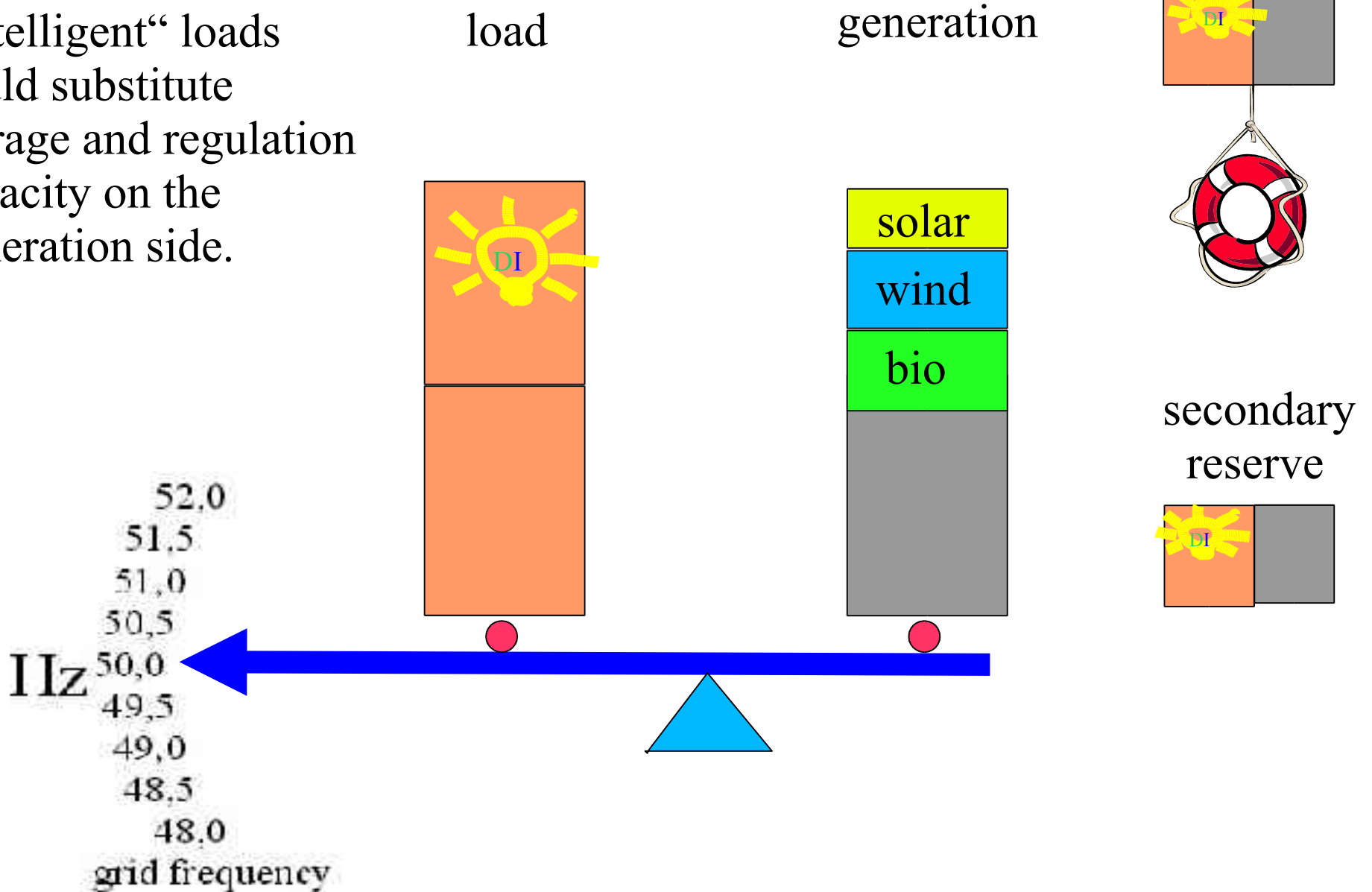
Geothermal is stored energy for thousands of years.

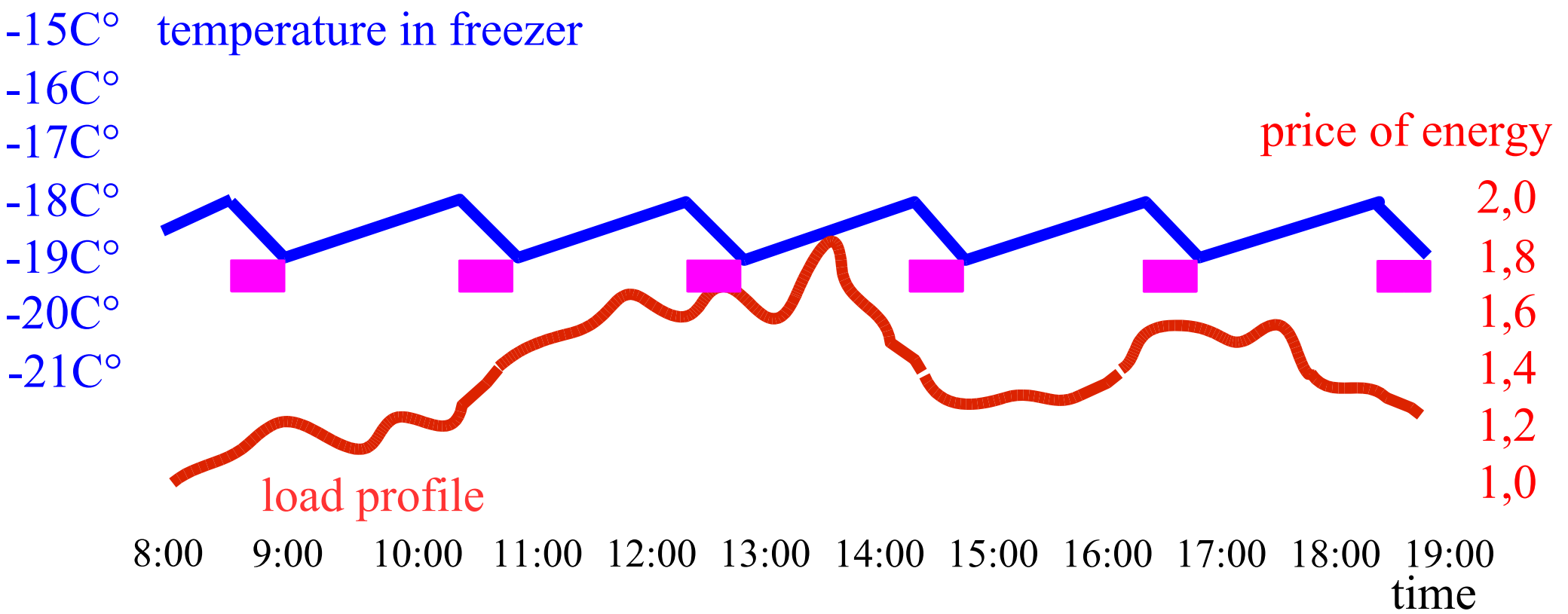


heat storage

Grid Regulation

„intelligent“ loads could substitute storage and regulation capacity on the generation side.





Loads are not „intelligent“.

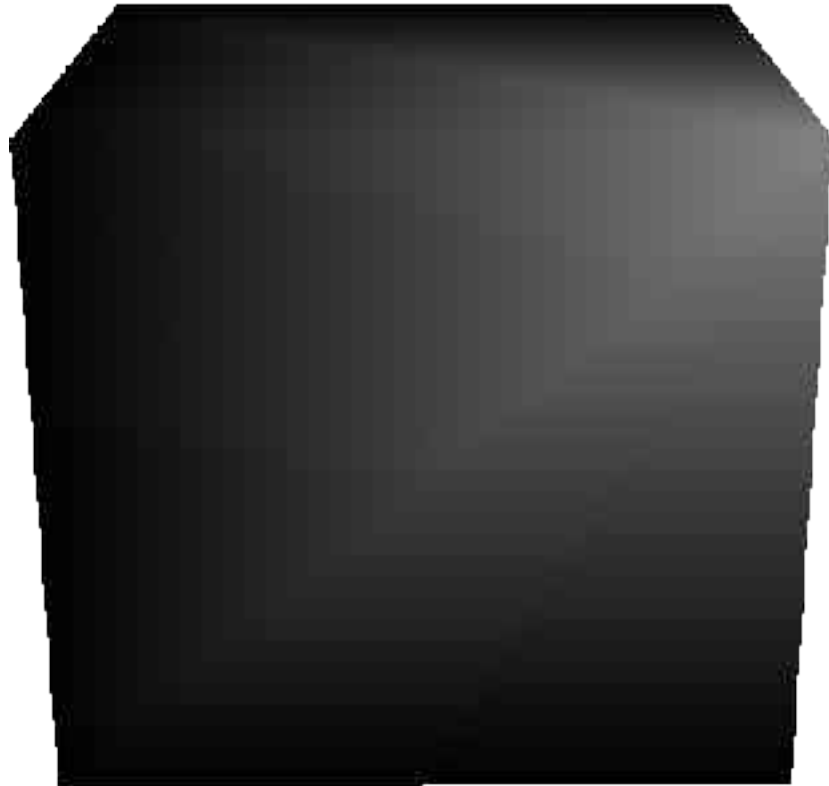


How to make loads
„intelligent“ ?

Imagine a black box and
put some engineers in it.

Give them instruments to
measure grid frequency
and voltage.

Give them the following
tasks:



watch frequency and switch off the load immediately if frequency is decreasing! This helps stabilizing the whole network.



Learn daily and weekly load profiles corresponding to voltage and learn how fast the temperature in the freezer is increasing and decreasing.



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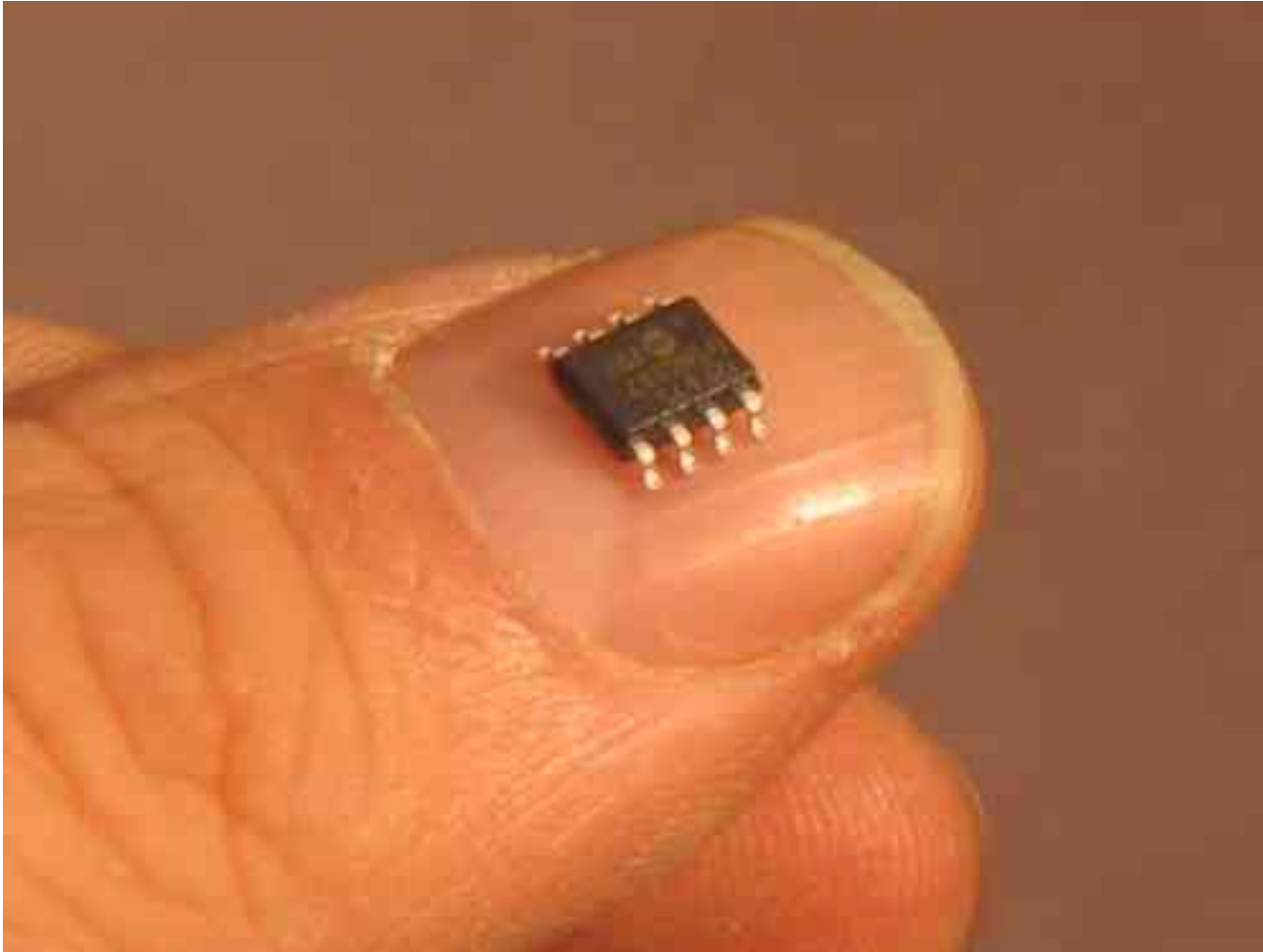


watch frequency and switch of the load immediately if frequency is decreasing! This helps stabilizing the whole network.

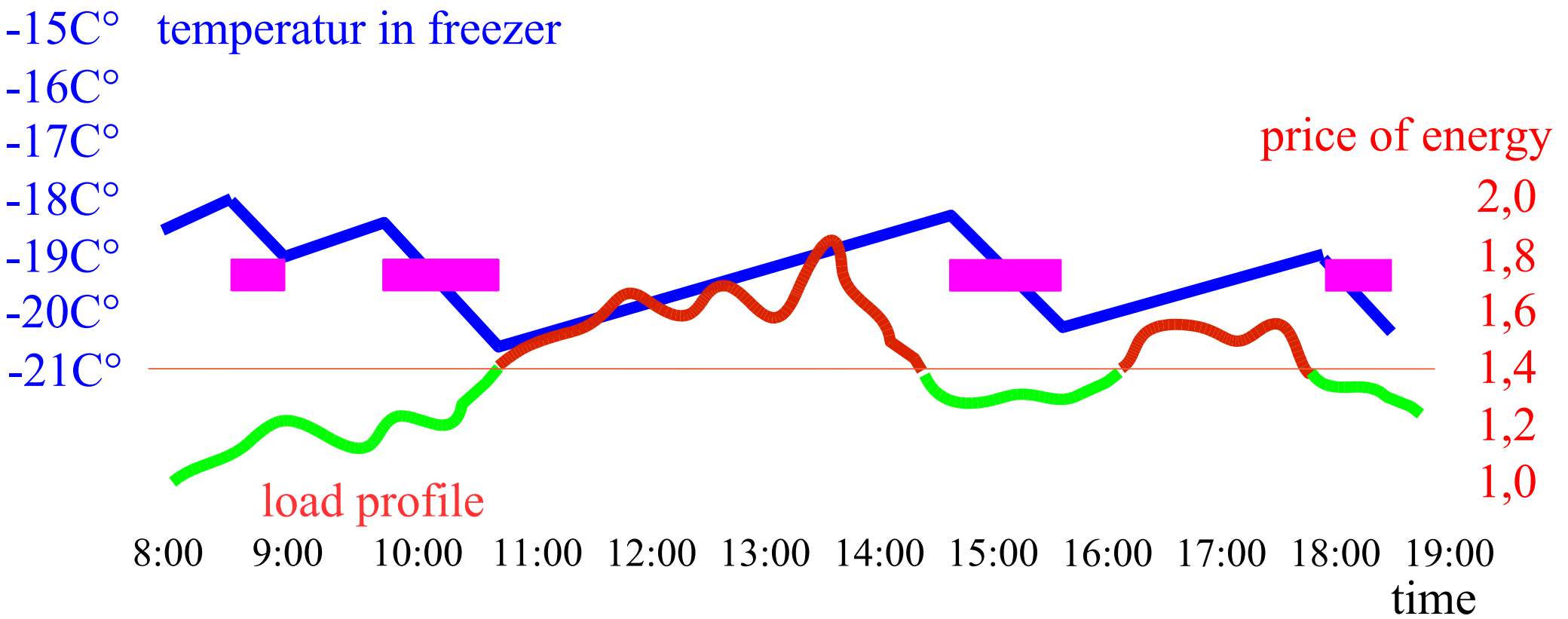


Make a strategy to switch on and off the cooling machine of the freezer avoiding times of higher grid load and using times of lower grid load.



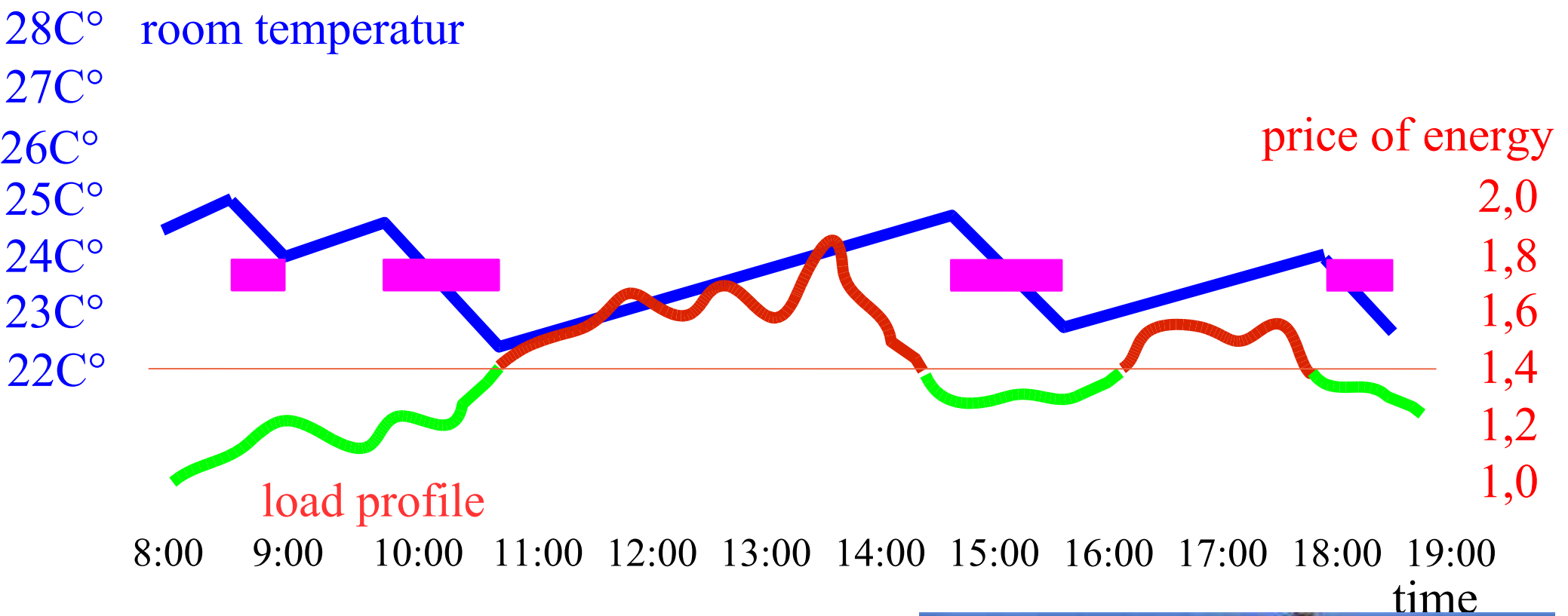


Today we are able to shrink this black box!



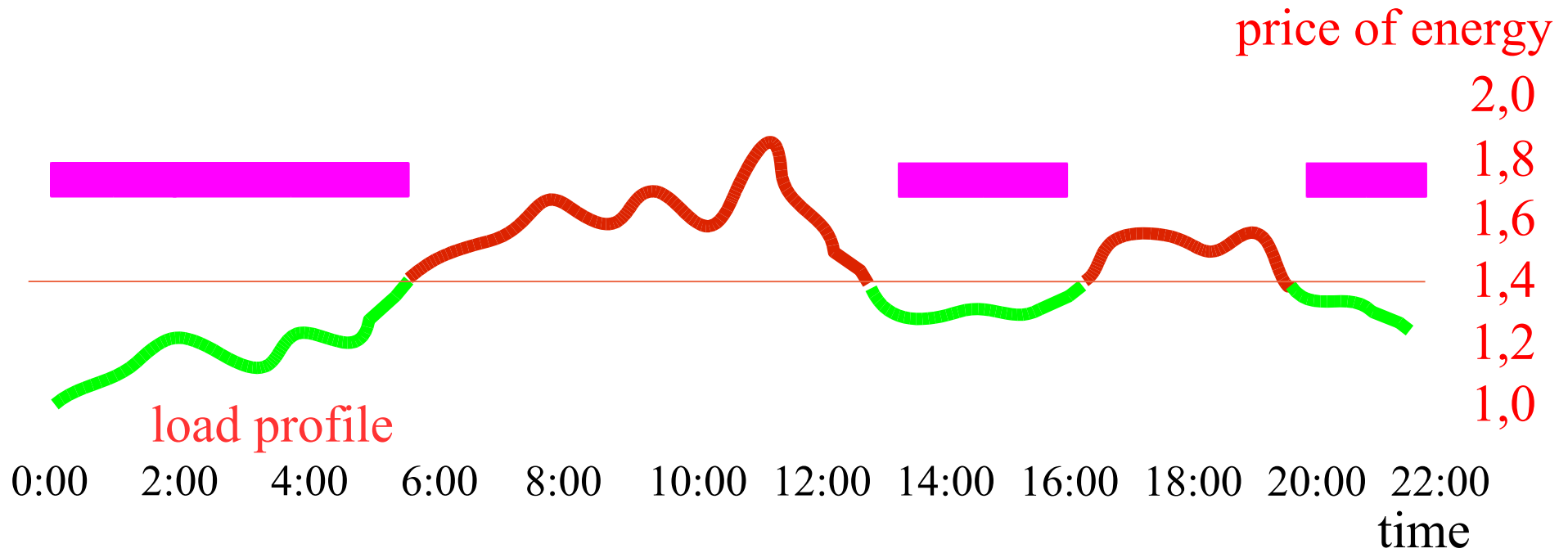
This is what our engineers found out to optimize the freezer.





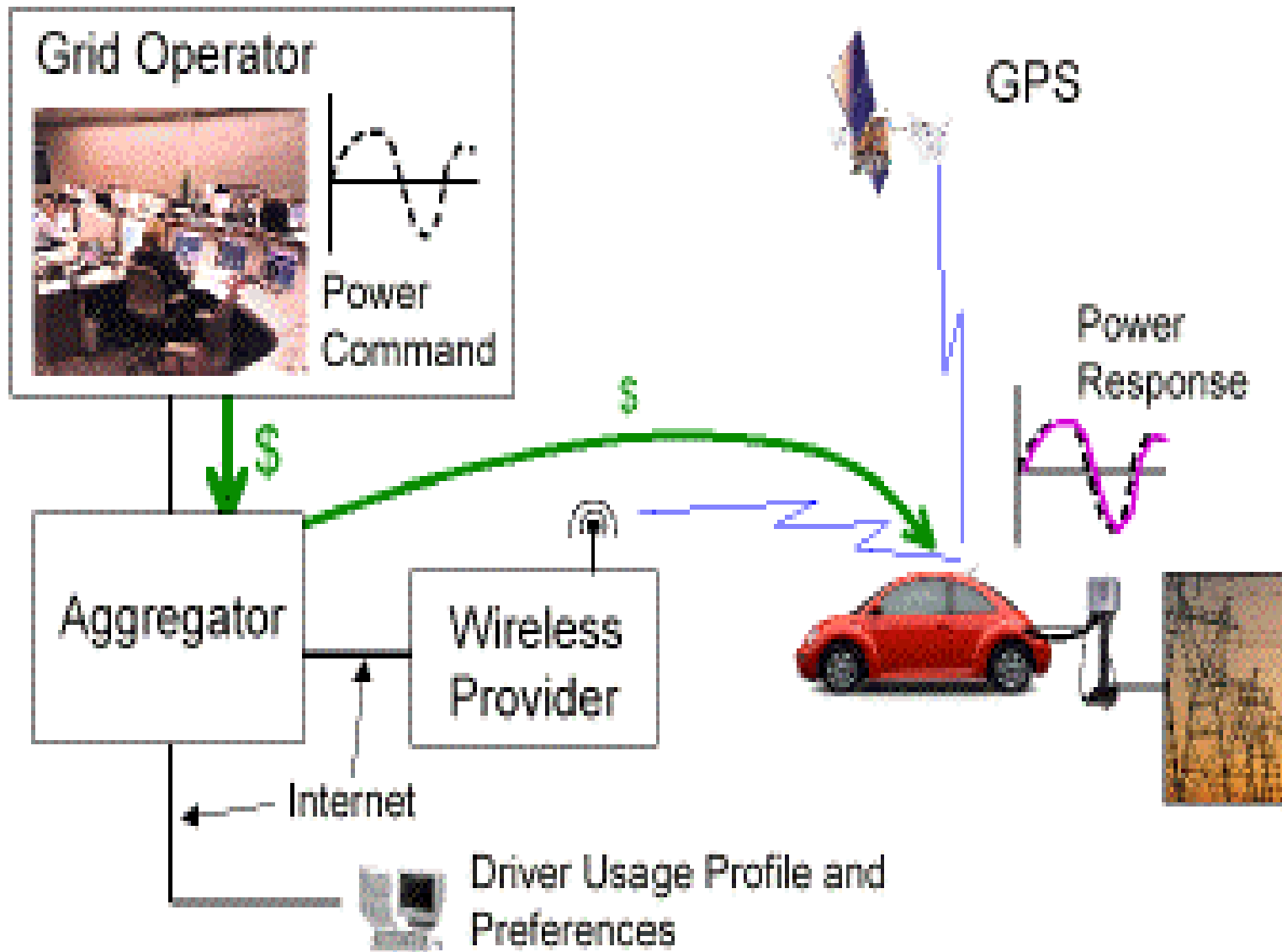
It could be used for airconditioning too.
 (This is the place of the Rio5 Conference)





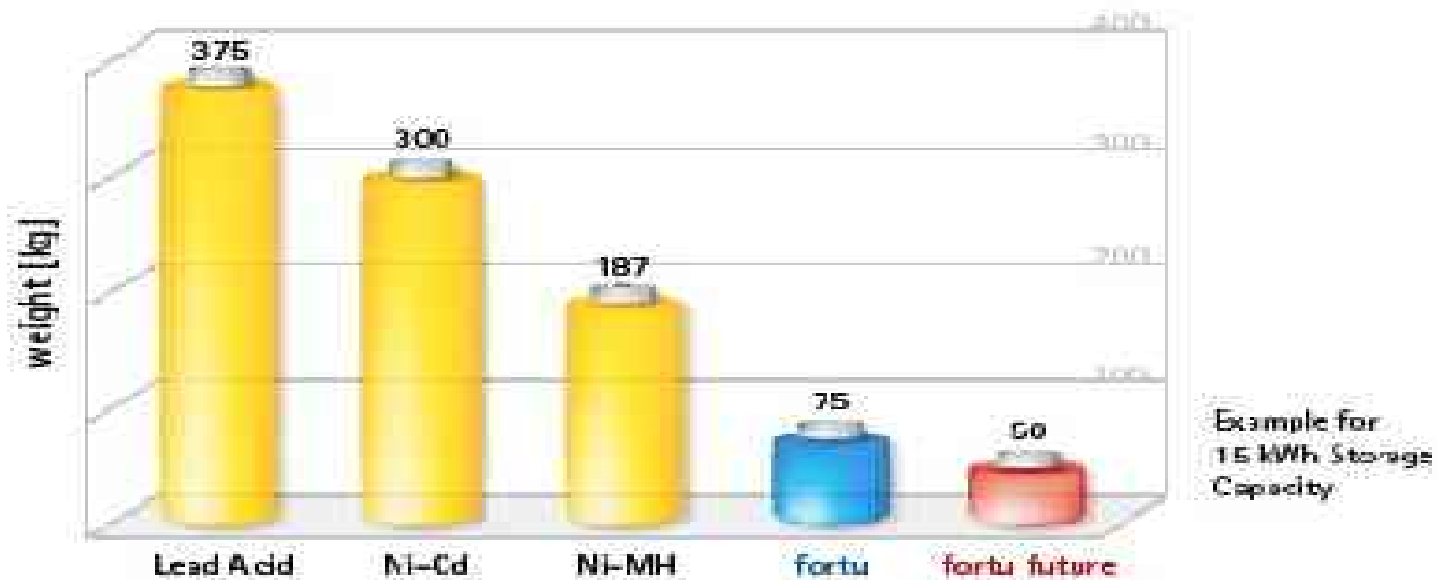
It could also be used for charging the batteries of electric vehicles.





In the Californian V2G (Vehicle to Grid) project vehicle batteries are used as an active power reserve for the grid via bidirectional inverters and wireless and internet based control. (www.V2G.com)

Comparison of fortu PowerCell with other evaluated vehicle batteries



New battery technologies could increase the range of electric vehicles dramatically.



Chinese style

tzero Earns Highest Grade at 2003 Michelin Challenge Bibendum



Californian style



Indian style



German style

Conclusions:

There are more of RE resources than we need. Some of them is stored energy und can be regulated to meet changing demands. Stabilization and regulation of the Power networks can be done with small distributed microelectronics. A future power network with distributed intelligence will be possible.



German style

