Solar Powered PRT

SOLAR 2007
Cleveland
July 7-12

Emerging Transportation

Ron Swenson

solarEVolution™

The Elevator Speech

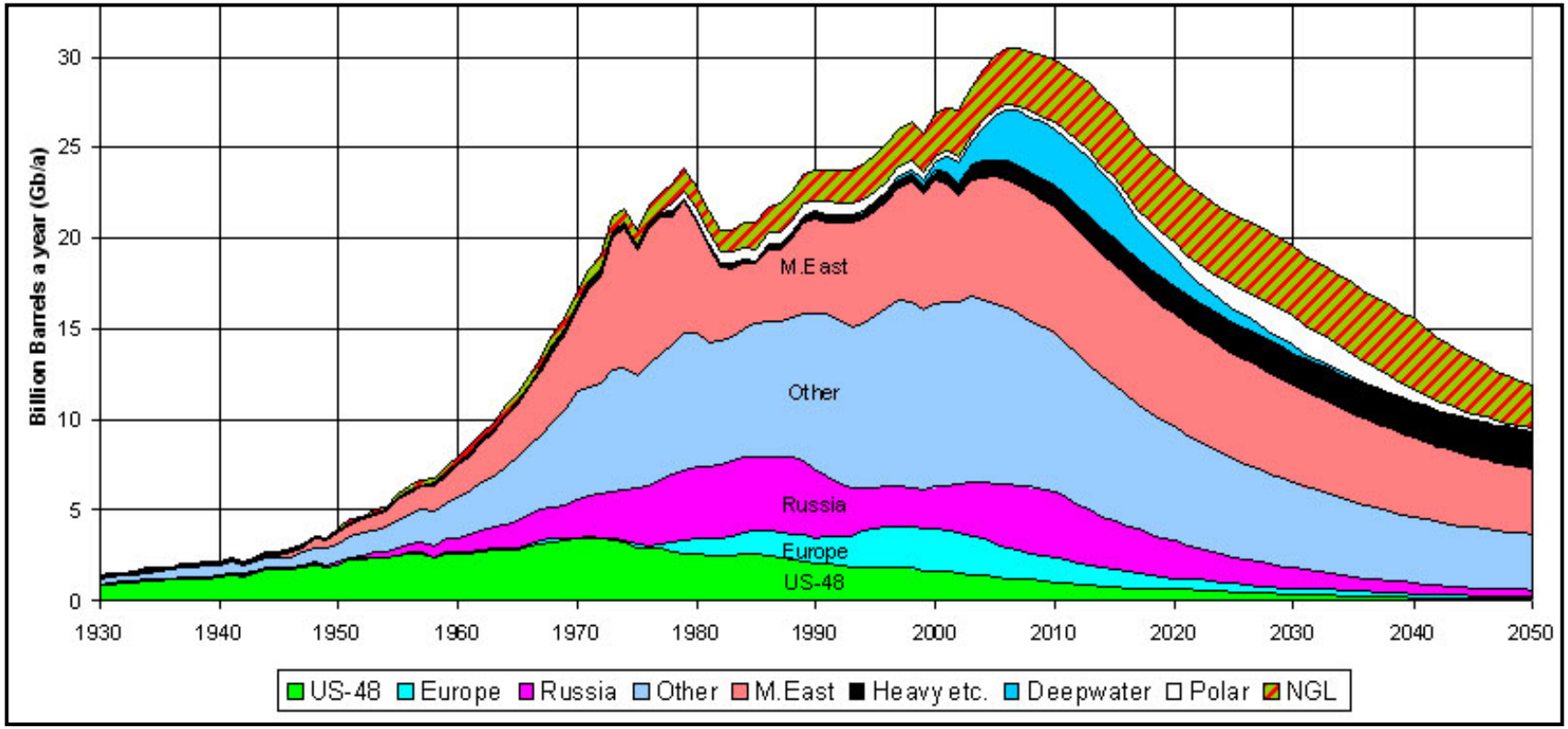
Without solar, energy independence is pure rhetoric.

- **Clinton's New Generation Vehicle**
- **Arnold's Hydrogen Highway**
- **GM's Yellow Gas Cap**
- **Bush's Cellulosic Ethanol.**

Only solar energy will do the job.

Solar is sufficient to power high capacity PRT *-- 100 percent --* using only the system's 4' to 8' right of way.

We know the peak is coming
… but what can we do about it?



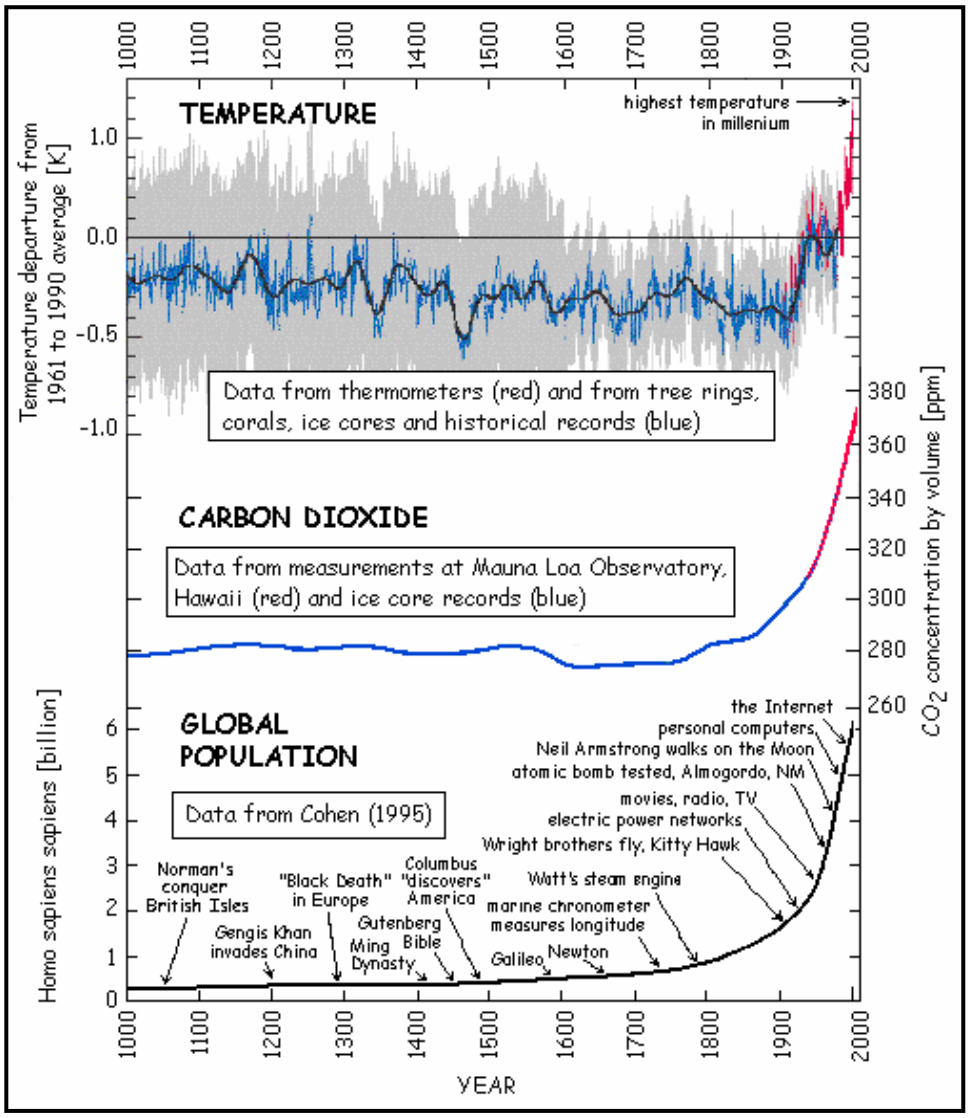
Can Solar Energy Replace Oil?

Global Warming over the Past Millennium

We are aware of two pressing concerns

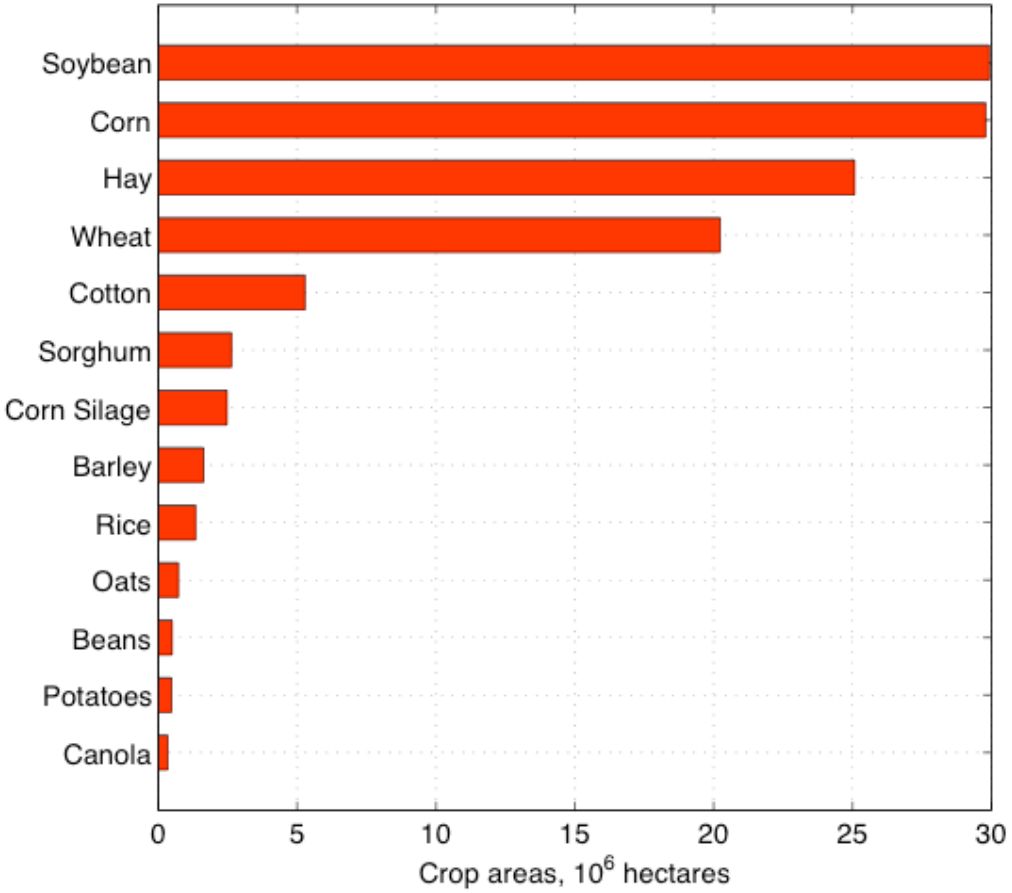
- **Global Warming and**
- **Peak Oil.**

But concerned parties are out of touch with each other.



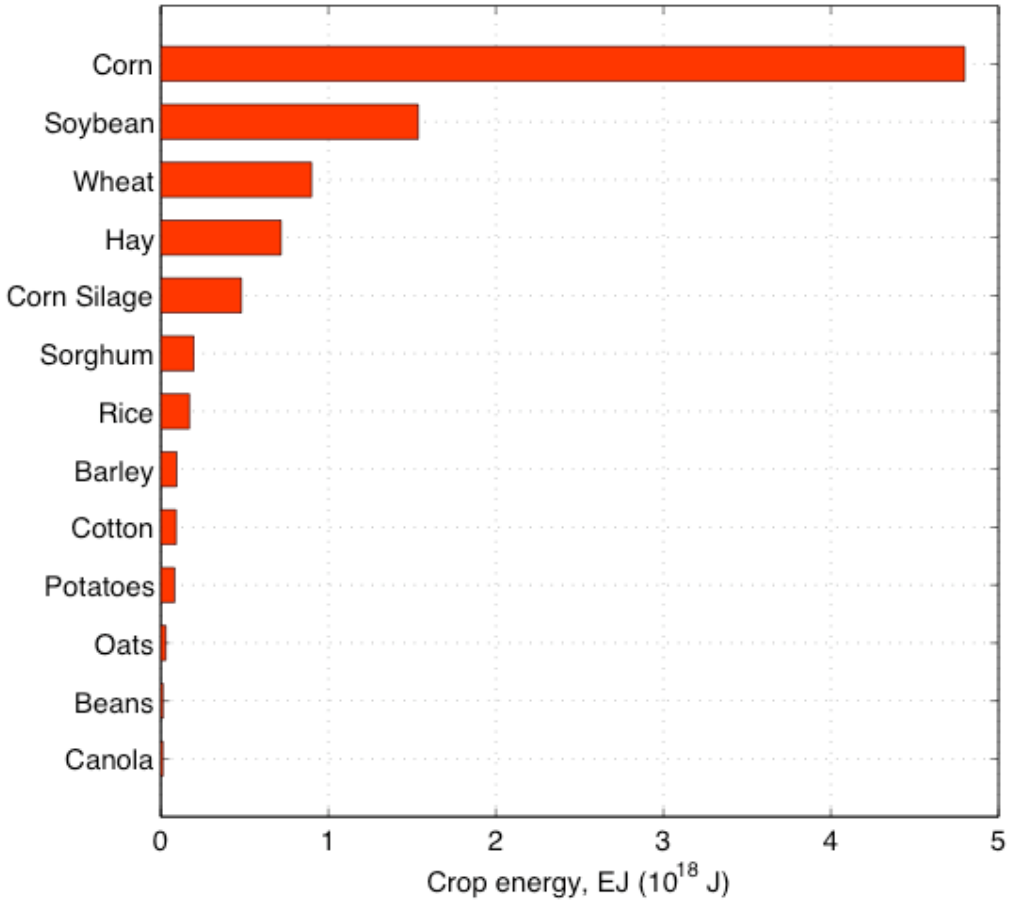
What about Corn Cars & Bean Buses?

US Agriculture: Crop Areas



www.oilcrisis.com/Patzek

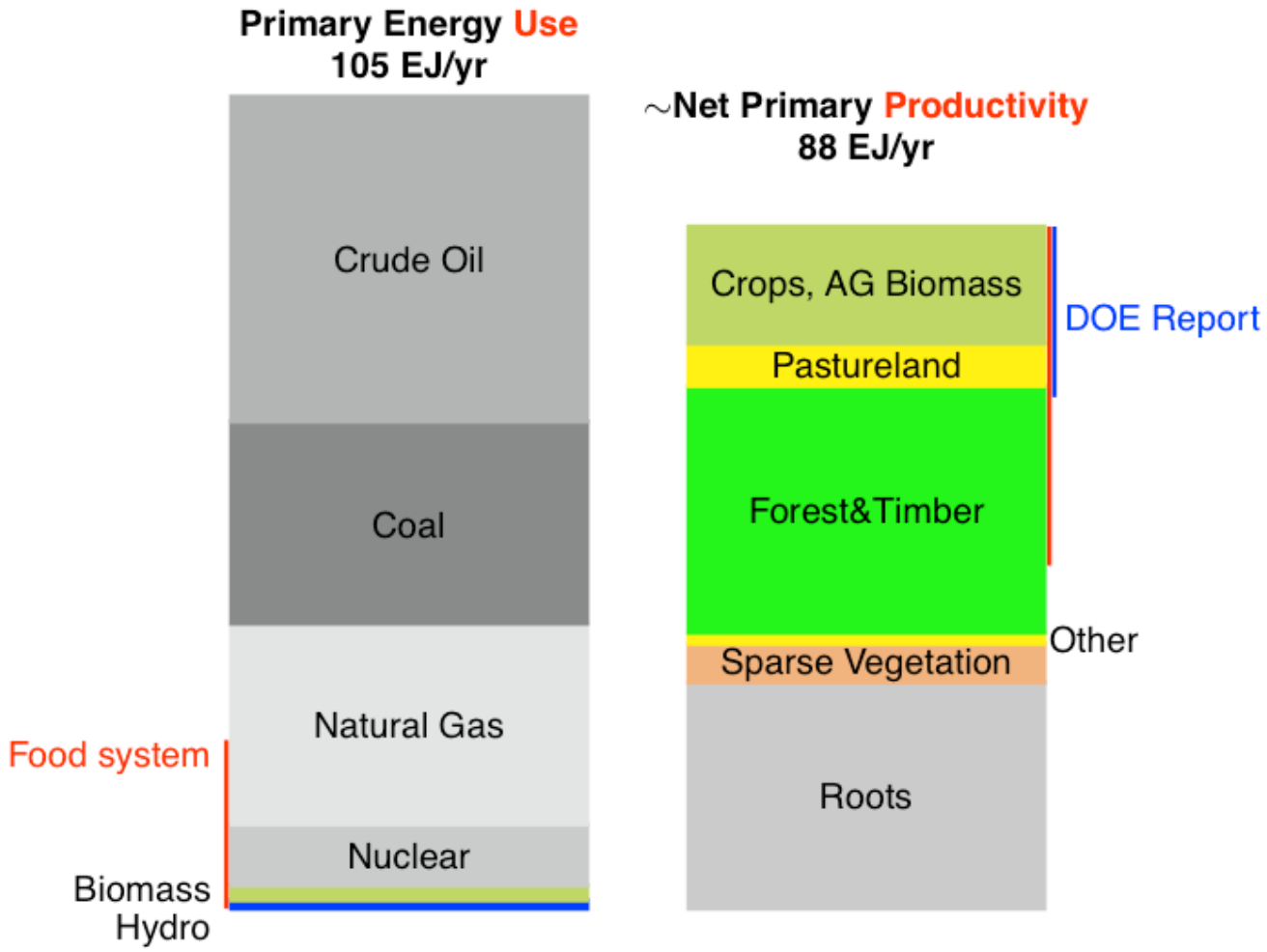
US Agriculture: Crop Energy



Total crop energy 9.14 EJ (9quads)

www.oilcrisis.com/Patzek

Net Production of Biomass in the USA



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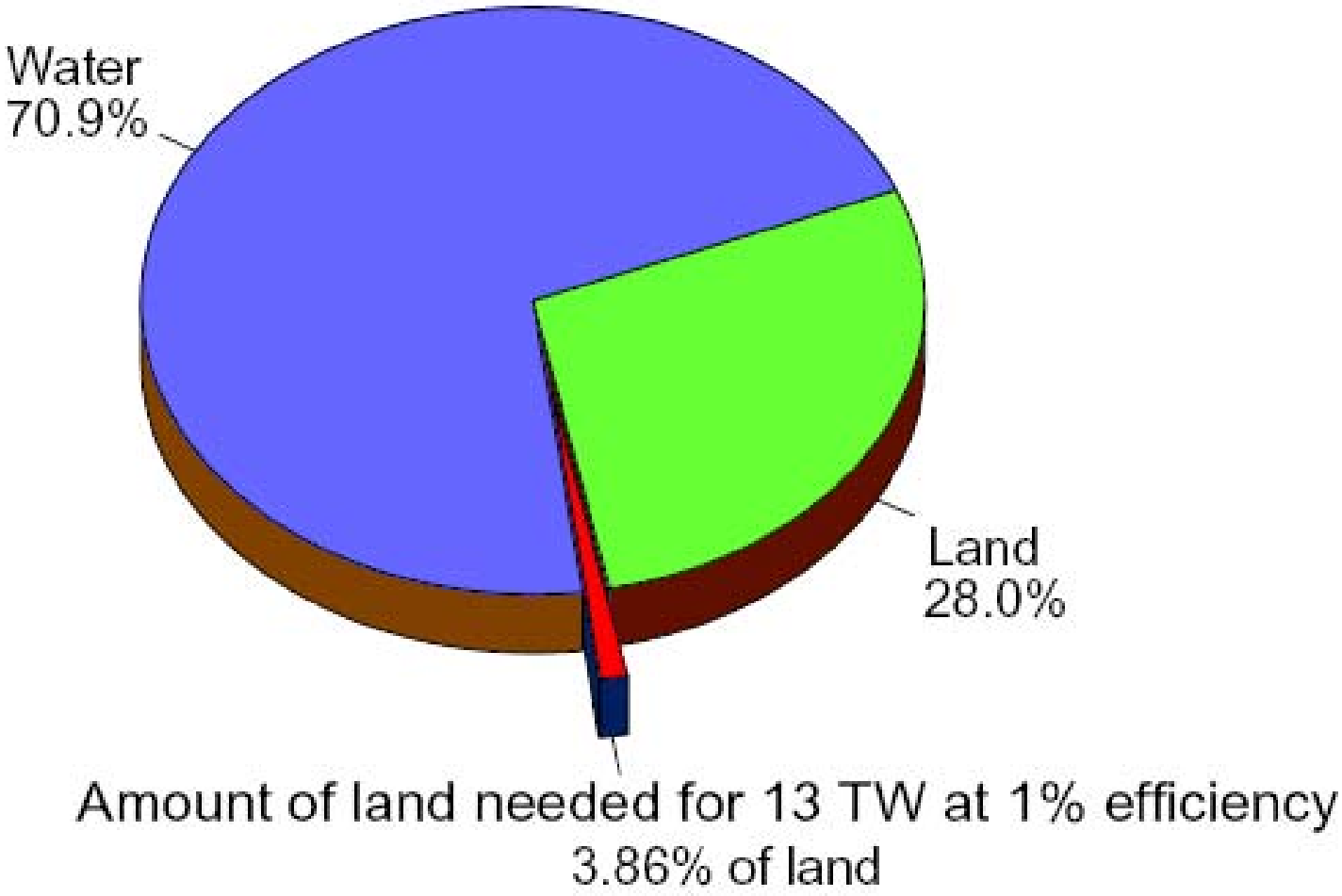
120,000 TW of solar energy received by the Earth



www.ecotopia.com/Apollo2

Personal Rapid Transit (PRT)

www.SolarEvolution.com/PRT

Freeway at Capacity

PRT
Personal Rapid Transit
International Conference

Vehicles Removed

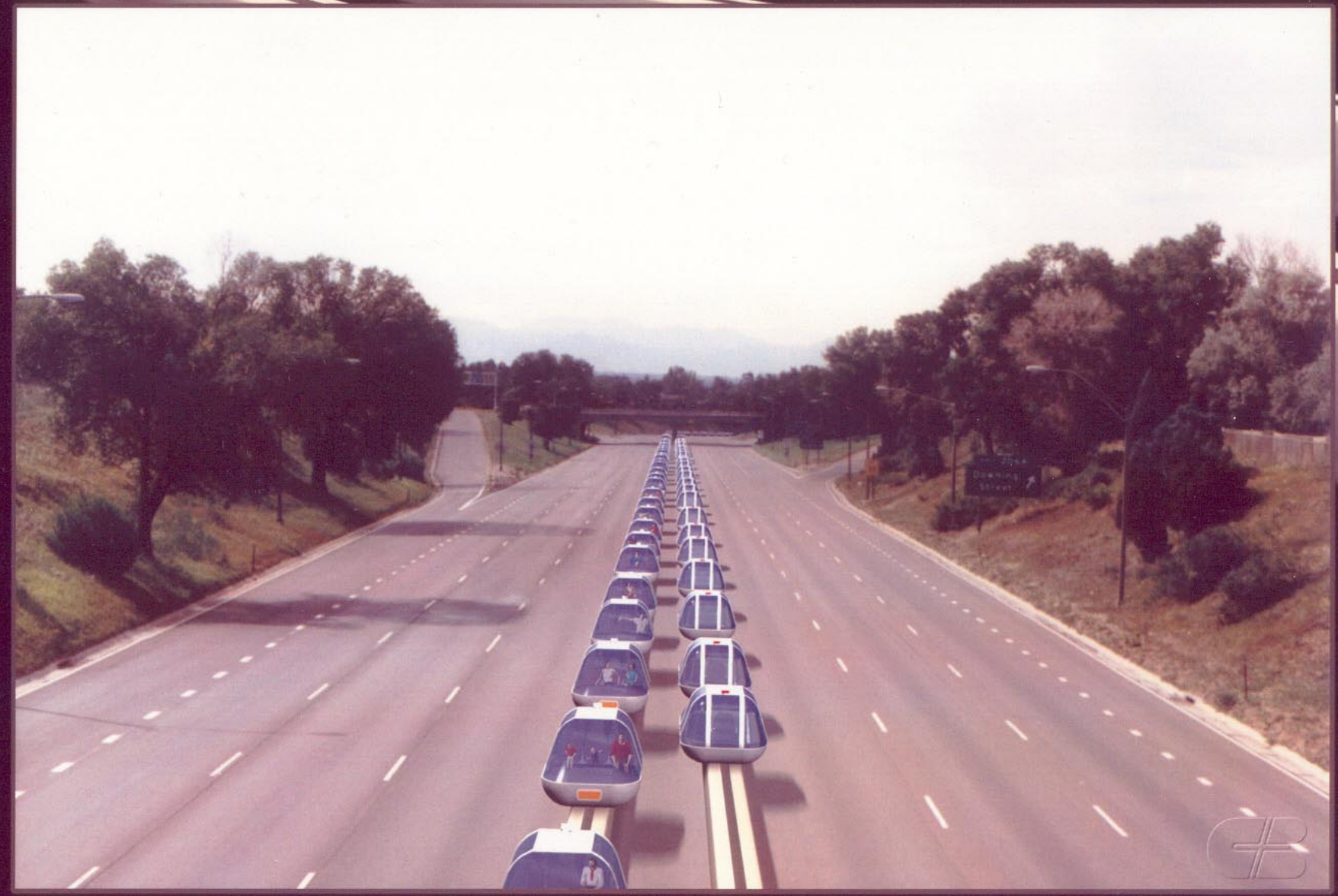
PRT
International Conference

PRT Passengers

PRT
International Conference

PRT System

PRT
Personal Rapid Transit
International Conference

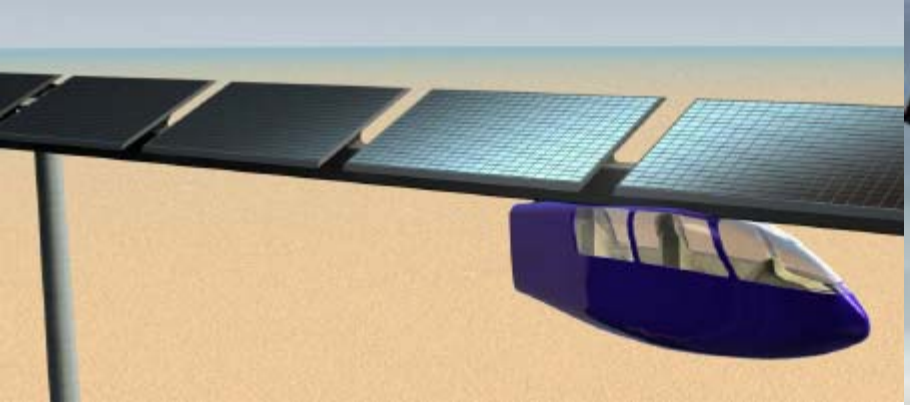


What is PRT?

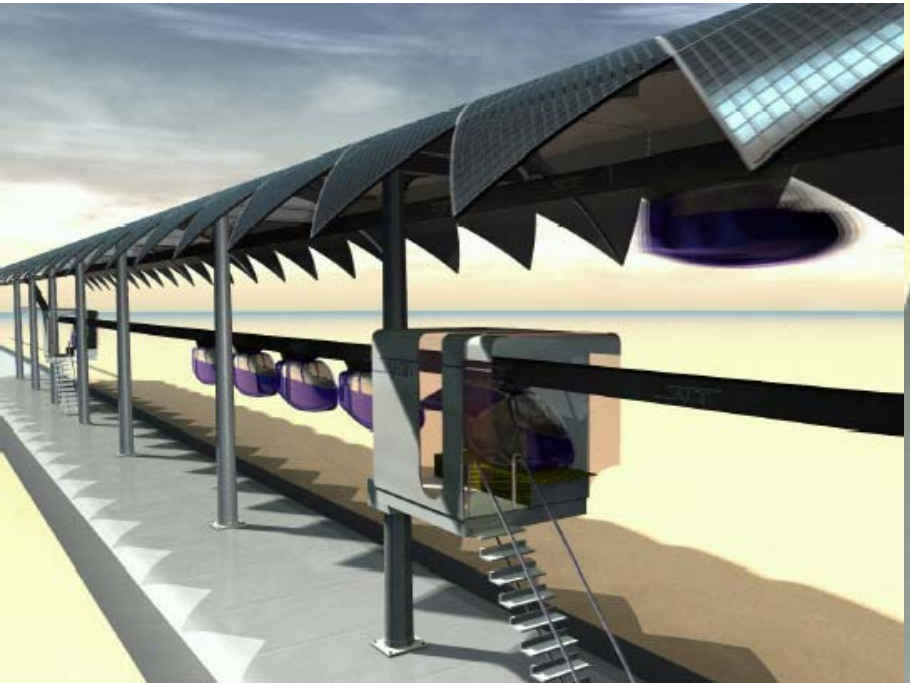
- Personal Rapid Transit also known as:
  - Pod cars
  - PAT (Personal automated Transit)
- Typically 1-4 passengers
- Driverless
- Solar powered and electric drive
- Non-stop travel
- Created in 1970s in Morgantown, WV for a college campus
- New service scheduled for 2008
  - London Heathrow, ULTra
- Active prototypes
  - SkyTran in Orange county and Vectus in Sweden

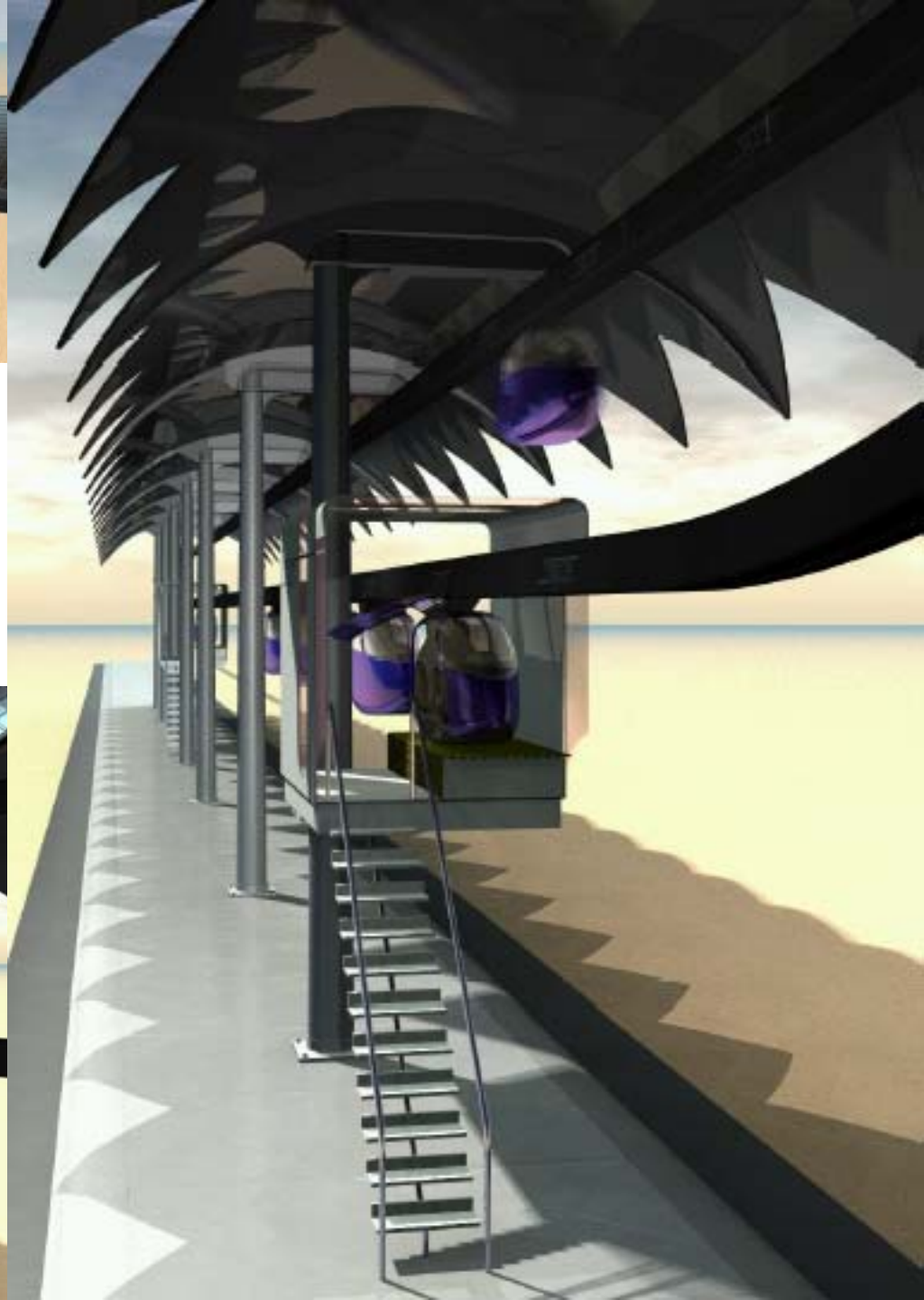
www.SolarEvolution.com/PRT

www.SolarEvolution.com/PRT/Sweden

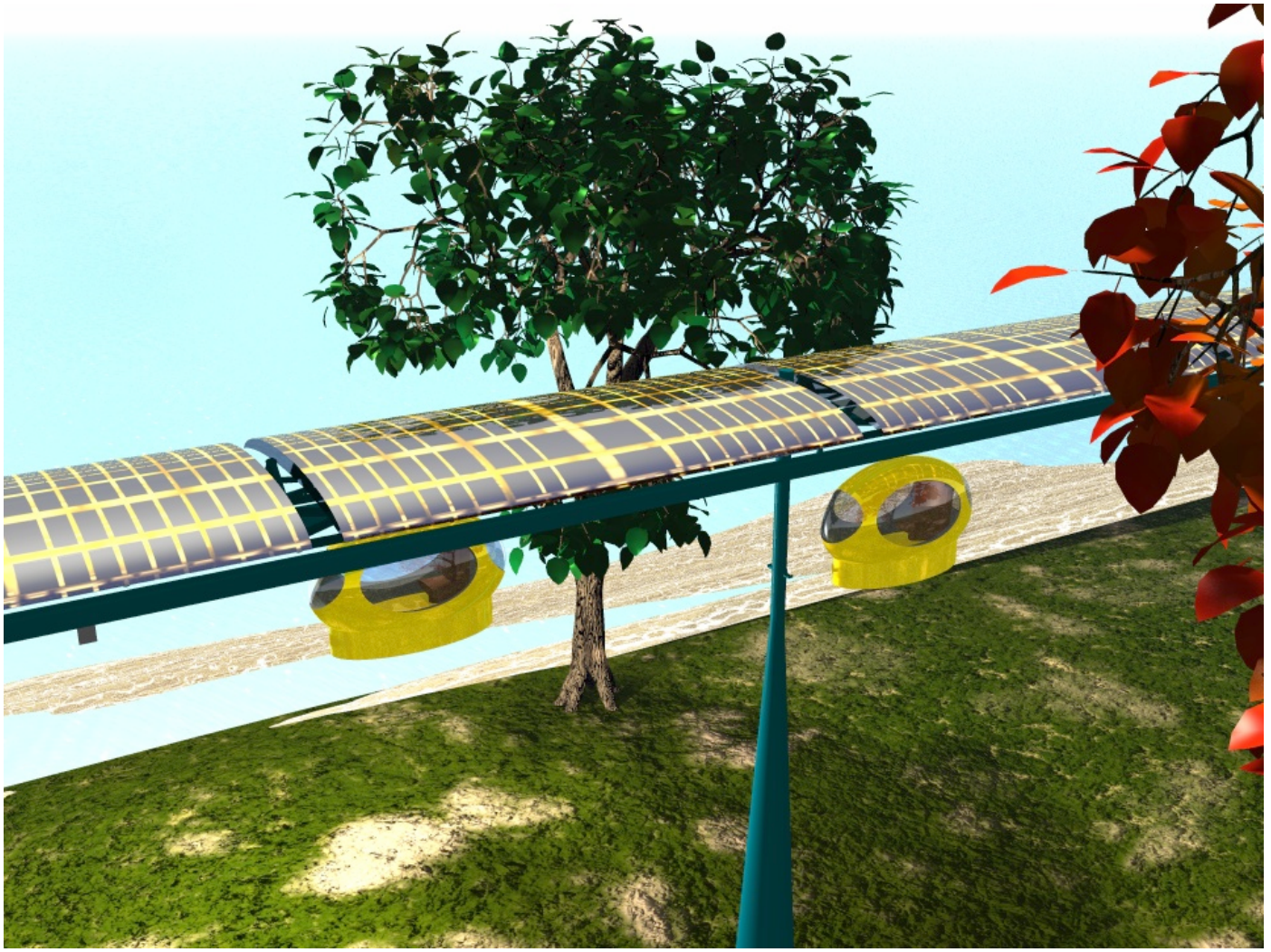


Solar SkyTran, with aesthetics emphasis and added power at stations





Podcars can be powered 100% by solar



www.jPods.com

Similar Solar Systems Exist

What about EV's?

	Battery Electric	PRT
Vehicles	100	20
Total weight (tons)	200	5
Battery weight (tons)	25	1
Recycle batteries	? %	99%
Embodied energy ratio	50	1
Battery losses	15%	<1%
Parasitic Energy Consumption (PEC)	275	6
Energy use, watt-hrs/mile	~150	~50 (SkyTran)
Safety	≈ two 747s/wk die	Very safe
Quality of life	1 hr per day lost	Quality time in transit

Calculate Solar size, cost per Mile

30	mph, operating speed
x 2	sec (vehicle interval)
= 88	ft between vehicles
= 60	vehicles/mi, separated by interval specified
x 2	kw @ operating speed
= 120	kw needed in a mile stretch
10	hrs at peak operation equivalent
÷ 4	hrs of peak sun equivalent (Coast = 4, Desert = 6)
= 2.5	solar factor
120 x 2.5 = 300	kW/mile
x $6.00	/watt
$1,800,000	/mi
16	watts / sq ft, SunPower, most efficient on market
3.5	ft wide solar panel to meet requirement

Compare Solar to Gasoline at $2.50/gallon

25	mpg, average fleet mileage
27,000	passengers per day to match
2.0	people/vehicle
13,500	vehicles/day
x $2.50	/gallon fuel price
= $33,750	Cost to travel fleet mileage daily
$ 12,318,750	Annual cost to travel fleet mileage
$ 45,000,000	Cost of solar to cover fleet mileage
= 3.7	**Years Payback *without subsidies*** **for solar system to offset gasoline prices**

www.SolarEvolution.com/PRT

PRT advantages

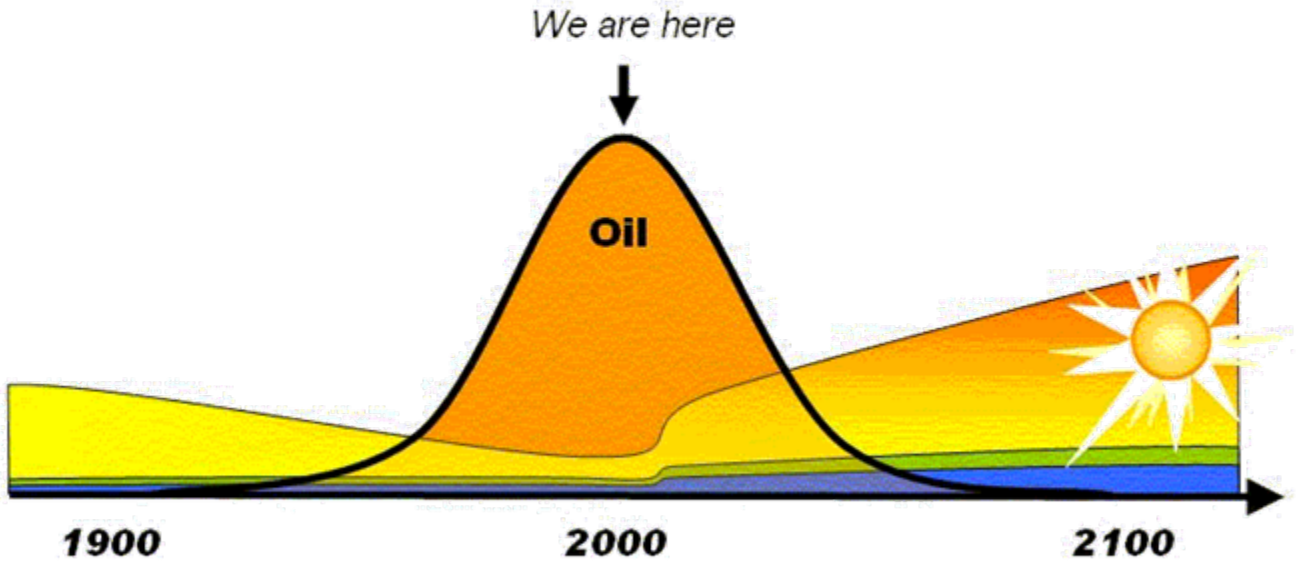
1. Faster average speed than light rail, buses or cars
2. Much safer than driving, more private than Metro
3. Lower energy usage than battery EV
4. Driverless, enjoyable commute time
5. Less embodied energy (lighter vehicles)
6. Lower risk, no battery breakthrough or recycling needed
7. No net fossil fuel emissions
8. Balance grid load via PV panels (net zero)
9. Quieter than cars
10. Fewer vehicles needed
11. Frees up roads for transit oriented development
12. Cheaper than cars

PRT considerations

- Requires government and public approval
- May obstruct views
- Longer distance to vehicle: 400 m > 10 m
- Upfront investment to realize savings
- Complex software required
- Entrenched interests

  Did we forego development of the car to preserve horse and buggy jobs?

Wake up!!!



...to the power of Solar

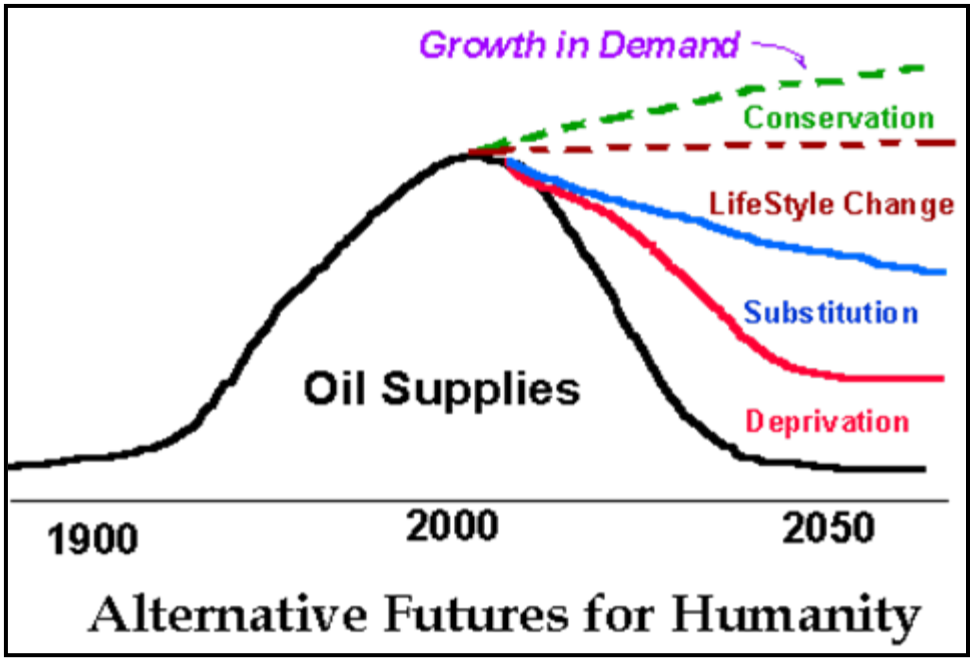
Ron Swenson, SolarQuest®

ASES

Cleveland

July 12, 2007

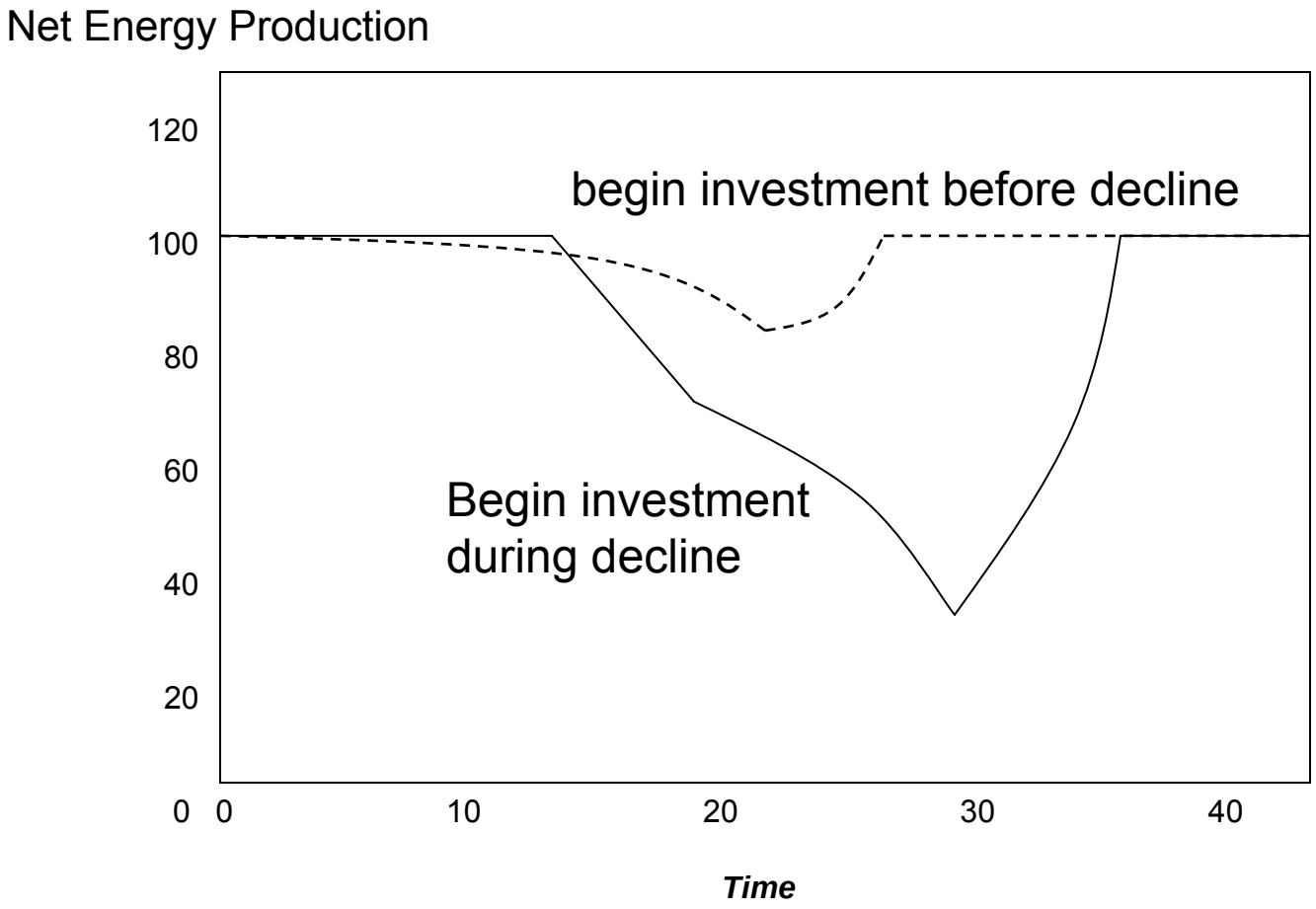
Swenson's Law



To avoid deprivation resulting from the exhaustion of non-renewable resources, humanity must employ conservation and renewable resource substitutes sufficient to match depletion.

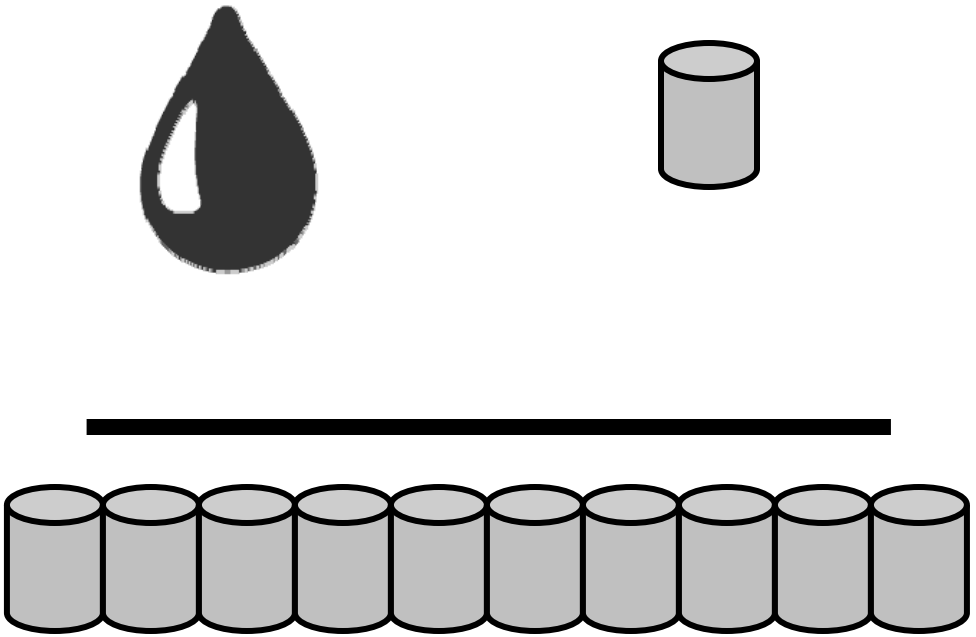
www.HubbertPeak.com/Swenson

Consequence of Delayed Investment



www.HubbertPeak.com/BeyondOil

Thermodynamics of Oil



And it's getting worse…

It depends …

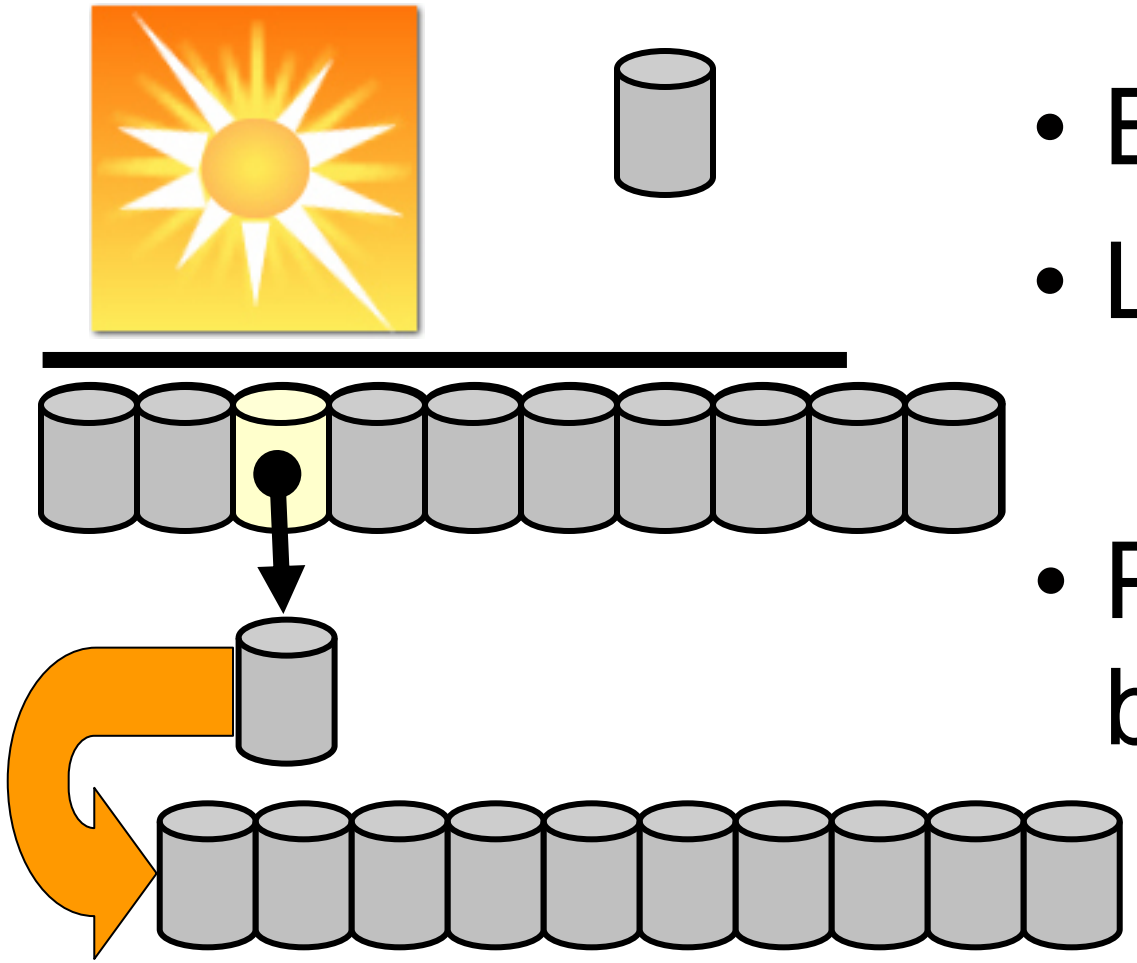
- Pennsylvania?
- Saudi Arabia?
- Off-shore?

Plus …

- Ravaged land/oceans
- Greenhouse gases
- Water contamination

EROI = 10±

Thermodynamics of PV



- EROI: 5 years
- Life: 50 years
- Plus it can be bootstrapped

And it's getting better…

EROI = 10→30 ~ electric

PRT roadmap

"*Land a transportation system on earth*"

- **Mercury** - PRT software contest
  - For example, with VR animation of thousands of cars (or toy trains) *hosted at NASA Ames*
  - Concept for simulator needed
  - PRT control system
    - Vehicle control - collision avoidance, switching
    - Navigation
    - Artificial intelligence for learning traffic patterns and optimal empty car utilization
- **Gemini** - Prototype testing of different drive mechanisms, interoperability standards
- **Apollo** - Small city installs working pilot

Who are the potential players?

- Vectus
- Skytran
- ULTra
- Private funding (VCs)
- Government
- Public-private partnerships

VC have shied away until now because governments must approve rights of way

Vectus Critical Design Features

- Vehicle rides on track
  - Slower speed but simpler design
  - $10m per mile track
- Aerodynamic (4 seats)
  - Larger footprint that SkyTran but better than cars
- Other features like SkyTran

SkyTran Critical Design Features

(page 1 of 2)

- Passive Maglev (safe during power failure)
  - Low friction, low maintenance, high efficiency
  - Vehicles will log 400,000 miles per year
- Light vehicle - lower energy consumption
  - Only $1m per mile track cost
- Aerodynamic (2 tandem seats)
  - Very low drag and frontal area
  - 100 mph possible for commuting
- Above ground - avoid traffic, improve safety
- Vehicle controlled switching (not track)
- Vehicle hangs below hollow track
  - eliminates twisting forces and derailment

SkyTran Critical Design Features

(page 2 of 2)

- Vehicles must be computer controlled
  - allow docking of cars to reduce drag
  - improve traffic
  - dispatch of empty cars
- No Rights-of-Way payments
  - 10” diameter steel vertical tubes supports overhead guideway.
- 3D track layout, no traffic lights only merging.
- No PRT stations, only track sidings for empty pods.
- Small on-board 20 lb. battery for power failures.

Passive Halbach array

- LNL / Inductrack
- neodymium-iron-boron permanent magnet
- NASA 3 yr contract for rocket propulsion
- 5 magnet array on car
- Coils embedded in track
- 2 km/hr min speed to levitate several cm.
- Magnetic friction decreases with speed.
- Lift force 50x weight of magnets