

# How Can We Turn Sun Radiation into Automotion?

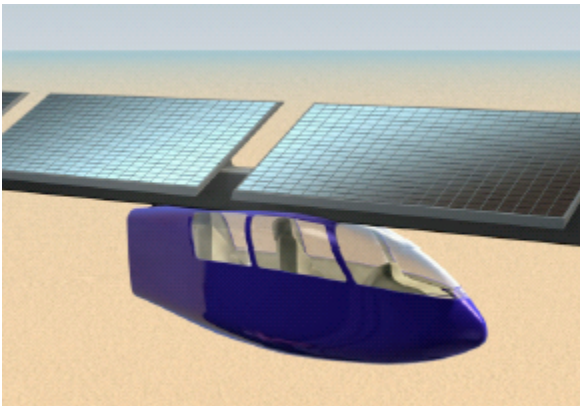
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## Abstract

Personal Rapid Transit (“PRT” or “Podcar”), a transportation alternative that does not require batteries or liquid fuels, is proposed to mitigate global warming, peak oil and congestion based on computered (driverless) vehicles that run on a solar-powered guideway suspended over existing highways.



Solar Powered PRT hanging from guideway



Cars linked for more capacity & less drag

## Introduction

The converging threats of global warming and peak oil are profoundly changing humanity's options for energy sources and mobility. The prevailing wisdom is that many small incremental measures will reduce oil use and mitigate global warming. This perspective may be reassuring, suggesting that everyone can carry on comfortably without making major personal sacrifices, but unfortunately the scope of these twin challenges is so immense as to be almost incomprehensible. At best, thinking small will only postpone the inevitable. In the worst case, well-intended small incremental steps will be interrupted by colossal breakdown of human societies – because we moved too slowly.

In his landmark treatise, *Collapse*, Jared Diamond demonstrated that throughout history some civilizations survived major environmental changes while others did not adapt. In light of the enormous threats we face, we must wonder whether human societies can adapt in time to avoid collapse. Anticipating the prospect of depleting petroleum which today fuels nearly 100% of transportation worldwide, at face value it would seem that the most pressing challenge is to find a substitute liquid fuel. However, such an approach does not take into account the deficiencies of fuel options or the inefficiencies of heat engines and the heavy, oversized, under-utilized vehicles that they propel.

Consequently, the existing transport system cannot survive the imminent decline of oil “production.” The lack of scalability and high carbon footprint of known substitute liquid fuels will be unacceptable. Furthermore, electric vehicles are heavy and as automobiles do not resolve congestion. Given these limitations, if a viable option for urban transport exists, its success will be predicated on rapidly abandoning the automobile. This “inconvenient truth” cannot be confronted head-on, but must be contravened by disruptive technological breakthroughs.

Sweden has taken an important first step in dealing with the peak oil issue through its initiative to achieve oil independence by 2020 – and it may be possible to realize that goal without being adversely impacted by other neighboring countries. However, at high latitude with major seaports, Sweden is especially vulnerable to global warming and will be impacted by the actions taken in other countries. Mitigation of climate change will depend upon international cooperation.

Of course political action in concert with other countries is a necessity in dealing with climate change, but past experience would indicate that political treaties are likely to remain insufficient to counteract business-as-usual in the larger high-carbon countries (the USA, China, India, etc.). Lacking the political clout to persuade the climate change debate in its favor, Sweden's influence is likely to be far stronger as a result of exporting technological breakthroughs that overwhelm the poor energy performance and disastrous economic/ social/ environmental impacts of the private automobile.

In this context, the lesson from Germany is compelling. With little more than half the average solar energy resource of the USA and other countries in the temperate zone, in the past 10 years Germany has become the locus of solar energy development worldwide.

In parallel with domestic advances in the field (over half of global solar installations in 2006 occurred in Germany), their manufacturing and service industries have gained the lead in the solar energy marketplace worldwide.

### **Personal Rapid Transit (“PRT” or “Podcar”)**

In like fashion, though it is little known, Sweden has just established a small but distinct lead in the global race to develop a compelling alternative to the automobile and the internal combustion engine. The Vectus Personal Rapid Transit (“PRT” or “Podcar”) test track in Uppsala and related PRT/Podcar initiatives offer a breakthrough unique alternative to urban transport dependent on liquid fuels. Rapid domestic deployment and export of solar powered Swedish Podcar technologies have the potential to accelerate rational responses to peak oil and global warming.

Powering transportation with solar energy will require extremely efficient vehicles. Battery powered vehicles pose difficult technical challenges that have not yet been proven in the marketplace. PRT provides a solution to transportation that does not require batteries or liquid fuel and solves the congestion problem based on a computered driverless vehicle that runs on a solar-powered guideway suspended over existing highways.

The potential market generated by this system is very large. We estimate that 575,000 miles of guideway in the USA would serve most urban centers and all major highways in rural areas. The goal is to provide a PRT station within 1/4 to 1/2 mile of every passenger. This would require 92.4 million KW of photovoltaics (“PV”) 3.5 ft wide in order to provide 100% of the electricity to drive PRT. Nighttime use could be offset by daytime excess power provided to the grid. The cost of PRT is significantly less than battery powered electric vehicles and could be implemented in the timeframe required to manufacture 200 million electric vehicles.

In Sweden, approximately 50% additional solar panel area would be required to deliver the same power, but economic payback would be comparable or better because gasoline prices in Sweden are double that of the USA. Combined with wind generators and hydroelectric power, solar Podcar technology offers an unprecedented potential for true sustainable travel.

### **Peak Oil**

The awareness of the looming peak and subsequent decline in oil “production” is growing. [For details, refer to *A Wake Up Call*, by Francis de Winter and Ron Swenson.] In this context, the important point is that there are no long-term liquid fuel options on the horizon. Plausible alternative fuels fail to meet environmental requirements and performance of the woefully inefficient automobile becomes marginal without access to high-energy inputs. This will become painfully evident to the general public when queues form at petrol stations again. Subsequently, deprivation and rationing are likely to lead to social disruption. If general transport systems based on renewable energy are adequately

demonstrated before this happens, human energies may yet be channeled into implementing viable mobility solutions.

High carbon substitutes won't work. The presently favored options (tar sands, oil shale, coal-to-liquid) have very low efficiencies of conversion from raw resources to fuels and would only exacerbate global warming.

Agro-fuels won't work either. With cooperation from governments, the agricultural sector has focused on finding a suitable liquid to put into an automobile's fuel tank, without questioning the limitations of photosynthesis, soil and water or the dubious viability of the automobile itself and its support systems. At a minimum, 80% of agro-fuels would be converted to heat and smoke – the internal combustion engine is less than 20% efficient in practice. In the short term agro-fuels are leading to the destruction of our planet's precious biological heritage. In the longer term, they cannot be taken to scale. [For details, refer to *How Can We Outlive Our Way of Life*, by Patzek.]

The answer? Electricity based on renewable energy. It is clean, compact, powerful, and efficient. It is available from many renewable sources. Electricity is deployable in real time *if* blended with wind, direct solar (PV, CSP), hydropower and geothermal sources.

## **Global Warming**

As indicated above, Sweden is already experiencing impacts of global warming, more than many countries because of its high northern latitude, and Sweden will see more in the years to come. How can Sweden defend itself against these impacts, when by far the largest contributors to the problem are countries not under Swedish jurisdiction?

Sweden cannot dictate enlightened environmental policy to sovereign governments in countries like the USA or China. Sweden will not be heard soon enough or sufficiently clearly in the key international forums. Even if Sweden had all the policy answers and offered its success as an example to the world, countries such as the USA cannot be relied upon within any international framework to follow Sweden's lead.

Nor can Sweden export its own agro-fuel industry. That will merely serve to destroy humanity's global biological heritage more rapidly. This conclusion may be painful to some, but it must be debated and resolved in time to focus societal resources where they can be most effective in light of the enormous challenges we all face together.

We hear talk of the potential for many small incremental steps. Yet those who advocate small steps often admit the futility of rearranging values: "Any single policy implemented by itself is unlikely to be able to do more than eliminate only a small part of our future increase." [Western Journey, the American Automobile Association's magazine] But small policies are inadequate when fuel costs increase by a factor of 10. The only urban transport option in evidence with the potential for rapid expansion and ultimate sustainability is the Podcar powered by renewable energy.

## 10X

What is the real potential for rapid Podcar development? In Silicon Valley, breakthrough performance attracts venture capital, where the goal of a ten-fold return on investment is often expressed as “10X”. Financial rewards are logically keyed to technological innovation, so venture capitalists seek technologies that are ten times better (10X) relative to previous generation products. If it is demonstrated that Sweden’s emerging Podcar transportation technology can achieve 10X improvements with respect to key metrics, Swedish industry can thrive, and global warming impacts can be moderated in spite of unresponsive governments in the dominant countries, as the global industrial sector mobilizes to take advantage of the robust savings inherent in Podcars, a potential market that is waiting to be tapped.

The following table conveys the extent of the improvements that can be anticipated:

Result	Improvement	Cars	Podcars	Metric
<b>Costs</b>				
10X	Operating Costs	34	3	Cents per vehicle-km traveled
5X	Capital Costs	30	6	Millions USD per km to build
<b>Human Factors</b>				
6X	Access	24	4	% of population that cannot drive/use
10X	Congestion	48	5	Hours lost to congestion each year
2800X	Safety	14	0.005	Deaths per 100,000
<b>Energy and Environment</b>				
11X	Energy efficiency	1100	100	Watt-hrs/kilometer
2125X	Emission Footprint	0.45	0.0002	Kg of CO2 per passenger km
25X	Land Use	10	1	Width of right of way, meters
10X	Weight	2000	200	Kg/vehicle
8X	Number of Vehicles	83	10	Vehicles per 100 people
80X	Embodied energy	166	2	Tons per 100 people
10X	Rolling resistance	5000	500	Watts per vehicle
9X	Aerodynamic drag	7000	750	Watts at 100 km/hr

## Conclusion

In spite of growing awareness that fossil fuels play a major role in climate change, international agencies are making plans for investing more than \$20 trillion in high carbon energy infrastructure over the next two decades. This may reflect the limits of the imagination of political leaders and investors who have never seen a model of a viable sustainable transportation system. If the Podcar actually holds the potential that has been proposed here, then in light of the disastrous outcomes that high carbon investments imply for Sweden, there is no time to waste in testing and developing that potential.

The US Congress is fortunate to have as a member Roscoe Bartlett, an elder statesman who founded the Peak Oil Caucus to bring light to the challenge of finding alternatives to oil. His words are prophetic in the context of Sweden's leadership in creating policy to prepare for a world beyond oil:

“It might seem possible to ‘fill the gap’ in the short term. However, in the long term, it will be impossible. For one thing, doing so will hasten the exhaustion of other finite resources. That will make the inevitable transition to renewable sources more difficult and more painful.”

What will be the outcome of applying Dr. Bartlett's wisdom to the question of setting priorities for transportation and energy development in Sweden?

## References

Francis de Winter and Ron Swenson, [\*A Wake Up Call\*](#)

Ron Swenson, [\*Biofuels: Science or Fiction?\*](#)

Tad Patzek, [\*How Can We Outlive Our Way of Life?\*](#)

## End Note

### Cost and sizing of a Solar System to meet 100% of PRT power requirements

30	mph, operating speed
* 2	sec (vehicle interval)
= 88	ft between vehicles
= 60	Vehicles/mi, separated by interval specified
* 2	kw @ operating speed
= 120	kw needed in a mile stretch
10	hrs at peak operation equivalent
/4	hrs of peak sun equivalent (USA Coast = 4, Desert = 6)
= 2.5	solar factor
= 300	kW/mile required (120 kw * 2.5 solar factor)
\$6.00	\$ per watt
\$1.8m	\$ per mile
16	watts / sq ft, SunPower/Sanyo, most efficient on market
3.5	ft wide solar panel to meet requirement

[Download Solar PRT spreadsheet](#) to calculate with new assumptions.