Biofuels for transportation and electric vehicles

There is currently room for both

January 2011

ABI

Transportation is almost wholly dependent on petroleum

Biofuels can be a viable alternative

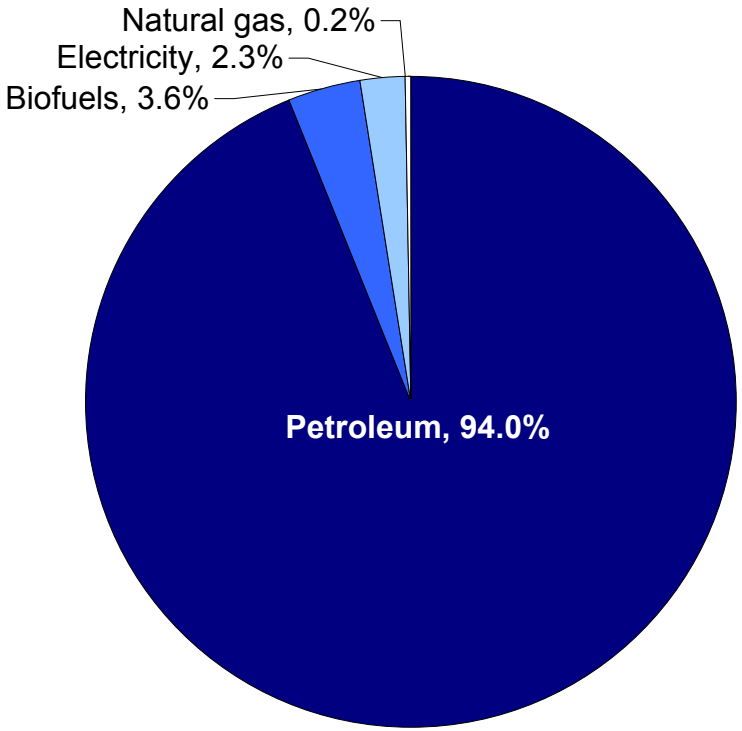
Electric vehicles have great potential

Currently, both can help slowly wean us off petroleum

Today, petroleum supplies almost all of the energy used for transportation

Energy used in EU transportation 2010

(road, rail, and air)



Alternatives are being sought

- To reduce emissions of greenhouse gases into the atmosphere
- To reduce our dependency on energy imports from a handful of countries, some of which are politically unreliable
- Because the world's reserves of easily accessible crude oil are finite and new fields are becoming increasingly costly and risky to access

Source: European Commission

Note: In the US, petroleum supplies 93.8% of the energy used in transportation according to the US Department of Energy

Transportation is almost wholly dependent on petroleum

Biofuels can be a viable alternative

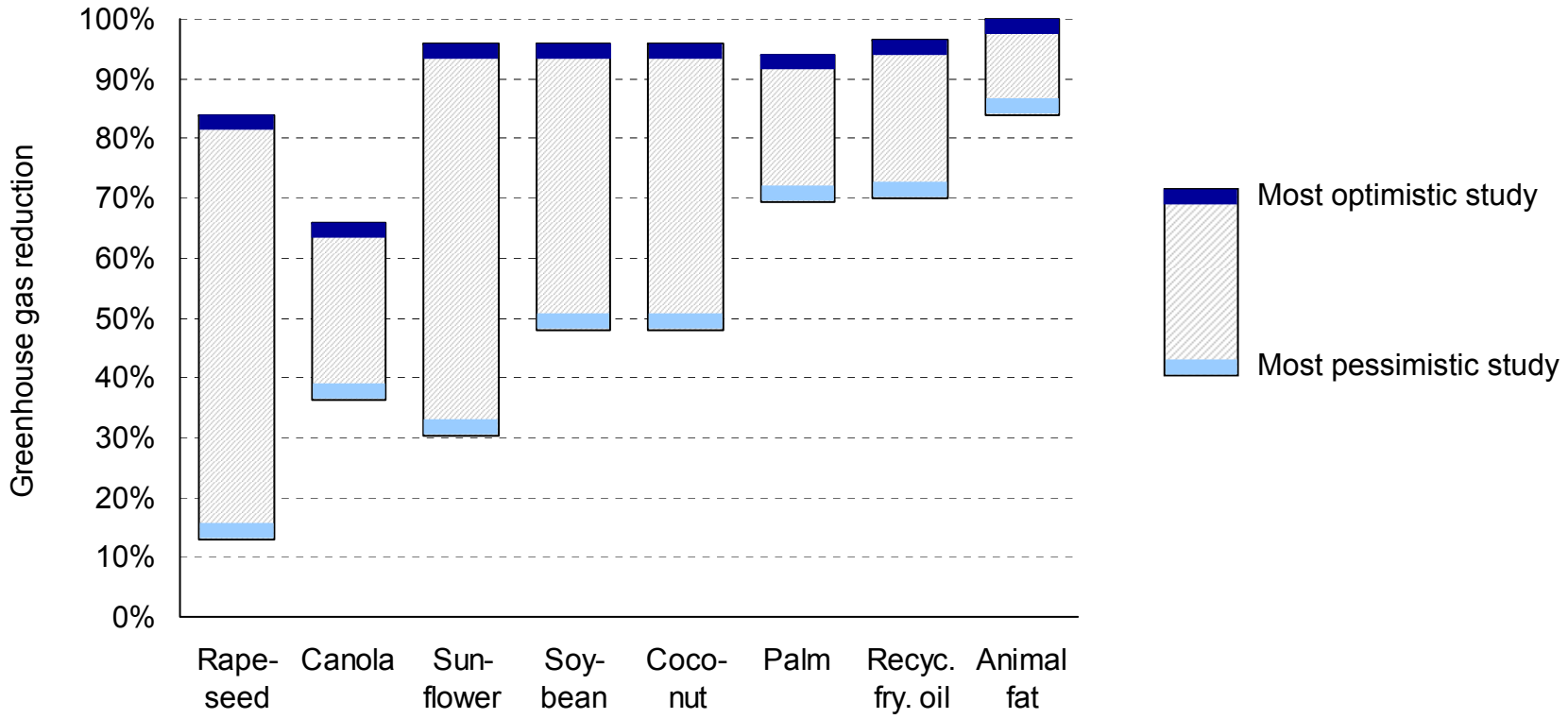
Electric vehicles have great potential

Currently, both can help slowly wean us off petroleum

All scientifically reputable studies show that the ongoing production of biodiesel does help reduce greenhouse gas emissions

Greenhouse gas savings achieved by substituting a liter of diesel with biodiesel

(by raw material, including all life-cycle emissions except the one time carbon release due to land use change)

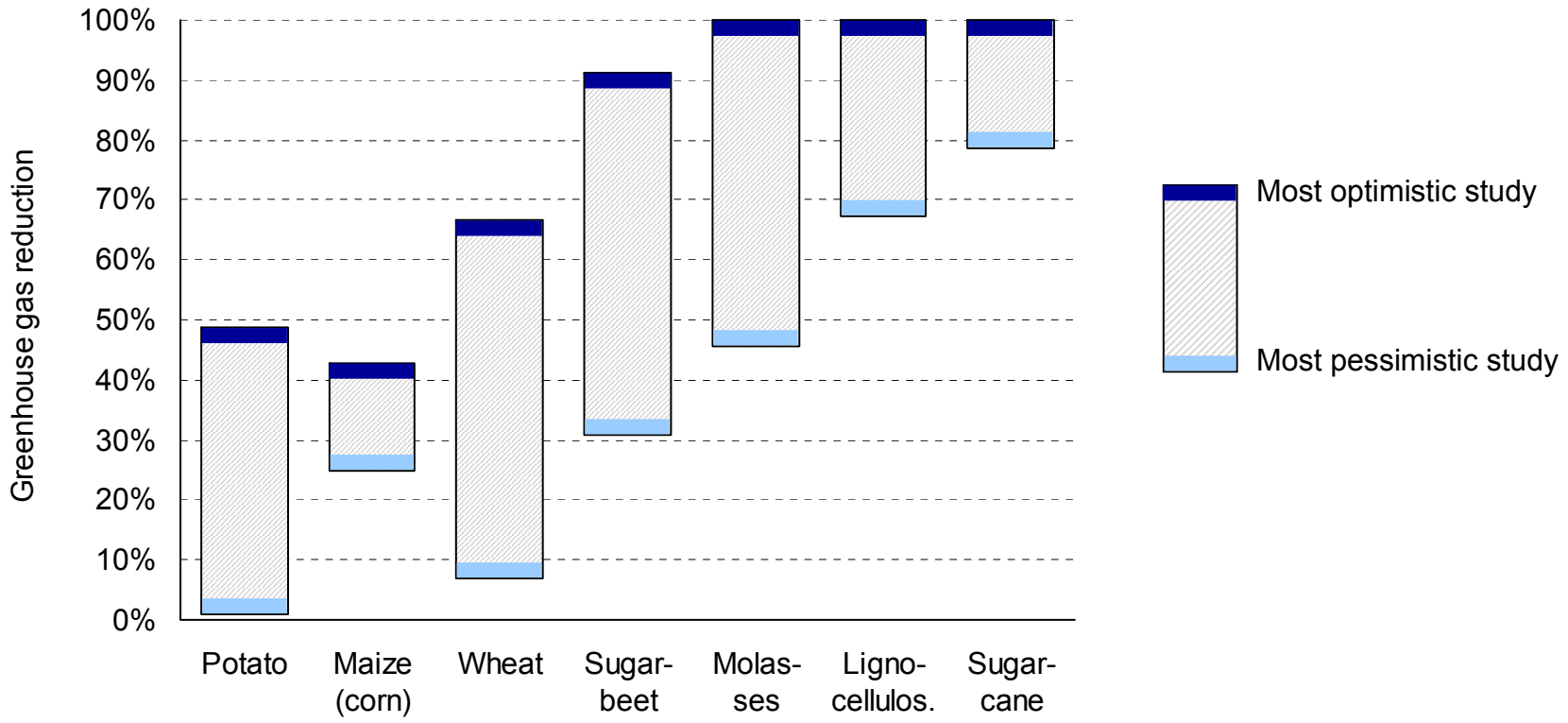


Source: Institute for Energy and Environmental Research Heidelberg, analysis of all published studies worldwide

Ethanol also reduces greenhouse gas emissions, but the savings vary more widely depending on the raw material used

Greenhouse gas savings achieved by substituting a liter of gasoline with ethanol

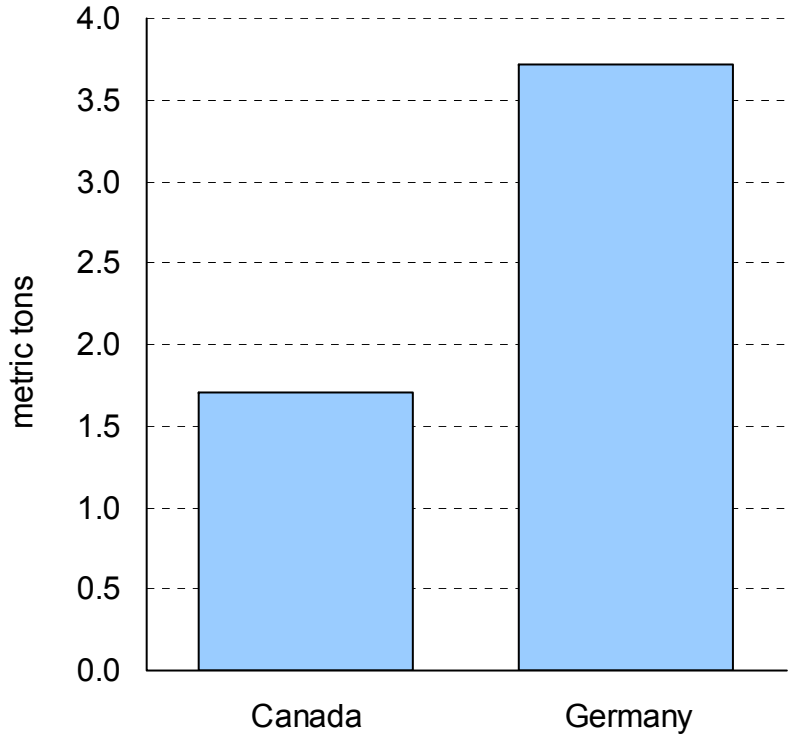
(by raw material, including all life-cycle emissions except the one time carbon release due to land use change)



Source: Institute for Energy and Environmental Research Heidelberg, analysis of all published studies worldwide

These greenhouse gas savings are possible without land use change, but the higher yields per hectare this would require would likely raise food prices

Rapeseed / canola average yield per hectare
(2006/2007 growing season)



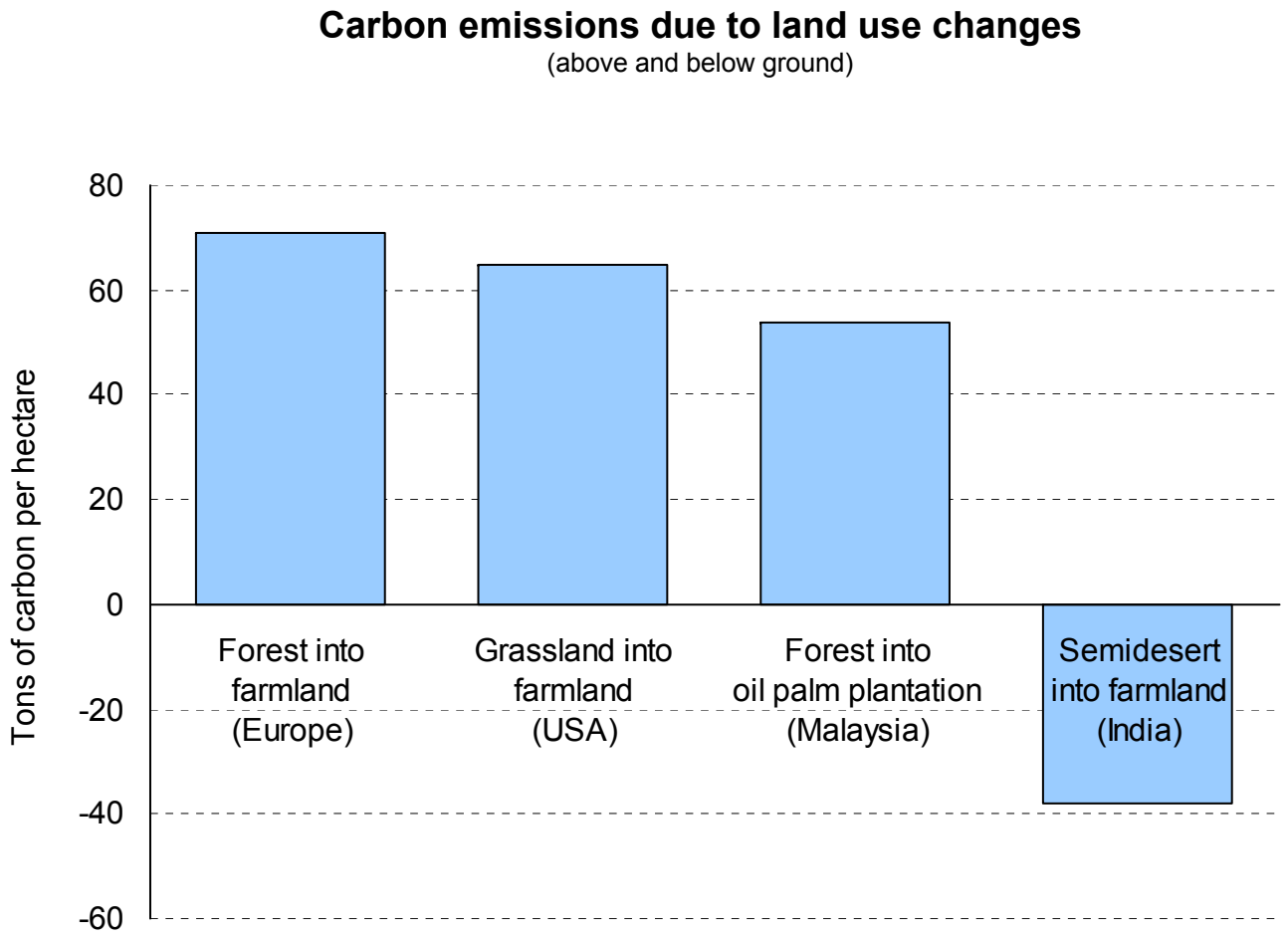
This would likely raise food prices

- The yield per hectare for rapeseed/canola is twice as high in Germany as it is in Canada because Germans farm their land much more intensively
- If yields were increased globally by 50%, we could produce as much food as we do today plus replace all petroleum in transportation with biofuels without deforesting any additional land
- However, to pay for all the fertilizer, GPS-guided farming equipment, R&D, etc., agricultural prices would have to rise
- Only few people are willing to accept higher food prices for the sake of renewable energy

Source: Oil World, US Energy Information Administration, Statistics Austria

Note: Biofuels supplied approx. 2.5% of global transportation energy needs in 2007 while 1.3% of agricultural land was harvested to produce this

If additional land is converted to agricultural usage instead, a one-time release of greenhouse gases into the atmosphere usually occurs

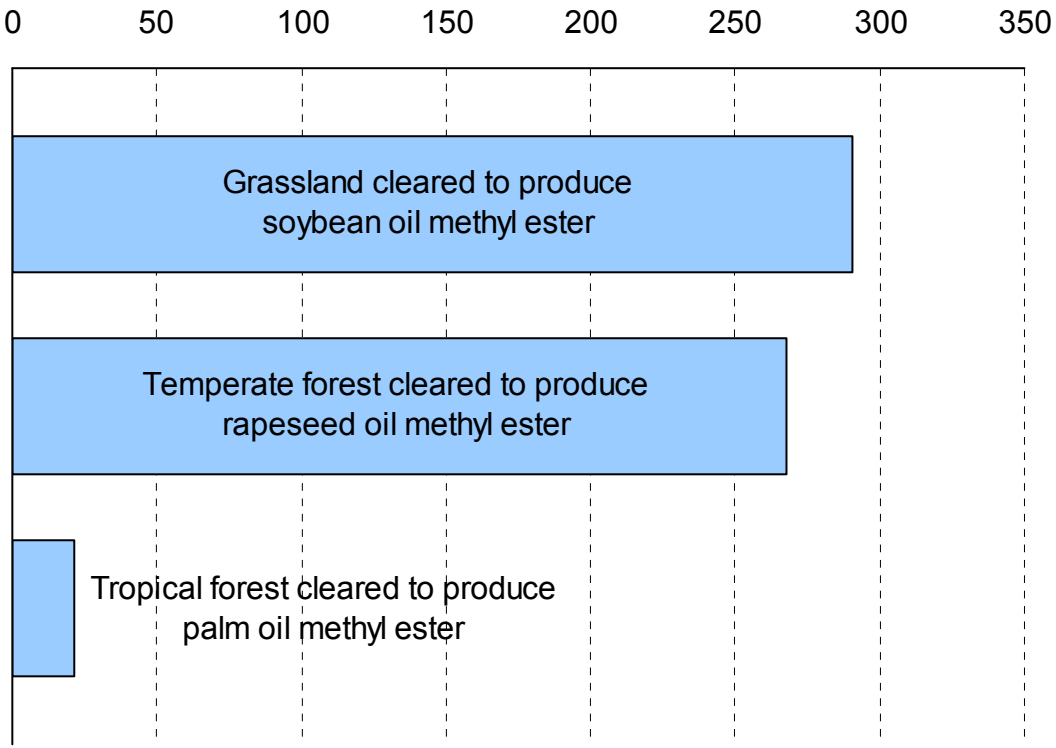


Source: IPCC

Note: The data from the UN FAO differs from that of the IPCC. The FAO data is more favorable towards biofuels

It usually takes many annual savings from biofuels to make up for the initial CO_2 release, though often less in the tropics than in temperate climates

Years of farming required to make up for one-time CO_2 release
(preliminary calculation)



Notes

- The carbon stock of the native vegetation, the carbon sequestration and annual yield of the crops planted, the value of the by-products, etc., vary widely
- Reliable data and methodologies to calculate the effects of direct and indirect land use change are just now being developed
- However, it seems clear that developing nations could often make up for the release much faster than developed nations did

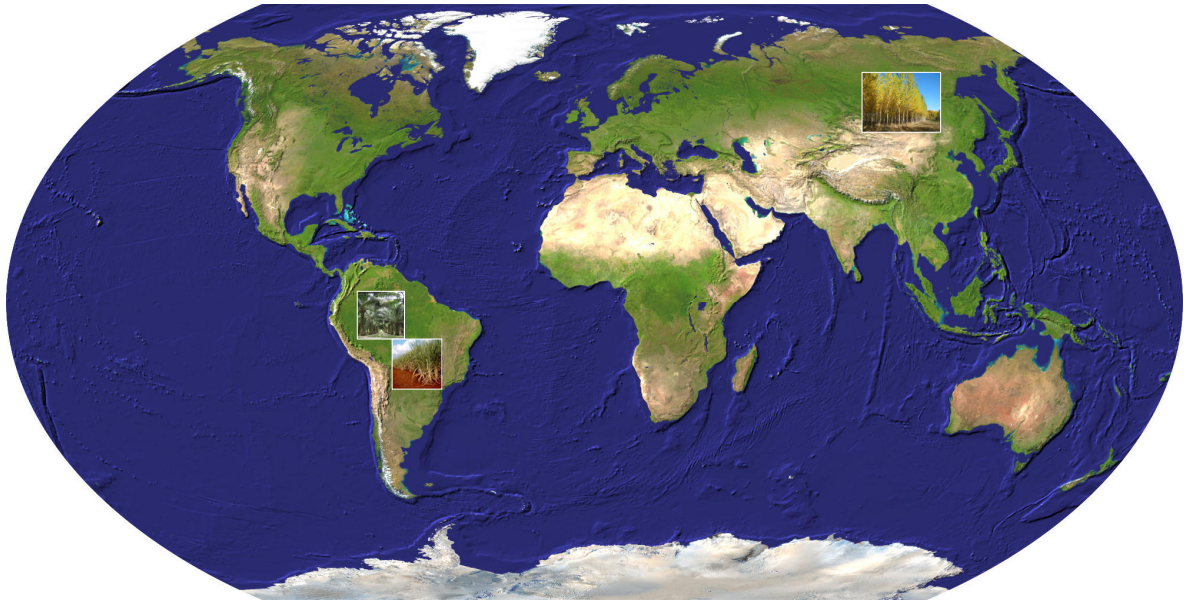
Source: IPCC, Oil World

ABI

The amount of land we would currently need to clear to replace all gasoline and diesel in transportation with biofuels is nonetheless not acceptable

Additional farmland required to replace gasoline and diesel for transportation with biofuels

(at current rate of consumption with current yields per hectare, size of boxes on map is to scale)



Option 1: first generation biofuel plantations in tropical climate. 255m hectares of oil palm to produce biodiesel and 280m ha sugar cane to produce ethanol

Option 2: second generation biofuel plantation in temperate climate. 535m ha hybrid poplar or switchgrass to produce gasoline and diesel substitutes. Effectively same yield per hectare as first generation technology achieves in the tropics

Source: IEA, IFEU, University of São Paulo, Oak Ridge National Laboratory

Note
- Rapeseed/canola, maize, wheat, etc. would require more land than the options listed above
- The entire EU-27 has an area of 432 m ha

ABI

Biofuels produced from agricultural and forestry wastes could most likely displace 4% to 10% of the petroleum we consume for transportation

Biofuels from agricultural and forestry wastes

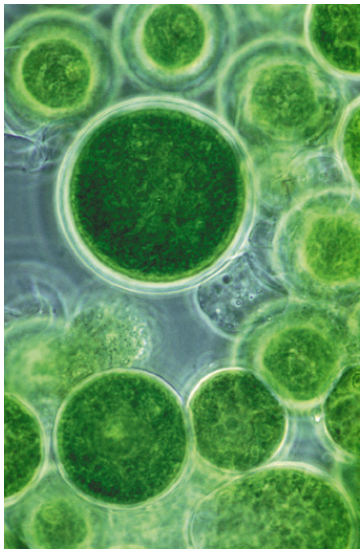
- Agricultural and forestry wastes could provide a source of raw materials without impacting food prices or requiring deforestation
- In 2010 the IEA estimated that if all agricultural and roundwood waste in the world were converted into biofuels, that could displace approximately 40% of our crude oil consumption for transportation needs
- However, since most of these “wastes” are already used to make MDF board, wood pellets, are ploughed back under to improve the soil, etc., it was estimated that only 10-25% are realistically available to convert into liquid biofuels

- Biofuels from agricultural and forestry wastes could therefore supply 4% to 10% of our transportation energy needs
- This is good, but cannot be the only solution to the world’s transportation energy problem

Source: IEA

Biofuels from algae hold great promise but have not been commercially proven yet

Biofuels from algae



- Algae is the fastest growing biomass on the planet
- It may be able to provide a plentiful source of feedstock that does not impact food prices or require deforestation
- Different strains are being engineered to produce:
  - oils for use in first generation biodiesel facilities
  - biomass for use in second generation facilities
  - biofuels within the algae cells themselves
- This source of biofuel feedstock and the technology to commercially exploit it are still being developed

Biofuels could replace petroleum, but research and development must continue

Quantity of biofuels

- Whether “first” or “second” generation technologies are used, biofuels produced from plants that grow in soil are not likely to be available in the quantities required to completely replace petroleum
- Biofuels produced from agricultural and forestry wastes will also be available in quantities that help supplement our energy mix rather than dominate it
- Algae may offer the opportunity to produce biofuels in the quantities required to completely replace petroleum, but further research and development are required

To increase sales of first generation biofuels in Austria, specific vehicles or fleets of vehicles compatible with blends above E5 or B7 must be targeted

Biodiesel in Austria

- Modern diesel vehicles with self-cleaning particulate filters can suffer engine damage due to oil thinning at biodiesel blending levels above 7%. Changes must be made to many vehicles on the road today if they are to be fuelled with blends above B7
- With its blending of 6.5% biodiesel into diesel in 2009, Austria is already close to the maximum that can be achieved with a fuel intended to be used in all diesel vehicles
- To increase sales further, higher concentrations of biodiesel must be used by specific vehicles or fleets of vehicles that are compatible with it

Ethanol in Austria

- All gasoline-powered vehicles are compatible with ethanol at blending levels up to 5%
- With its blending of 4.9% ethanol into gasoline in 2009, Austria is already close to the maximum that can be achieved with a fuel intended to be used in all gasoline vehicles
- To increase sales further, Germany introduced E10 as the standard gasoline at public filling stations in January 2011. Vehicle owners must check whether their cars are compatible with it and if not, they can purchase "Super Plus", which still contains only 5% ethanol
- To increase sales of ethanol in Austria, concentrations above 5% must be used by specific vehicles or fleets of vehicles that are compatible with it

Source: UFOP, Austrian Federal Ministry for Agriculture, German Federal Ministry for the Environment

Note: Since Austria is already a net importer of agricultural products, increased domestic production of biodiesel and ethanol will lead to increased imports

ABI

Transportation is almost wholly dependent on petroleum

Biofuels can be a viable alternative

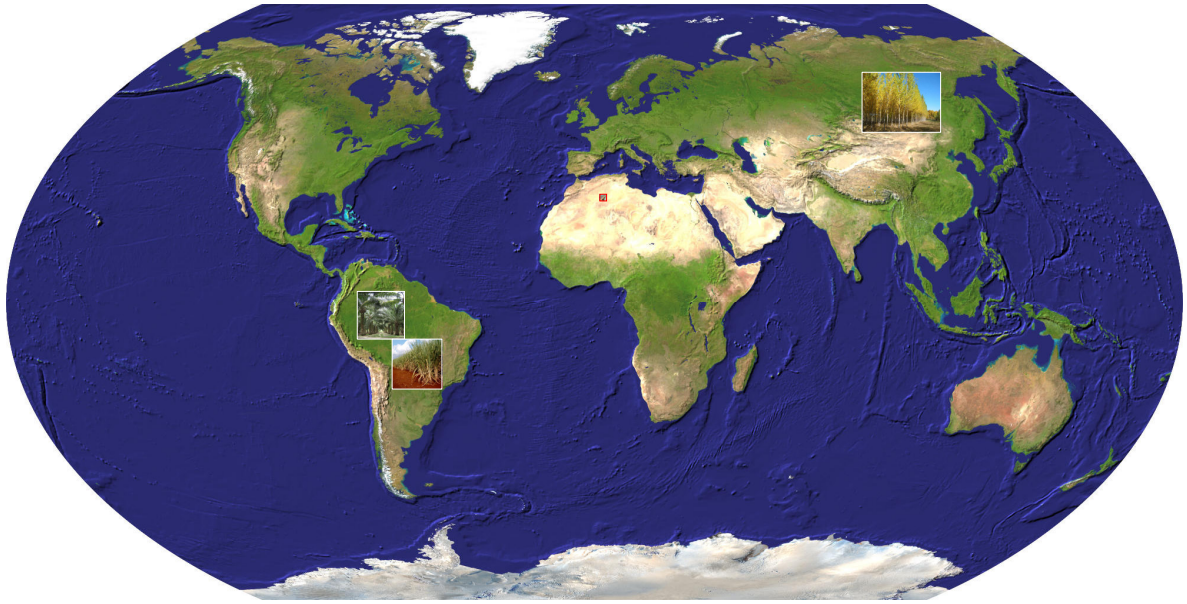
Electric vehicles have great potential

Currently, both can help slowly wean us off petroleum

Concentrating solar thermal power plants convert more of the sun's wavelengths into usable energy than photosynthesis does and therefore require much less land

Land required to replace gasoline and diesel for transportation with renewable energy

(at current rate of consumption with current yields per hectare, size of boxes on map is to scale)



Option 1: first generation biofuel plantations in tropical climate. 255m hectares of oil palm and 280m ha sugar cane

Option 2: second generation biofuel plantation in temperate climate. 535m ha hybrid poplar or switchgrass

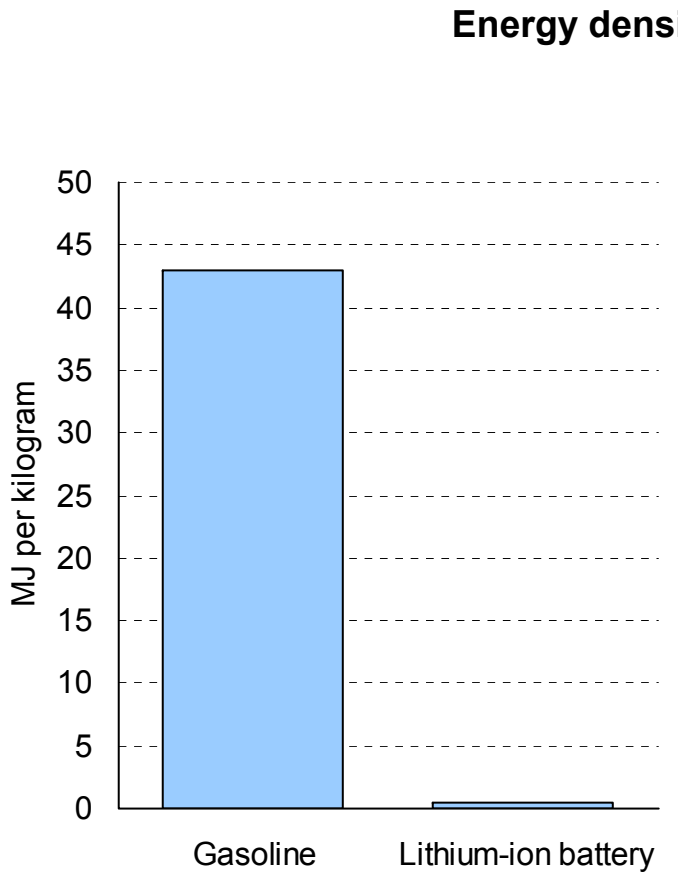
Option 3: 5m ha concentrating solar thermal power plant in a desert. With technology available today, a power plant of this size would produce as much energy as gasoline and diesel currently provide for global transportation needs

Note: Global demand for gasoline and diesel in transportation is currently approximately 17 600 TWh annually and global demand for electricity is currently approximately 17 000 TWh annually. Replacing gasoline and diesel in transportation with electricity would therefore require a doubling of global electricity generation capacity

Source: IEA, IFEU, University of São Paulo, Oak Ridge National Laboratory, Desertec Foundation

ABI

However, the batteries needed to store this energy for portable uses still require further development



- Lithium-ion batteries currently store approximately 1% as much energy per kilogram as a liquid fuel
- The 450 kg battery in the Tesla Roadster stores as much energy as 4.4 kg of gasoline or diesel
- For vehicles, storing liquid fuels on board currently still has major advantages over storing electricity

Source: Tesla Motors, European Commission

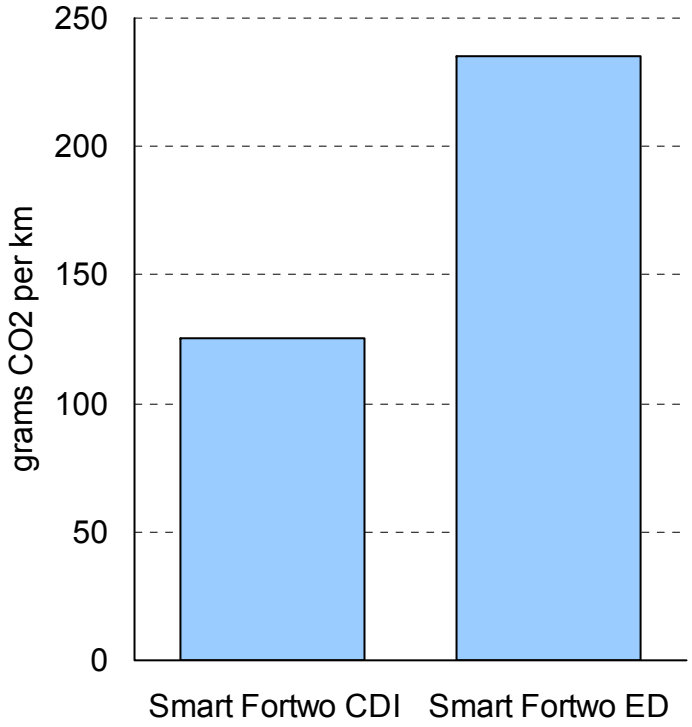
With our current system of power generation, electric vehicles will most likely be charged with electricity from coal power plants

Night time electricity generation

- Charging a battery slowly maximizes its service life so the expensive batteries in electric vehicles will often be charged slowly, over night
- The electricity will have to come from power plants that are not running at capacity over night and can be throttled up
- Hydroelectric power plants already operate at capacity and wind and solar facilities feed electricity into the grid whenever the wind blows or the sun shines
- Coal power plants, however, are throttled down over night and have additional generating capacity
- The strong desire of electricity companies to take advantage of this unused capacity led to the introduction of “Nachtstrom” in Austria and Germany in the 1950’s and 1960’s. “Nachtstrom” – selling electricity at a discount in the night time – was specifically introduced to increase over night demand. Due to the negative environmental impact increasing the base load on coal power plants has, “Nachtstrom” is being phased out
- Electric vehicles will most likely raise the night time base load just as “Nachtstrom” did and the electricity will most likely come from the same source - coal power plants that are throttled down somewhat less over night

Using night time energy from coal power plants, electric vehicles would increase our emissions of greenhouse gases

CO_2 emissions diesel vehicle vs electric vehicle



- When charged with energy from a coal power plant, an electric Smart Fortwo ED emits almost twice as much CO_2 per kilometer as a diesel powered Smart Fortwo CDI
- If the power consumed by electric vehicles is generated from fossil fuels, they will not help us significantly reduce our CO_2 emissions

Source: Auto Motor und Sport, US EPA, TU Graz

Note: As tested by Auto Motor und Sport, a Smart Fortwo ED consumed 22.4 kWh per 100 km and a Smart Fortwo CDI consumed 4.7 liters of diesel per 100 km

ABI

Electric vehicles could help break our addiction to petroleum but to reduce greenhouse gas emissions, new power plants will have to be built

The impact of electric vehicles

- Charging electric vehicles with the spare night time capacity of fossil fuel power plants would help us reduce our crude oil consumption and would reduce our energy imports from politically questionable sources
- Not bleeding money out of our economy by buying foreign energy would bring economic benefits to the population
- However, electric vehicles will not significantly help reduce our greenhouse gas emissions unless the additional electricity consumed is generated in additional renewable or atomic power plants

Transportation is almost wholly dependent on petroleum

Biofuels can be a viable alternative

Electric vehicles have great potential

Currently, both can help slowly wean us off petroleum

Both biofuels and electric vehicles may be able to displace petroleum in the future and both technologies can help start the change today

Renewable energy in transportation

- As the concentration of greenhouse gases in our atmosphere increases, as new oil fields become ever more difficult to access, and as petroleum continues to be supplied by some politically questionable sources, we must consider alternatives
- As yet, no one source of renewable energy can fully replace petroleum in transportation. We can not yet feasibly produce enough biofuels nor can we meet all of our energy needs with renewable electricity
- However, both technologies have the potential to replace petroleum in the future, alone or in concert, and both can help reduce our consumption of crude oil today