Projects for a better Earth

There are several projects and ideas that try to improve our world. Let's take a look at some of them.

1 Sustainable ideas

1.1 Cradle to cradle

A normal trend in sustainable thinking, is to reduce the amount of waste. In the **cradle to cradle** (C2C) ideology, things are done differently. It is attempted to create only waste that can be used in other products as well. A very important in C2C thinking is **waste equals food**. By applying C2C methods, we should make our footprint on our environment smaller, or even negative. We should work with nature, rather than against.

How should we implement C2C? It depends on the kind of product. For biological products, we should create a **bio-cycle**: The waste should be used as food by something else. For technological products, we should create a **techno-cycle**: We have to recycle the parts that can not be put back into nature. To accomplish this, it is wise to make products return to the producer. It is the duty of the producer to recycle the parts. This will make producers use parts that are more easy to recycle. The risk of the products to the environment are therefore not taken by the society anymore. Instead, they are taken by the producers.

1.2 Feed in system

A **feed in system** is a system that can be used to enlarge the market for a new technology. Once the market is large, the production costs will be lower. The feed in system is a concept succesfully applied in Germany to introduce solar energy. We'll examine this system by examining what was done in Germany.

In Germany, in 1995, the government ensured that people, putting solar panels on their roof, would get 1€$/kWh$ for the next 20 years. The government got this money from the people not getting the solar panels. (The plan was thus cost-neutral for the government.) Due to this promise, quite some people put solar panels on their roof. On the long run, they made a slight profit. The people not involved in the project payed a little. But, since there were a lot more people out of the project than in it, they didn't have to pay much. So they hardly noticed it.

In 2005, due to higher production rates, the price of solar panels had been reduced. So now the government promised 0.65€$/kWh$ for the next 20 years. More people started getting solar panels. So the group of people that was not in the project (and that are effectively paying for it) got smaller. However, the costs of the project also became lower. So, the people didn't have to start paying more.

This process continues, until the solar panels become a viable alternative to normal electric energy. By this time, the market for solar cells has become large enough to sustain itself.

We have just shown one way in which the feed in system can be applied. Of course, it can be applied in other situations as well. It could, for example, be used for the introduction of electric cars. (We'll discuss electric cars later.)

2 Making cars sustainable

Cars take up a lot of energy. They cause a big part of our climate problems. Making them sustainable would be a massive step forward to a sustainable planet. But how can we make cars sustainable?

2.1 Electric cars

Let's examine a car. An average car drives about $15000km/y$. It uses $1l$ of fuel for every $15km$ driven. So in one year, a car uses $1000l$ of fuel. Fuel costs about $1.5€/l$. So, driving for one year on fossile fuels costs €1500.

However, we can also let a car run on electricity. A car needs about $1kWh$ of electricity for a distance of $10km$. So in one year, a car needs $1500kWh$ of electricity. Electricity costs something like $20cts/kWh$. So driving for one year now only costs 300 euros.

Driving on electricity is thus meach cheaper. This is mainly caused by a difference in efficiency. When burning fossile fuels, our engine only has an efficiency of about 15%. However, when using electricity, we have an efficiency of 90%. That saves a lot!

Let's consider an idea: we put solar panels on our garage. These solar panels then power our car. In this case, electricity is a bit more expensive. It now costs something like $35cts/kWh$. So driving for one year costs 525 euros. It's still a lot cheaper than using fossile fuels. So, let's all use electric cars!

2.2 Vehicle to grid

Conventional power plants have a big downside. They can only generate a constant amount of power. (Starting up a power plant usually takes a week.) But the demand for power is not constant. The demand during the day is much higher than the demand during the night. So, power needs to be stored. This is usually rather difficult and expensive.

But now let's suppose that all cars are electrically driven. The batteries of these cars can be used for storage. Let's examine such a battery. If a car needs to drive $200km$ on one tank, then it needs a capacity of $20kWh$. If we use **lead acid** batteries, with specific capacity $0.03kWh/kg$, then we have $700kg$ of batteries. But if we use **lithium polymer** batteries, with specific capacity $0.2kWh/kg$, then we only have $100kg$ of batteries. That's good enough to put in a car.

Now let's look at what we need to store. An average household uses $4000kWh/y \approx 0.5kW$. This means that a car can store for about 40 hours worth of electricity. That's sufficient for a household to get through the day. So, if we connect cars to the electricity grid, then the whole energy storage problem is more or less solved. By the way, this idea, of connecting cars to the electricity grid, is called **vehicle to grid** (V2G).

2.3 Using hydrogen as fuel

We can also let cars drive on hydrogen. Hydrogen can contain much more energy than fossile fuels. (Burning $1kg$ of hydrogen (H_2) gives 8 times more energy than burning $1kg$ of methane (CH_4).) Plus, converting hydrogen to electricity can be done with an efficiency of 50% to 70%, where this is only about 15% for fossil fuels.

Hydrogen is positive in many other ways too. Hydrogen is sufficiently available on our planet. The world production of hydrogen is already quite big ($50MT/y$), and it's expected to rise in the coming years. Hydrogen cars aren't dangerous, as many people believe. Instead, normal fuels are more dangerous to use than hydrogen. Fuel cells are also very safe. They are silent, and hardly have moving parts, so they require few maintenance.

3 Contests

Several contests are being held, aiming to promote sustainable thinking. These contests also often result in interesting new developments. Let's take a look at some of these contests.

3.1 The World Solar Challenge

The **World Solar Challenge** (WSC) is held every two years in Australia. It is a race of over $3000km$. Teams drive from eight o'clock in the morning to five o'clock in the afternoon.

In 2001, the Nuna 1 participated. First, we'll examine the **roll drag** of this car. Its mass was $m = 350kg$. The weight was thus $W = 3500N$. With a friction coefficient of $\mu_k = 0.01$, the roll drag was only $D = \mu_k N = \mu_k W = 35N$. With a velocity of $30m/s$, this gave a power of $P_{roll} = 1000W$.

Now, let's examine **aerodynamic drag**. The frontal surface area was $S_{front} = 1.1m^2$. The drag coefficient was $C_D = 0.1$. So, the effective drag surface was $S_d = C_D S_{front} \approx 0.1m^2$. The dynamic pressure was $\frac{1}{2}\rho V^2 \approx 500Pa$. The power necessary to compensate for the aerodynamic drag thus is $P_{aero} = 1500W$. In reality, the Nuna team managed to lower these figures even further, to $P_{roll} = 700W$ and $P_{aero} = 1400W$. So, $P_{total} = 2100W$.

To generate power, solar cells were used. A surface area of $S = 9m^2$ was used. The solar cells had an efficiency of $\eta = 24\%$. In Australia, during the summer, the average solar intensity is about $I = 1000W/m^2$. This thus gave a power production of $P_{prod} = 2160W/m^2$. There is therefore sufficient production of energy to power the car.

The newest Nuna, the Nuna 5, will get an efficiency of roughly $\eta = 35\%$. Also, its drag coefficient will be a lot lower. So we can expect great things from this new solar car.

3.2 Fryslan Sinneboat Race

The **Fryslan Sinneboat Race** (Frisian for Frisian Solarboat Race) is a race for solar boats. It's also held once every two years. In 2006, the first edition was held. A team from Delft won, having an average speed of $13km/h$. In 2008, Delft won again. This time the speed was $20km/h$. And the plans for 2010 are even more ambitious.

4 Other projects

There are several other projects, which may potentially improve our planet. Let's examine a few.

4.1 Sailing boat

Let's examine a sailing boat. We could put something like an inverse propeller on this boat. Normally, a propeller uses energy and propels the boat. The inverse propeller does the opposite: it provides energy. In this way, two persons can live on the boat. And, to have enough energy, they only have to sail one day per week.

Let's do some calculations. We say that the boat has $S = 30m^2$ of sail. The wind speed is $V_w = 10m/s$ on average. The dynamic pressure is thus $q = \frac{1}{2}\rho V_w^2 \approx 60Pa$. We thus have a force of $F = qS = 18kN$. The boat usually sails at a speed of $V_b = 4m/s$. So, the available power is $P = FV_b = 72kW$. Assuming that the inverse propeller has an efficiency of 10%, the battery receives $7kW$ of power. If the battery has a capacity of $350kWh$, then we only need to sail 50 hours (2 days) to fill the batteries.

Now let's look at how much power we need. An average household uses $4000kWh/y \approx 0.5kW$. Let's say that the boat, including equipment, uses twice this amount, being $1kWh$. We can thus use our battery without sailing for 350 hours, which is over two weeks.

Let's examine the costs. The sail costs about 10.000 euros. It lasts for two years, which equals about 17000 hours. The sail costs thus are $0.6€/h$. When sailing, we generate $7kW = 7kWh/h$. So, our energy costs $0.6/7 \approx 0.1€/kWh$. Of course the other equipment has to be taken into account as well. But still, it's quite a good price for electricity.

4.2 The Superbus

The **Superbus** is a new kind of bus that is still in development. It will be powered by batteries. It is supposed to be driving on its own lanes called Super Lanes. Building these Super Lanes (the infrastructure) is rather expensive. But it is still less expensive than building rails. So the Superbus could, in time, be a viable alternative for replacing trains.

The superbus will be travelling at velocities between $150km/h$ and $250km/h$ outside of cities. Because of its unique aerodynamic shape, and its low position above the road, it is aerodynamically very efficient. Due to this, not much power will be needed for propulsion. The Superbus is thus an economically feasible project.

4.3 The Laddermill

When you hold up a kite against the wind, it tends to go up. But, when you have an aircraft in the air, it tends to come down. These principles are used in a **laddermill**. A laddermill consists of a chain kites.

Let's consider one such kite. Its area will be about $10m^2$. Its cost is around 30 euros, when it is fabricated in China. The power provided by the kite is between $3kW$ and $5kW$. The cloth of the kites lasts for about $500h$. So a kite generates at least $1500kWh$. This implies that the cost of electricity, coming from the laddermill, is about $30/1500 = 0.02€/kWh$. This is very cheap for electricity. Of course there are several other operational costs. But still, the laddermill seems to be a viable way of generating cheap electricity.

4.4 Solar cells on the Afsluitdijk

In the North of the Netherlands is a $30km$ long dike, called the **Afsluitdijk**. We can put solar cells on it. The height of the dike is about $6m$. We thus have a surface area of $180000m^2$. Fixed solar panels in the Netherlands usually give an energy of about $110kWh/m^2y$. The whole Afsluitdijk can thus provide us with $55000kWh$ every day.

Now let's look at the cars driving over the Afsluitdijk. There are 18000 of them every day. If these cars would have been electric, each one would have needed $3kWh$ to cross the afsluidijk. So all cars together would need $54000kWh$. The solar panels on the Afsluitdijk could then provide power for all the cars driving over it. Isn't that amazing?