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Charting a Course to Energy Independence

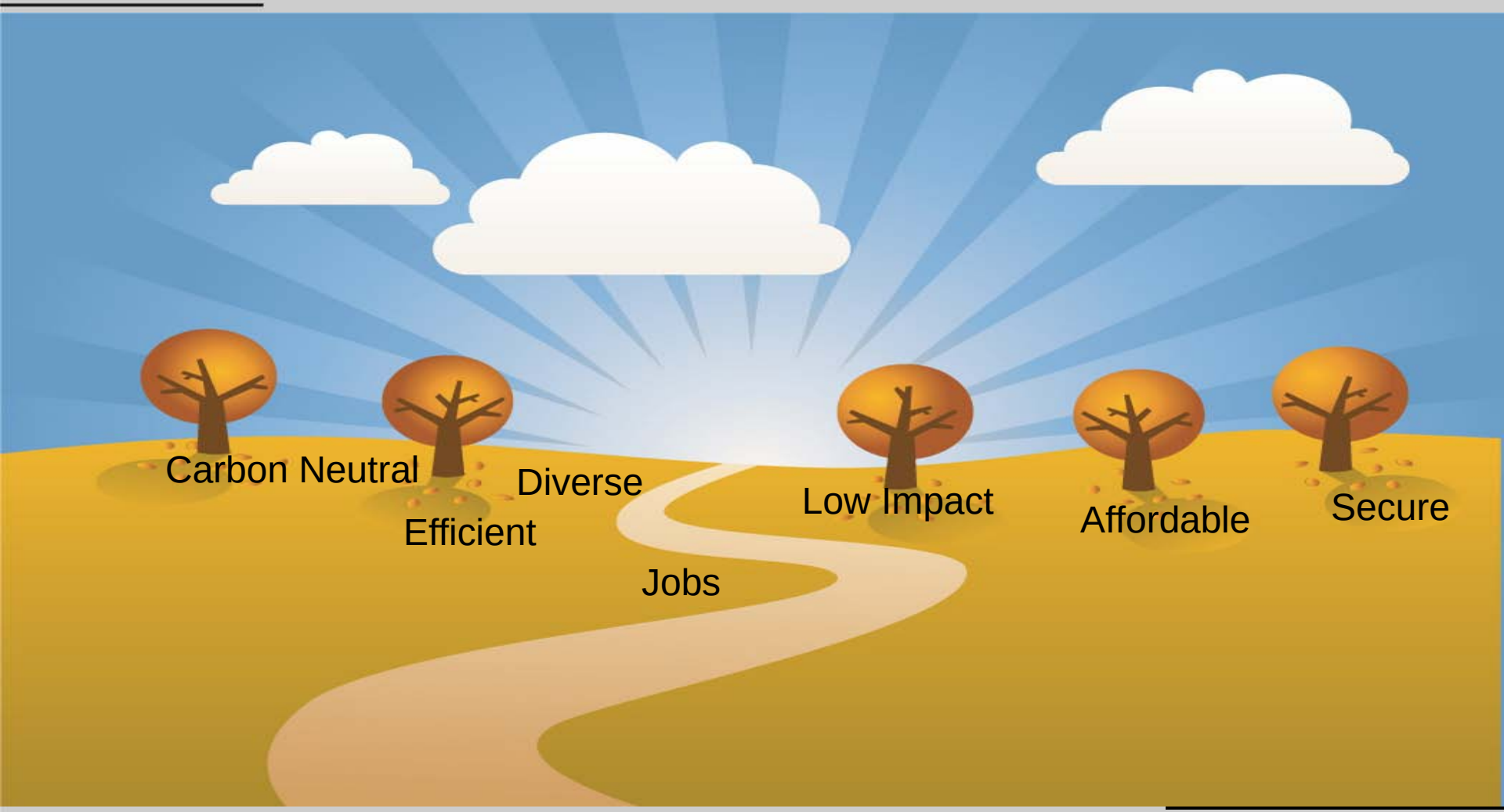
Providence, RI
August 9-12, 2009

Renewable Energy

What's new on the horizon?

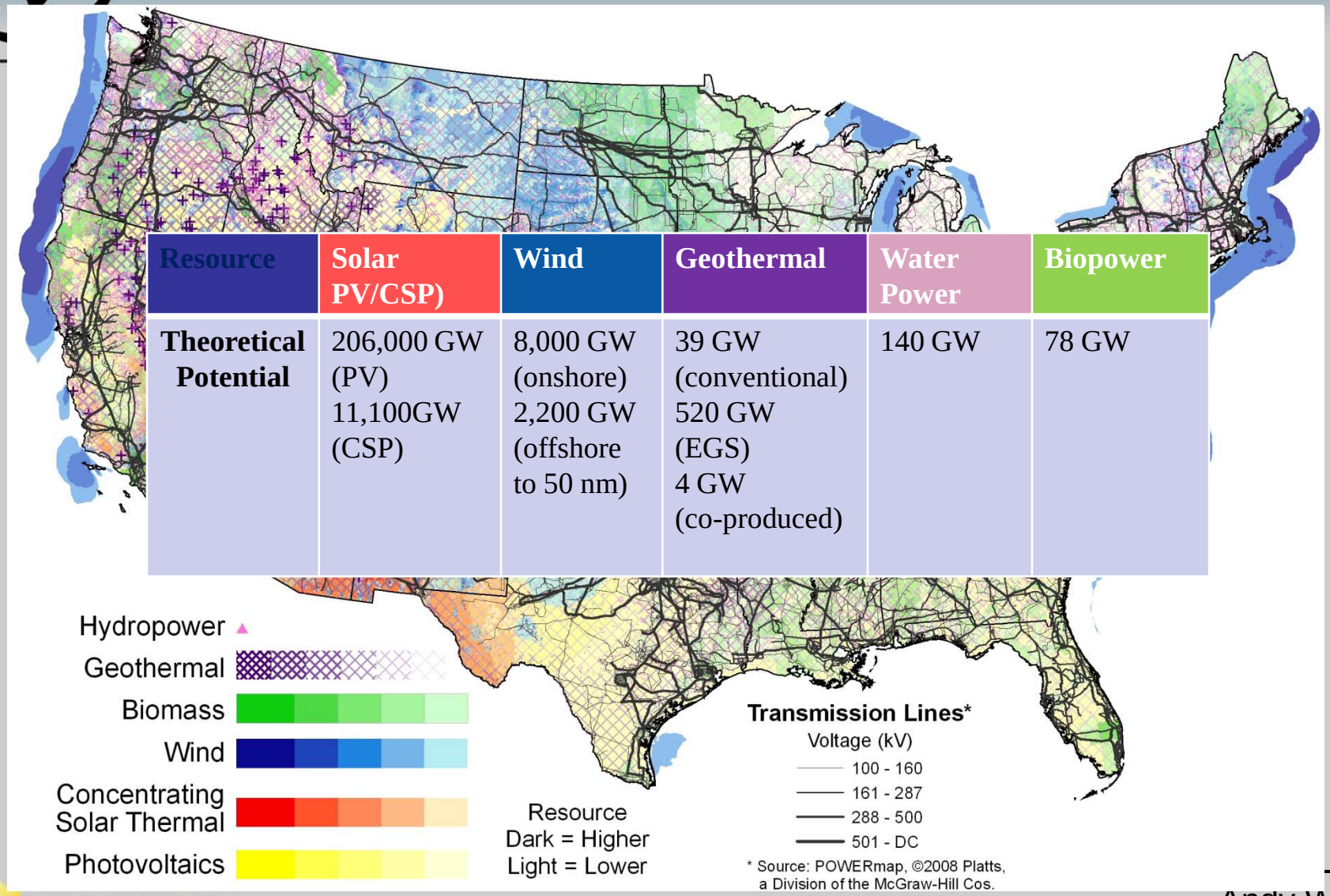
Andy Walker PhD PE
NREL
andy.walker@nrel.gov

Renewable Energy on the Horizon.



Andy Walker

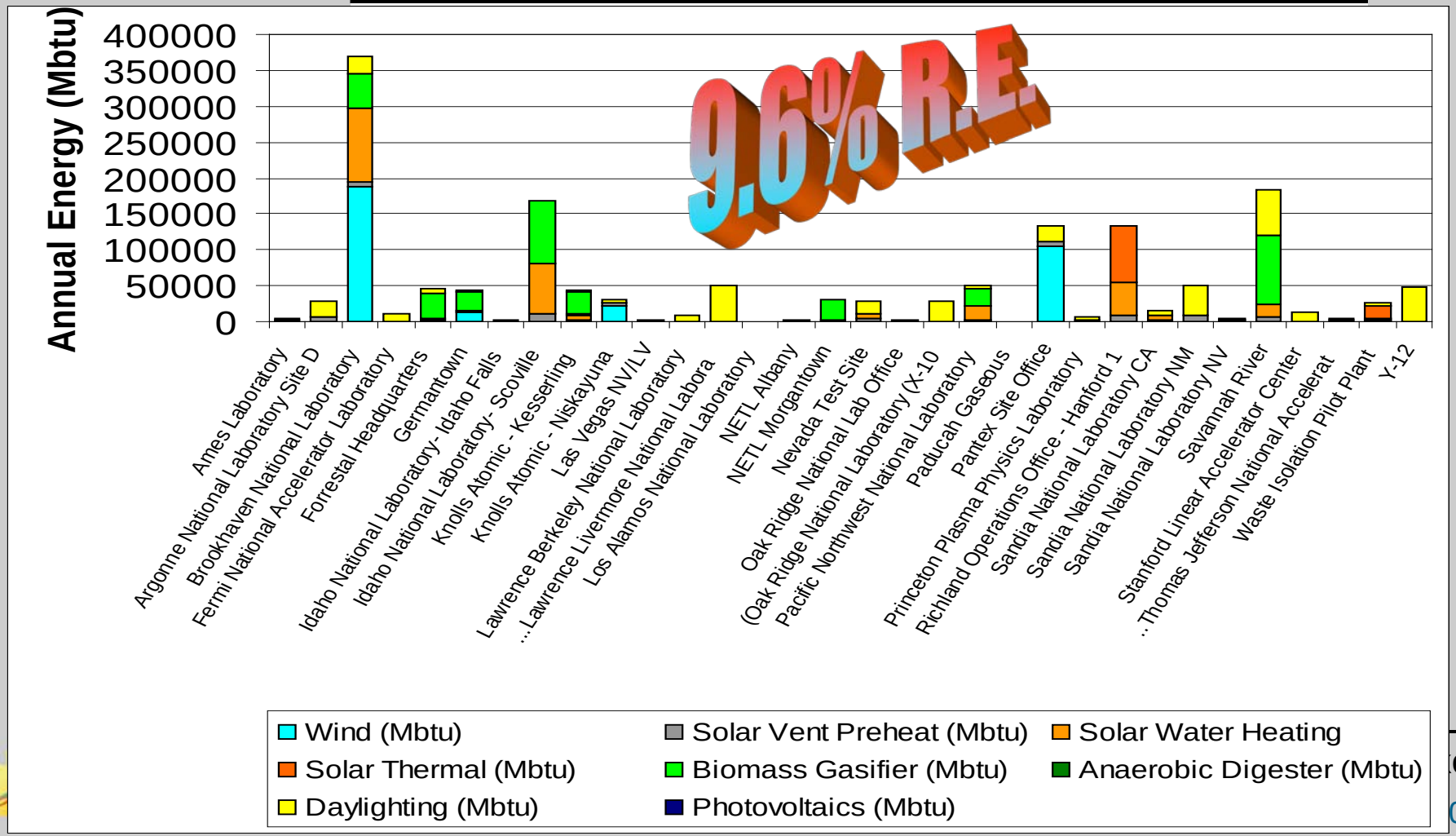
New: Integrated Analysis Tools (GIS)



Resource	Solar PV/CSP)	Wind	Geothermal	Water Power	Biopower
Theoretical Potential	206,000 GW (PV) 11,100GW (CSP)	8,000 GW (onshore) 2,200 GW (offshore to 50 nm)	39 GW (conventional) 520 GW (EGS) 4 GW (co-produced)	140 GW	78 GW

RE Optimization 31 DOE Sites

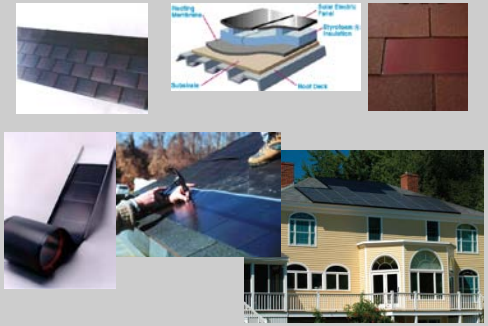
Initial Cost for Renewable Energy Projects ($)	$269,634,839
Annual Electric Savings (kWh/year)	217,734,776
Annual Gas/Fuel Savings (therms/year)	8,693,565
Annual Cost Savings ($/year)	$26,241,533
Simple Payback Period (years)	10.3
Rate of Return	11.3%



Horizons for Cost Effective Zero Energy Buildings

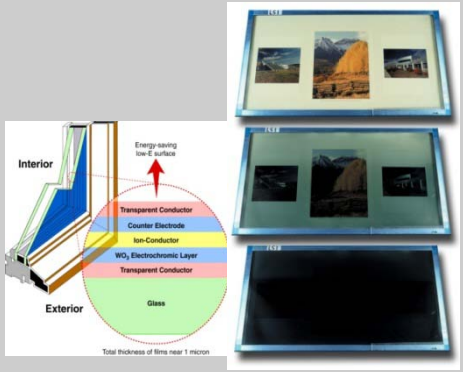
NREL Zero Energy Habitat House

BIPV Products & PV-T Array



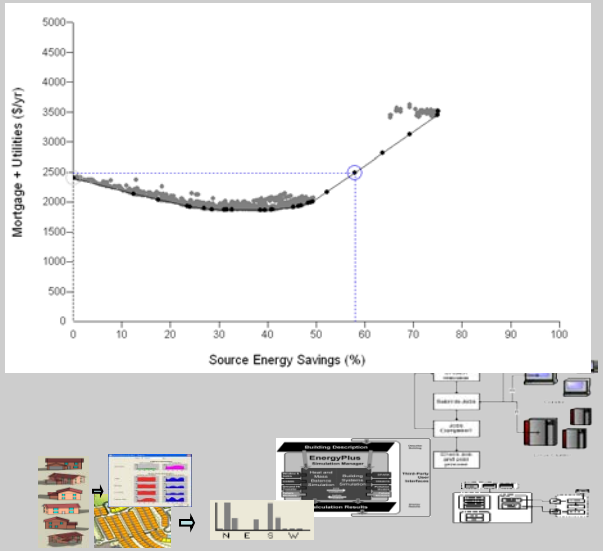
Compressorless Cooling

Electrochromic Windows



Polymer Solar Water Heaters

Computerized optimization & simulation Tools



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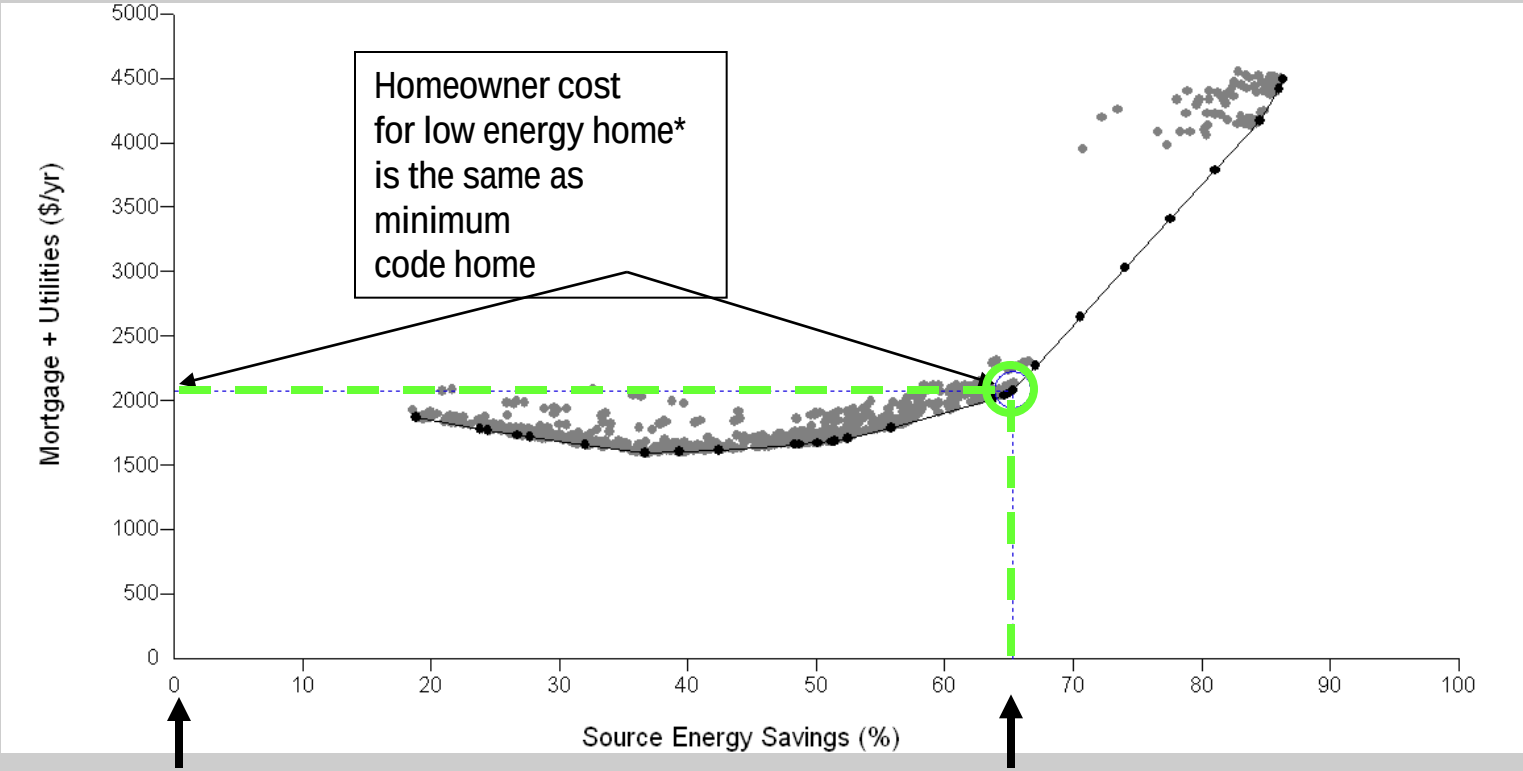
Net-Zero Energy Homes That Are Cashflow Neutral

- NREL Analysis using BEOpt software for Boulder,CO climate



Average 1990's home

* low energy home requires 65% less energy

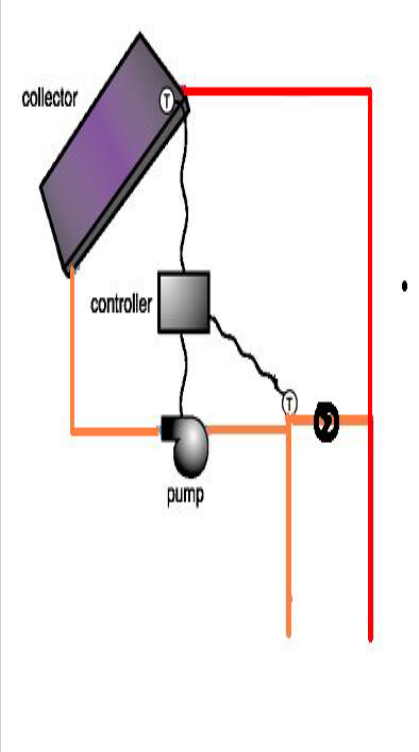
Example taken from the "GEOS" Neighborhood. Courtesy of Wonderland Hills Development, Boulder, Colorado

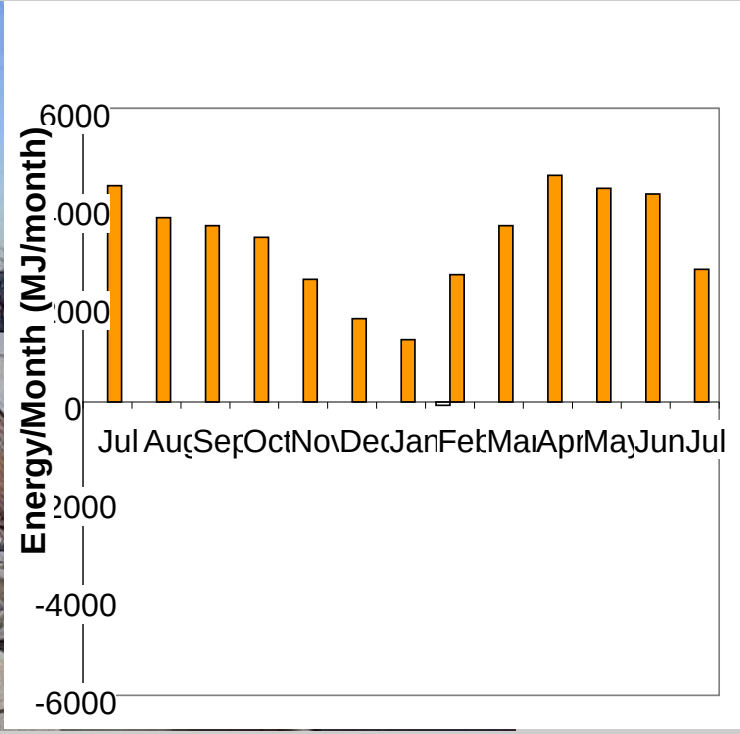
Best Paper Award
Proceedings of the ASME 2009 3rd International Conference of Energy Sustainability July 19-23, 2009, San Francisco CA

MODELING, TESTING, AND EVALUATION OF A BUILDING-INTEGRATED PHOTOVOLTAIC-THERMAL COLLECTOR

Charles D. Corbin and Michael J. Brandemuehl

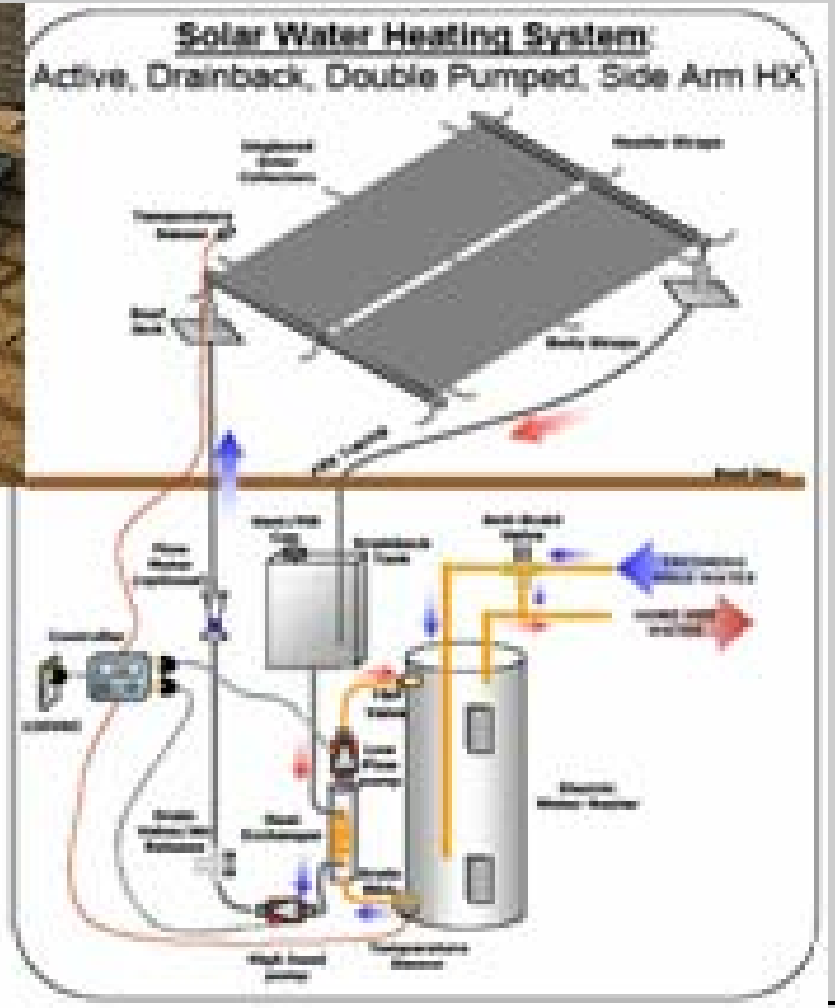
Solar Heating of Hot Water Recirculation Loop





SSA Philadelphia: Bob Stitler
Reheats Recirculation Loop
180 Evacuated Heat-Pipe Collector tubes, 27 m2 gross area
Cost $37,500
Delivery of 38 GJ (36 million Btu)/year measured
Installed 2004.

Polymer Solar Hot Water Systems



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Freeze-tolerant PEX piping

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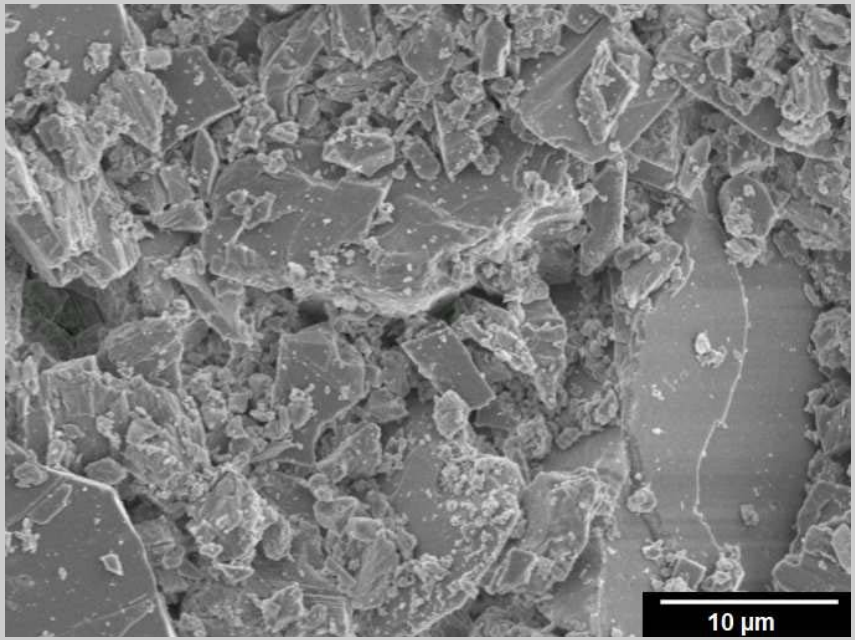
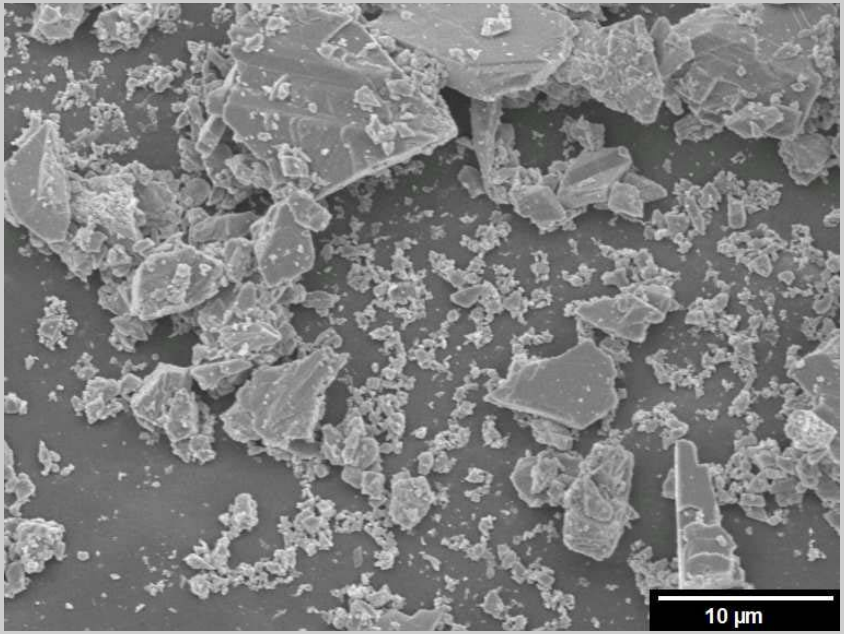
SHEAR INDUCED REMOVAL OF CALCIUM CARBONATE SCALE FROM POLYPROPYLENE AND COPPER TUBES

Matt Royer, Jane H. Davidson, Lorraine F. Francis, and Susan C. Mantell

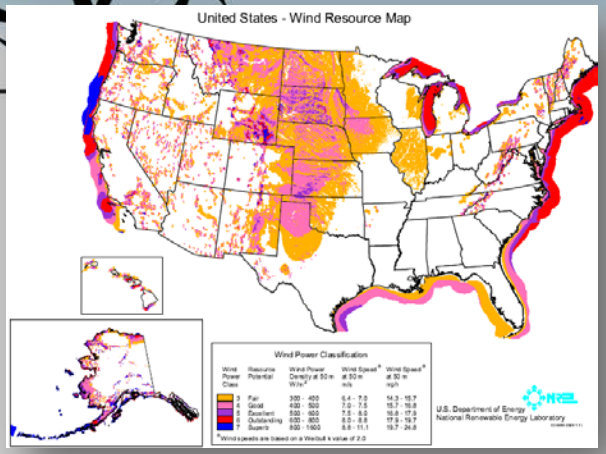


Copper Tube



Polypropylene Tube

Horizons in Wind Energy



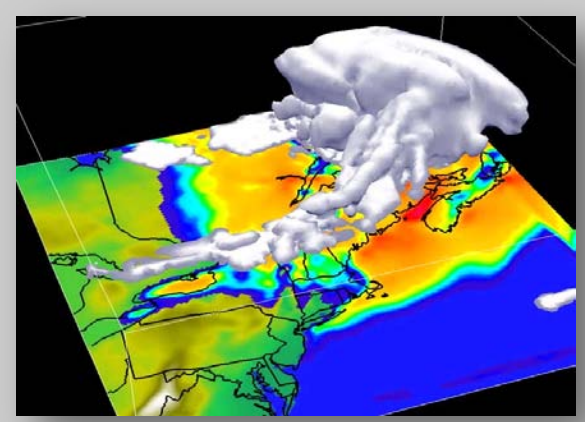
Resource assessment and planning

Offshore Wind

Advanced Blades

Innovative Tall Towers

Giant Multi-megawatt Turbines



Courtesy:WindLogics, Inc. St. Paul, MN

Wind Forecasting

Bigger Turbines

45 m 2004

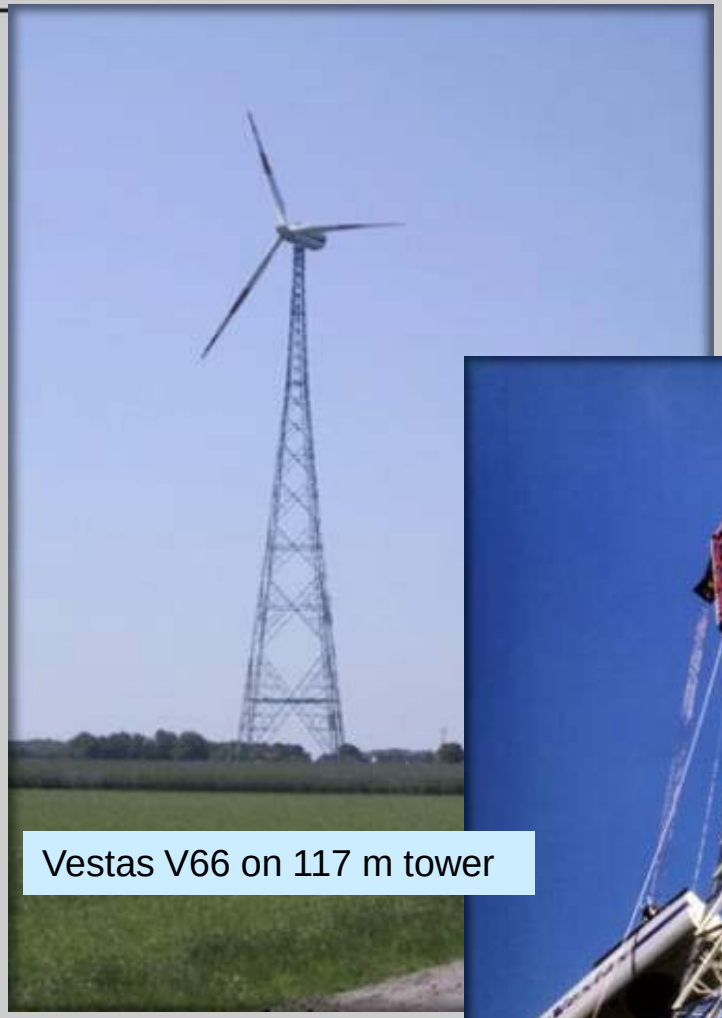
Bigger Turbines

Enercon 4.5MW 112 meter rotor

50kW to 5000kW in 20 years
Fixed →Pitched Blades
61.5 m blades
Cost per kW ↓ as size↑

440 metric tonnes

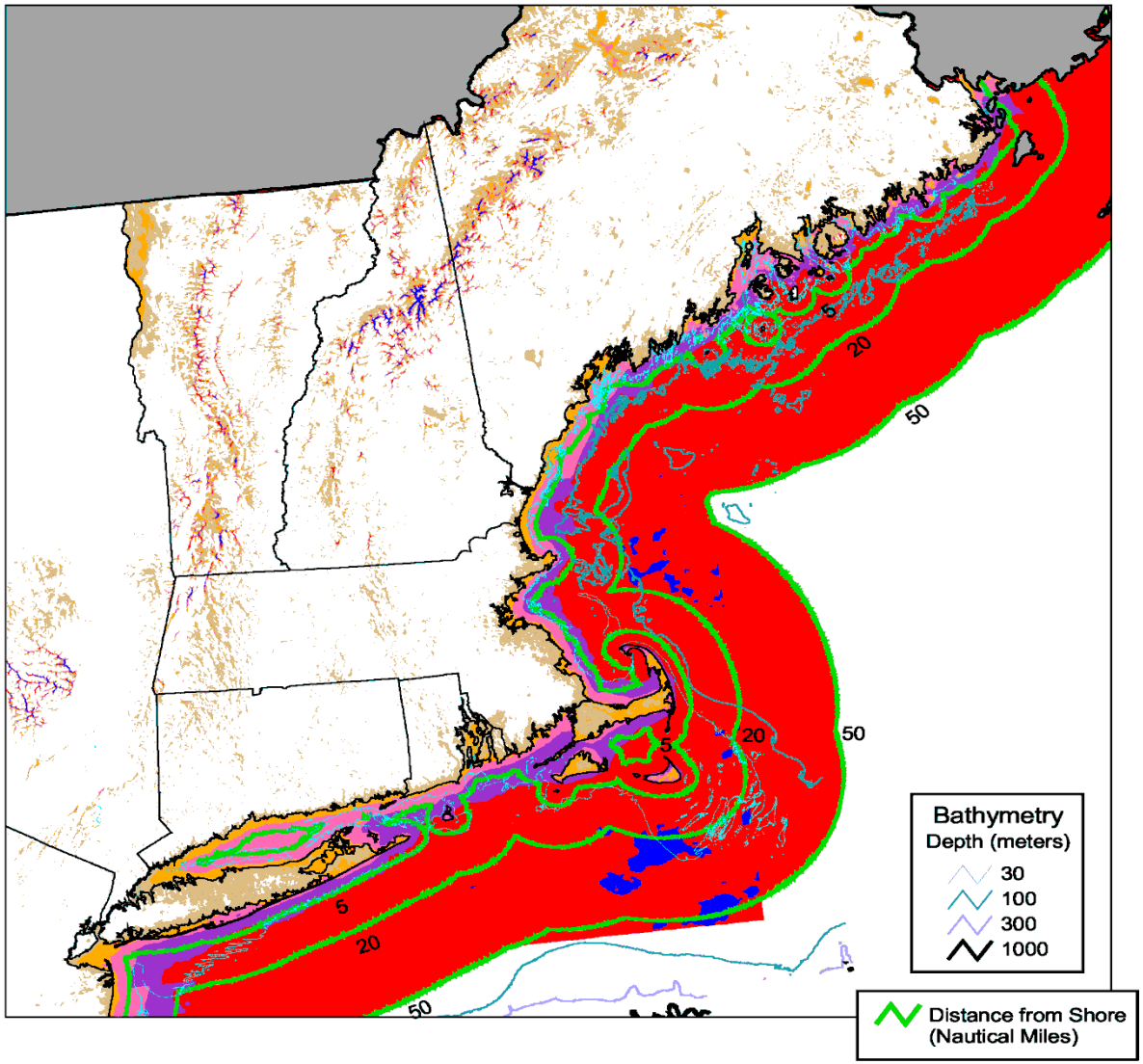
Tall Tower Concepts:



Vestas V66 on 117 m tower

- Novel Steel tubes
- Truss towers
- Pre-stressed concrete
- Composite
- Hybrid towers
- Self-erecting/no cranes
- On-site manufacturing
- Tower load feedback control

Future Wind - Offshore



New England Offshore Wind Resource Potential

All areas > 5 nautical miles offshore likely to be class 4 resource or better.

Area 5-20 nautical miles from shore (67% excluded):
- 10,300 sq. km. (51,500 MW)
- 1,980 sq km (9,900 MW) <30m depth

Area 20-50 nautical miles from shore (33% excluded):
- 33,800 sq. km. (169,000 MW)
- 540 sq km (2,700 MW) <30m depth

The wind power resource data for this map was produced by TrueWind Solutions using the Mesomap system and historical weather data, and has been validated by NREL.

The bathymetry contour lines were derived from NOAA's coastal relief models (nominal resolution 1 km) from NOAA's National Geo-physical Data Center.

Wind Power Classification

Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m^2	Wind Speed[a] at 50 m m/s	Wind Speed[a] at 50 m mph
2	Marginal	200 - 300	5.6 - 6.4	12.5 - 14.3
3	Fair	300 - 400	6.4 - 7.0	14.3 - 15.7
4	Good	400 - 500	7.0 - 7.5	15.7 - 16.8
5	Excellent	500 - 600	7.5 - 8.0	16.8 - 17.9
6	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
7	Superb	> 800	> 8.8	> 19.7

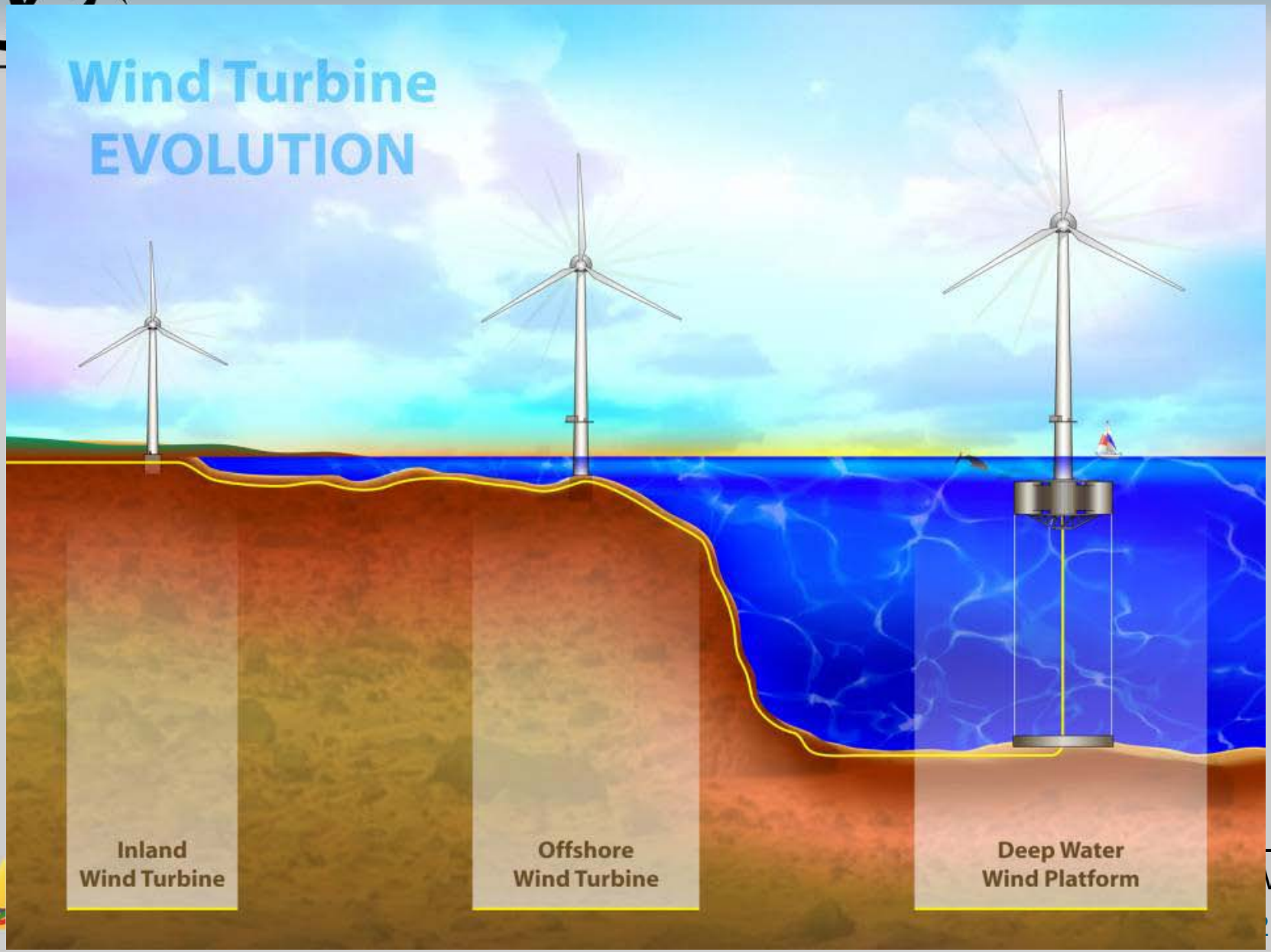
[a] Wind speeds are based on a Weibull k value of 2.0

U.S. Department of Energy
National Renewable Energy Laboratory

NREL

30-JUL-2003 2.1.2

Future Wind Turbines



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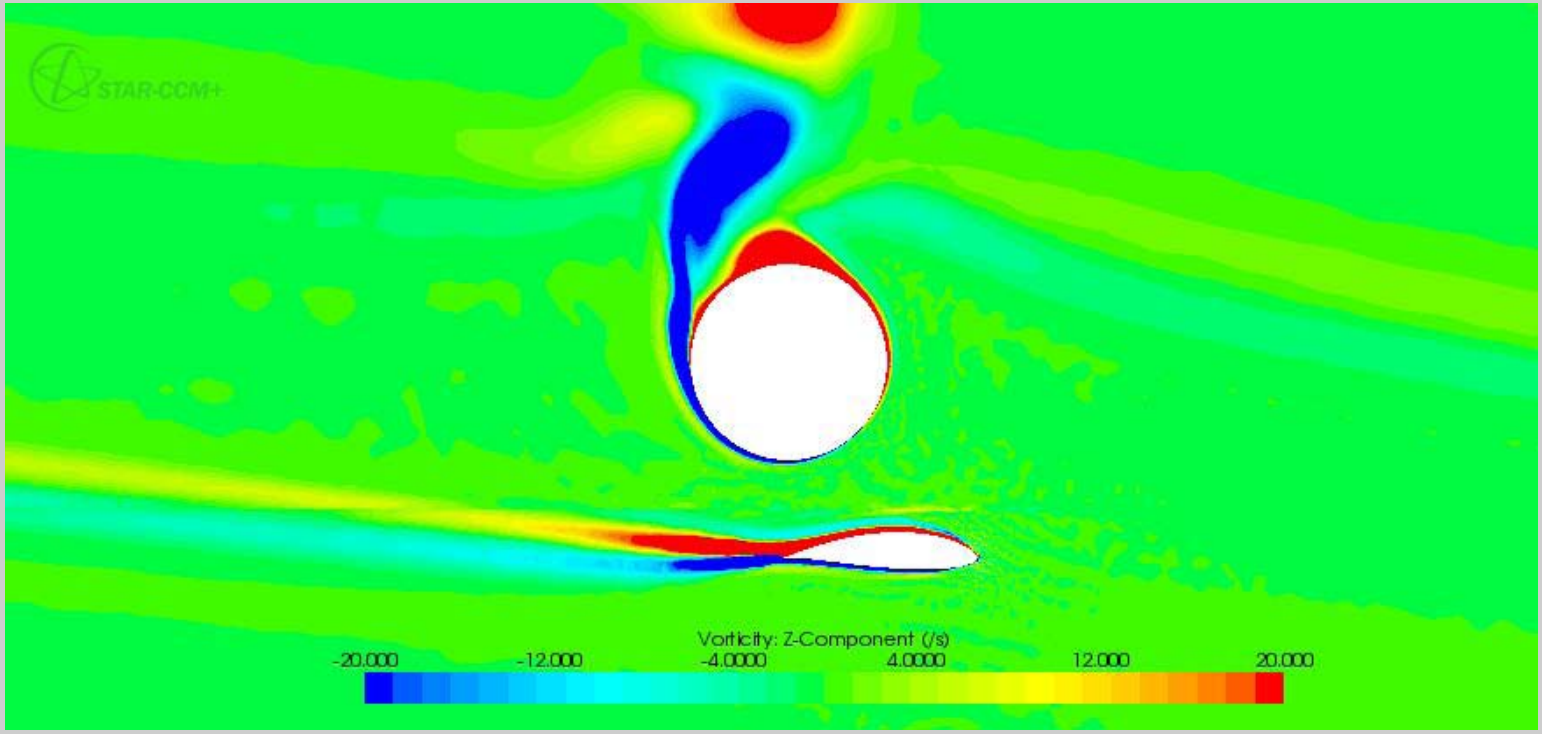
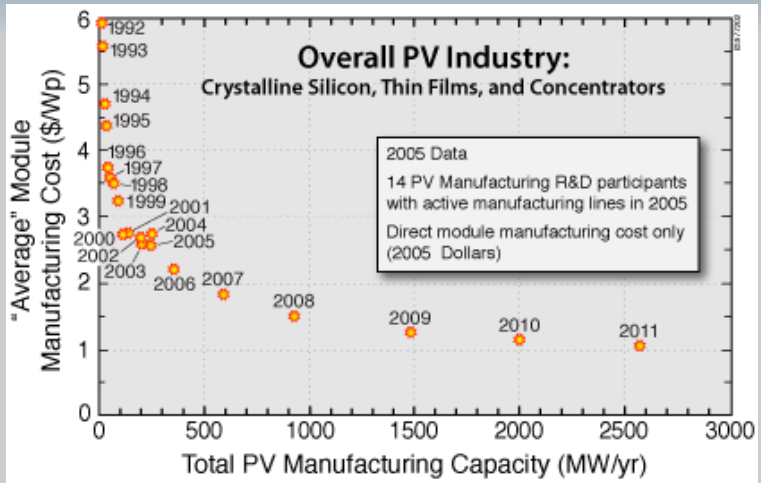
MODELING OF PULSATING LOADS ON WIND TURBINE BLADES

Alejandro Gomez and Joerg R. Seume



Photovoltaics on the Horizon

Applications



Cost Reductions

Materials and Devices:

CdTe, CIS, CIGS, 3/5, 2/6, Organic

Surface treatments

Manufacturing

Tracking and Concentration

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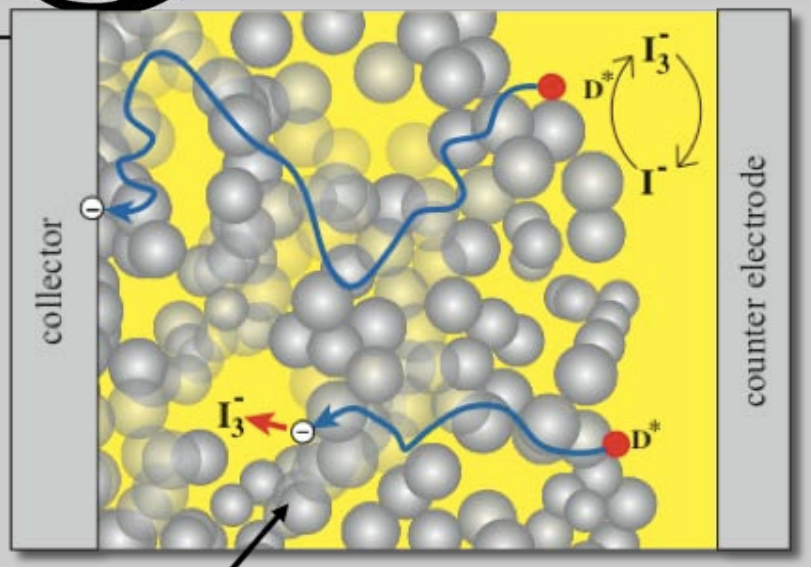
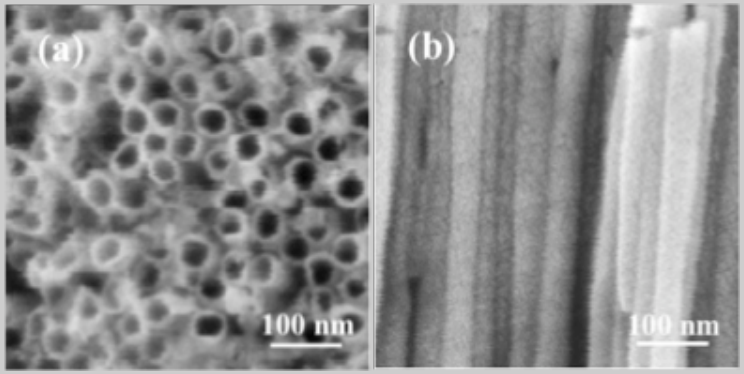
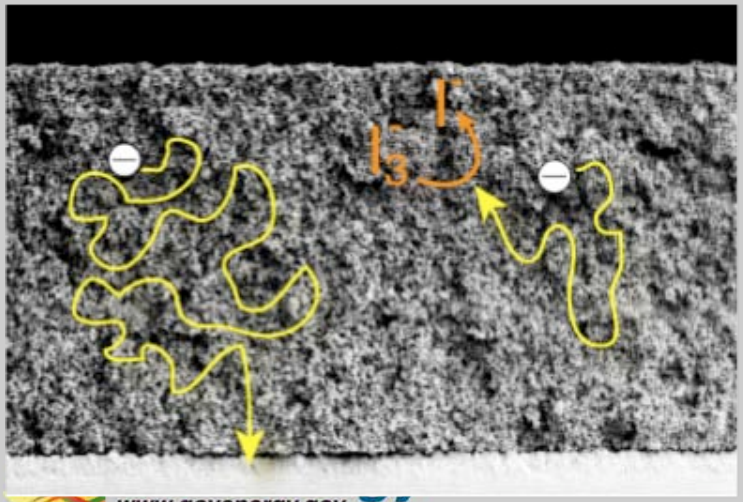
Current Research Moves from Nanoparticles to Nanotubes to Improve Electron Transport



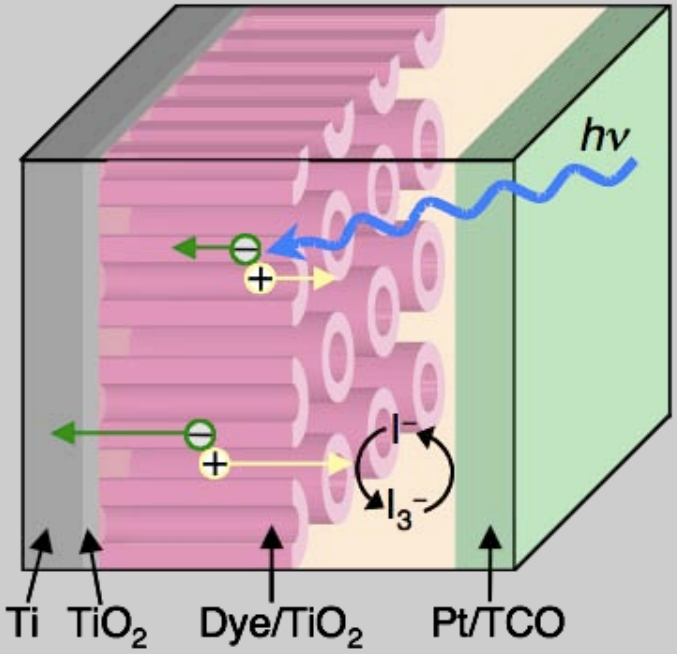
Disordered (randomly packed) nanoparticles





10-15 µm
500-750 particles

SnO_2 - collector



Credits: Andy Walker

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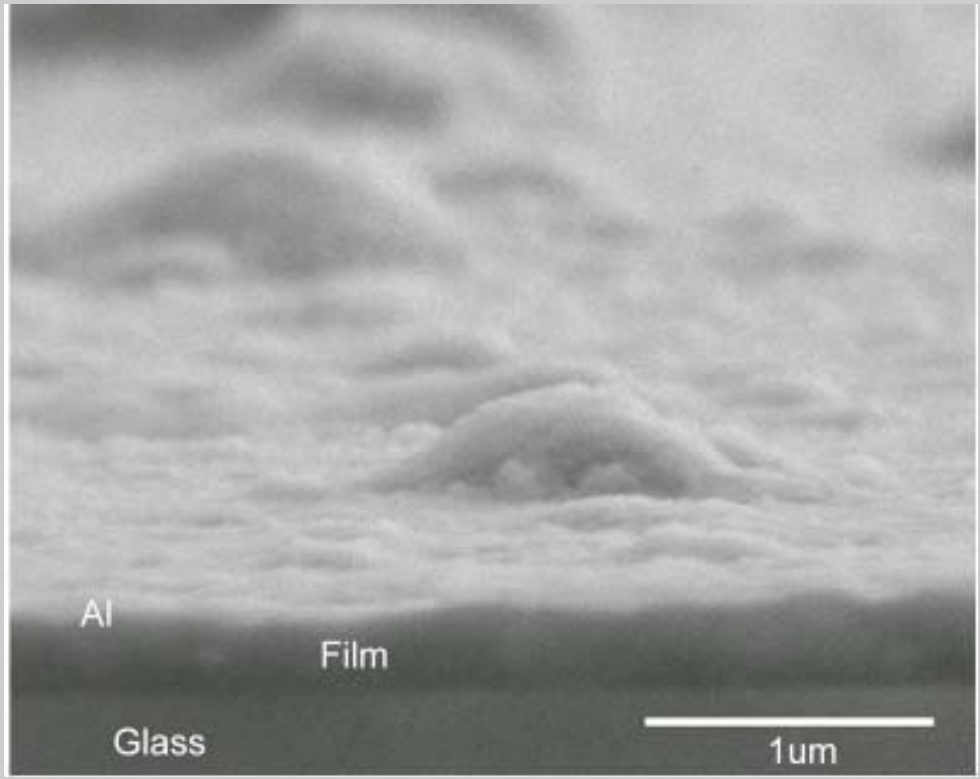
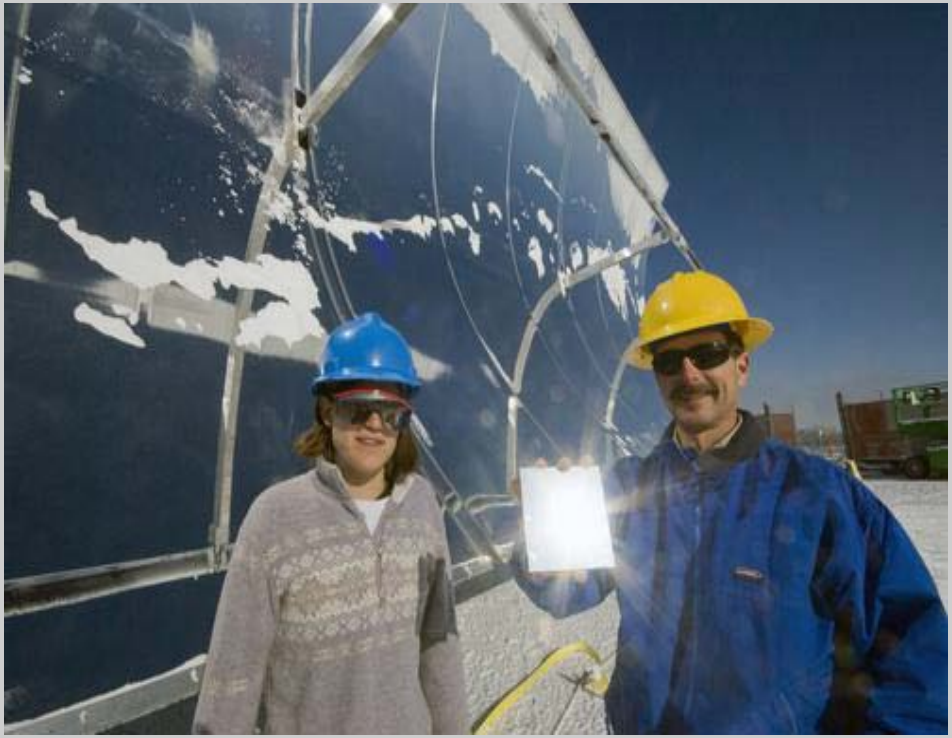
HYBRID SOLAR CELLS FROM SILICON NANOCRYSTALS AND CONDUCTIVE POLYMERS

Chin-Yi Liu and Uwe R. Kortshagen



Horizons of Solar Thermal



Bigger Troughs
Frame Development
- fewer parts
- less weight
- faster assembly

Direct Steam Generation
Hybrid Cooling
Non-glass mirrors

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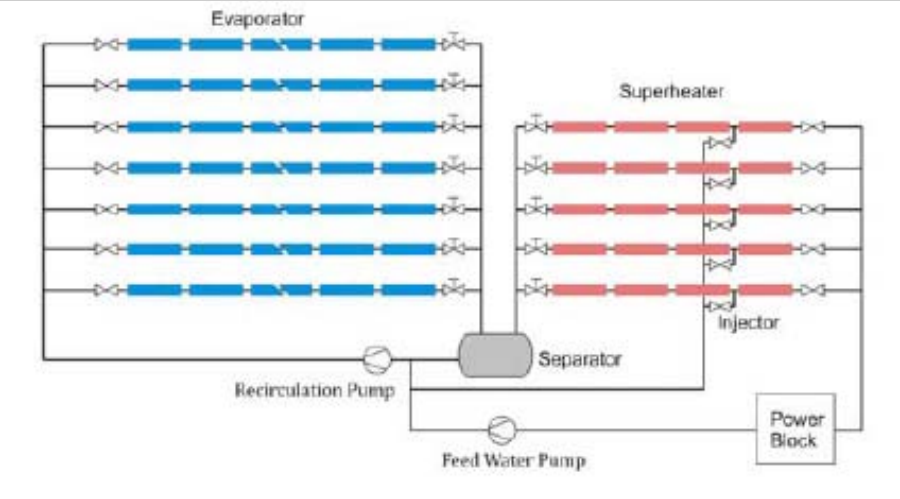
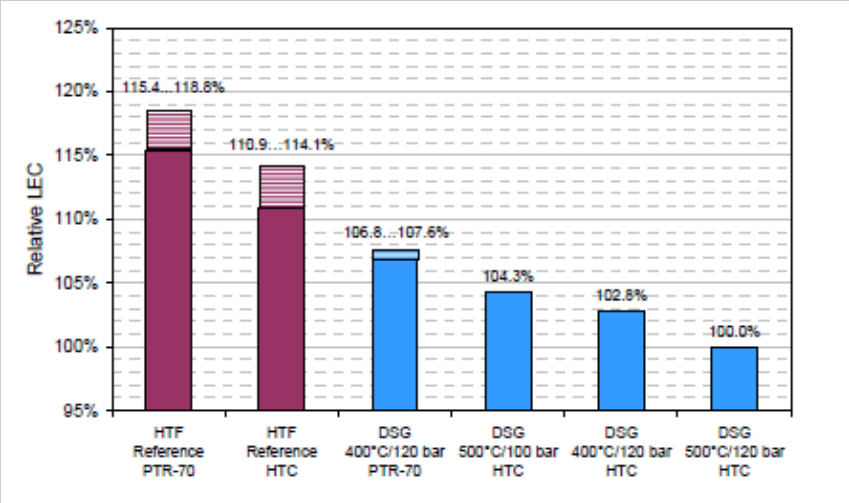
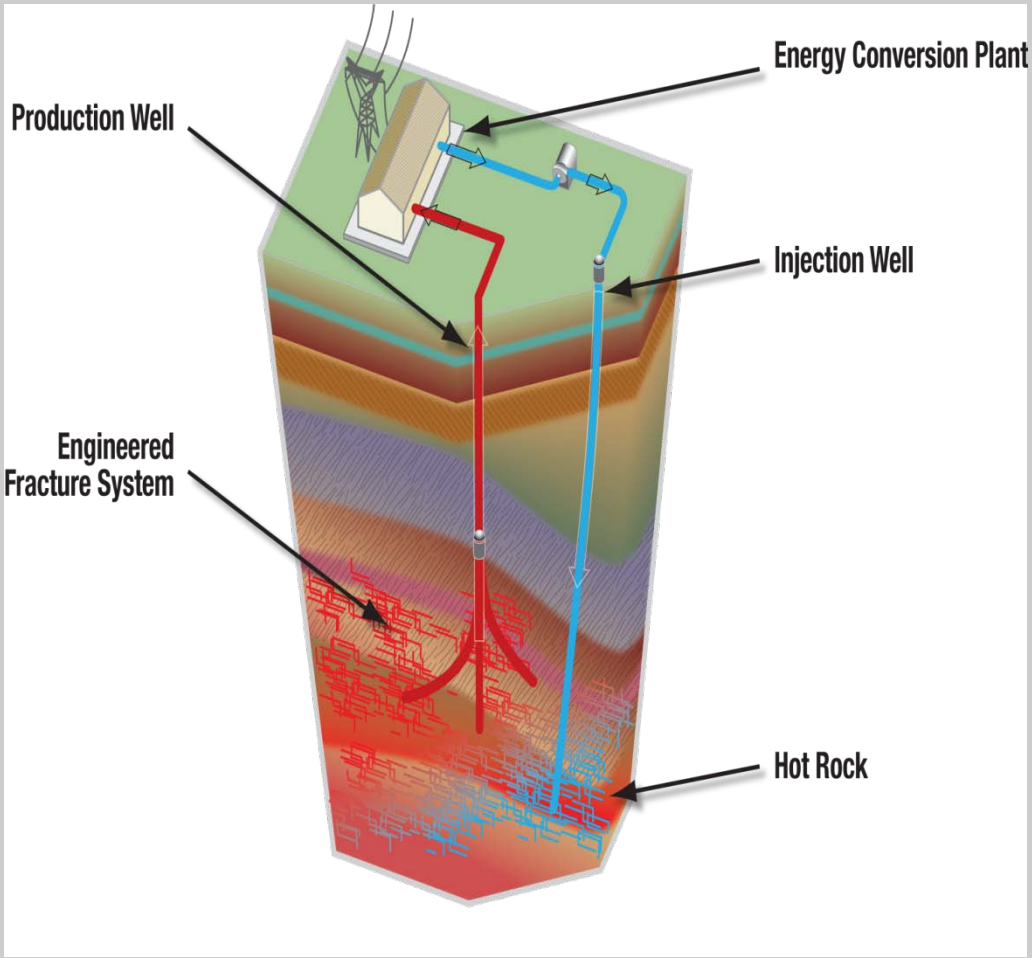
ECONOMIC POTENTIAL OF SOLAR THERMAL POWER PLANTS WITH DIRECT STEAM GENERATION COMPARED TO HTF PLANTS

Jan Fabian Feldhoff, Daniel Benitez, Markus Eck, Klaus-Jürgen Riffelmann





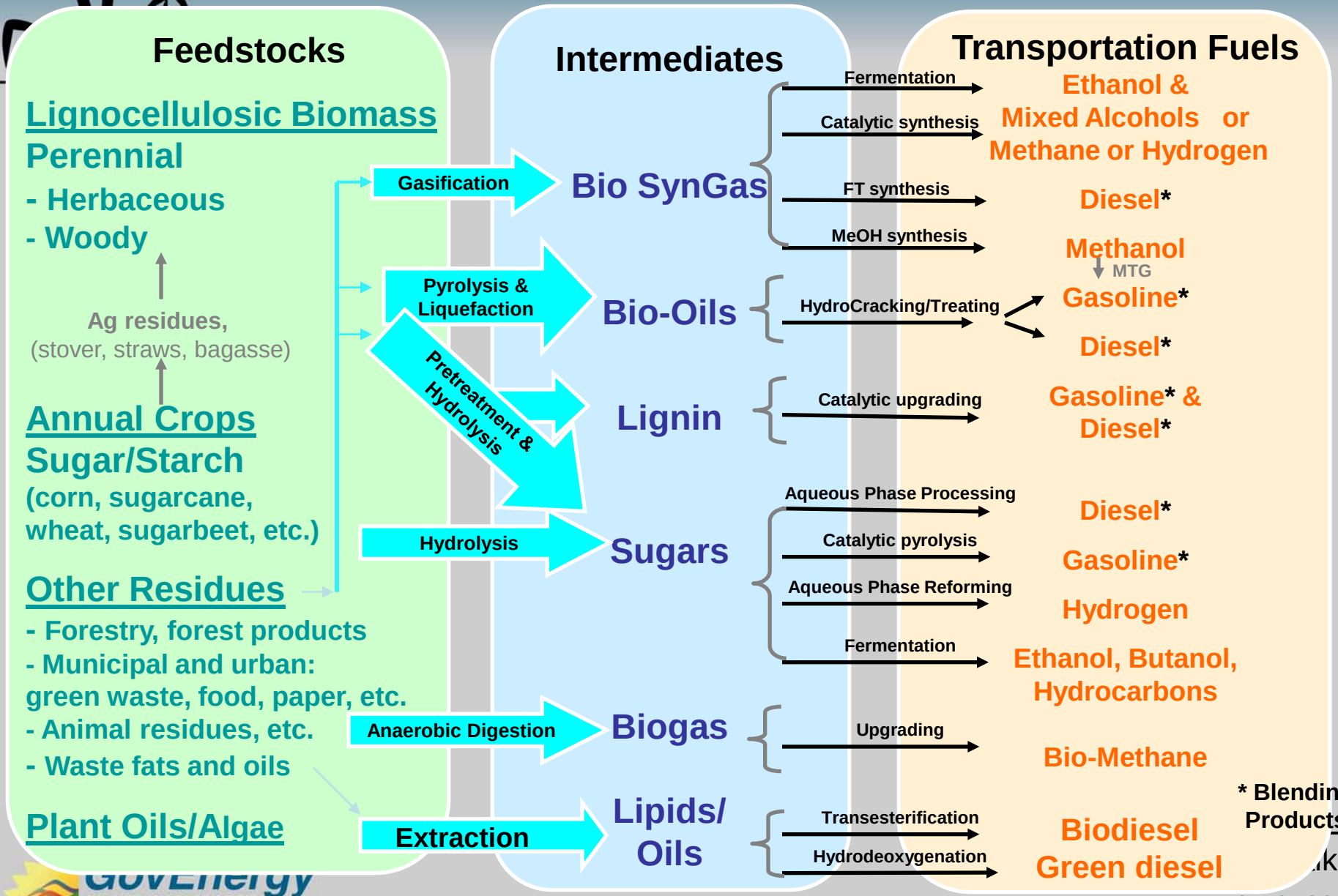
Horizons of Geothermal Research



Source: NREL

- Engineering below-ground systems.
- pathways to commercialization
- Systems engineering/integration
- Geothermal energy conversion RD&D
- Low temperature geothermal, direct use
- Ground source heat pump RD&D
- Dry cooling and hybrid cooling

Wide Range of Biofuel Technologies



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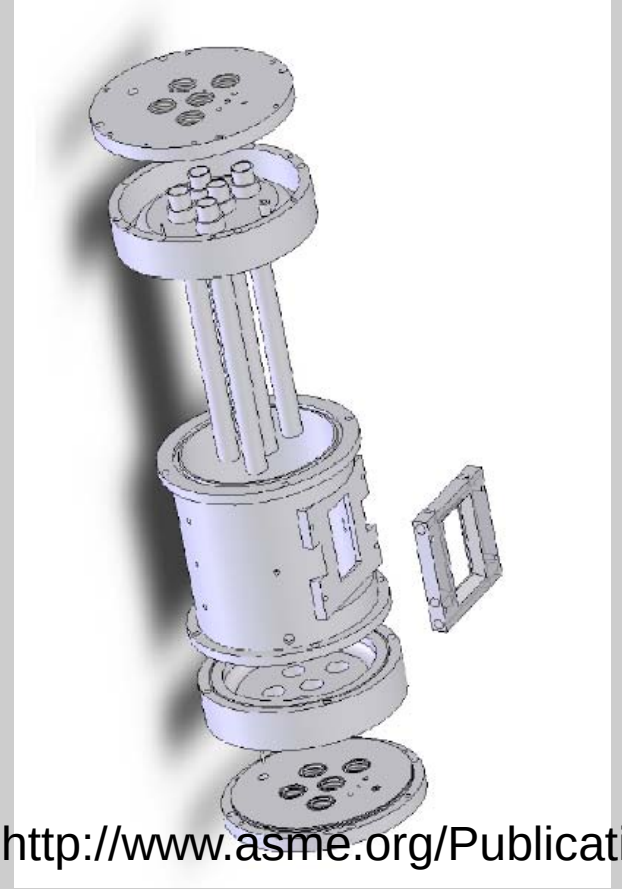
RAPID HIGH TEMPERATURE SOLAR THERMAL BIOMASS GASIFICATION IN A PROTOTYPE CAVITY REACTOR

Paul Lichty, Christopher Perkins, Bryan Woodruff, Carl Bingham, Alan Weimer



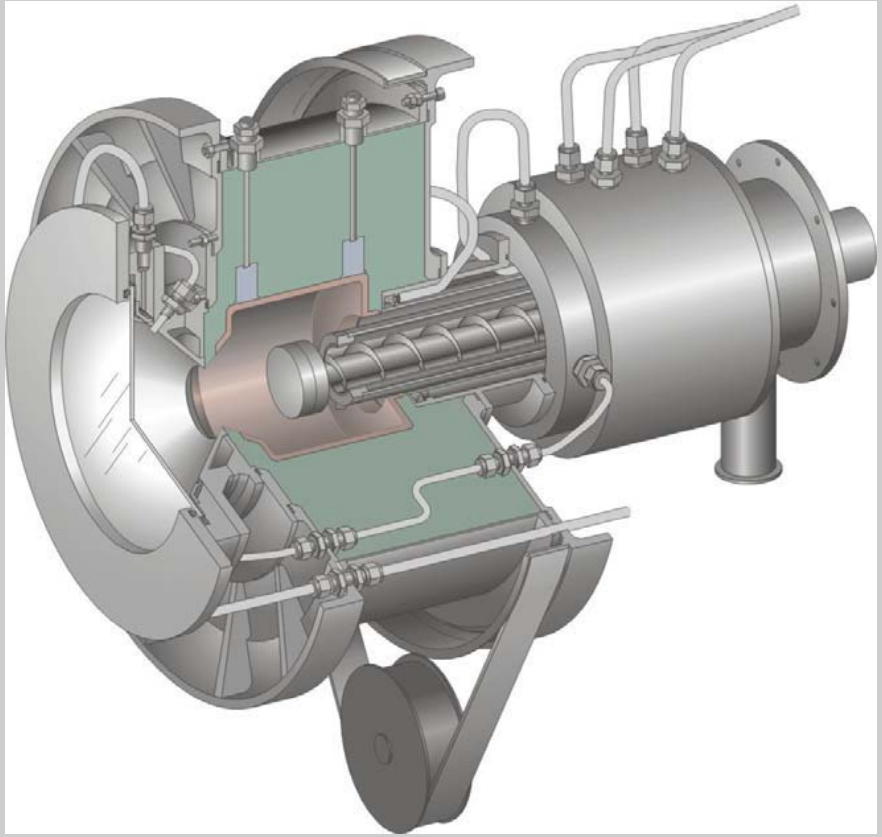
http://www.asme.org/Publications/ConfProceedings/

Yellot Award Lecture
ASME 2009 3rd International Conference of Energy Sustainability

July 19-23 2009, San Francisco CA

FUELS FROM SUNLIGHT, WATER, AND CO2

Aldo Steinfeld



$ZnO \rightarrow Zn + 1/2\ O_2$

$Zn + H_2O \rightarrow ZnO + H_2$

Thank You!