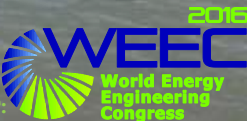


RENEWABLE ENERGY & SUSTAINABLE DEVELOPMENT

# “ENERGY BREAKTHROUGHS THAT ARE EXPECTED TO HAVE PUBLIC IMPACT”

FEBRUARY 23-24, 2018  
 THOMAS F. VALONE, PHD, PE  
 INTEGRITY RESEARCH INSTITUTE  
 BELTSVILLE MD  
 USA



ALSO PRESENTED AT:


Thomas Valone - Integrity Research Institute

## Earth’s Last 400,000 Year Climate History

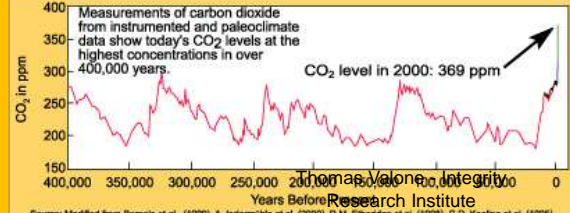
credit: Dr. Jim Hansen, NASA Goddard Inst. for Space Studies

**CO<sub>2</sub> and the “Omery Climate-Beast”**

Overnight history is concentrated in the last 10,000 years. Atmospheric concentrations of carbon dioxide and other greenhouse gases change the world. The past 100,000 years show a steady increase in CO<sub>2</sub> levels. There is no doubt that the concentration of CO<sub>2</sub> levels is increasing. The last 10,000 years show a steady increase in CO<sub>2</sub> levels. There is no doubt that the concentration of CO<sub>2</sub> levels is increasing.



On right is the same CO<sub>2</sub> data from ncdc. noaa. gov



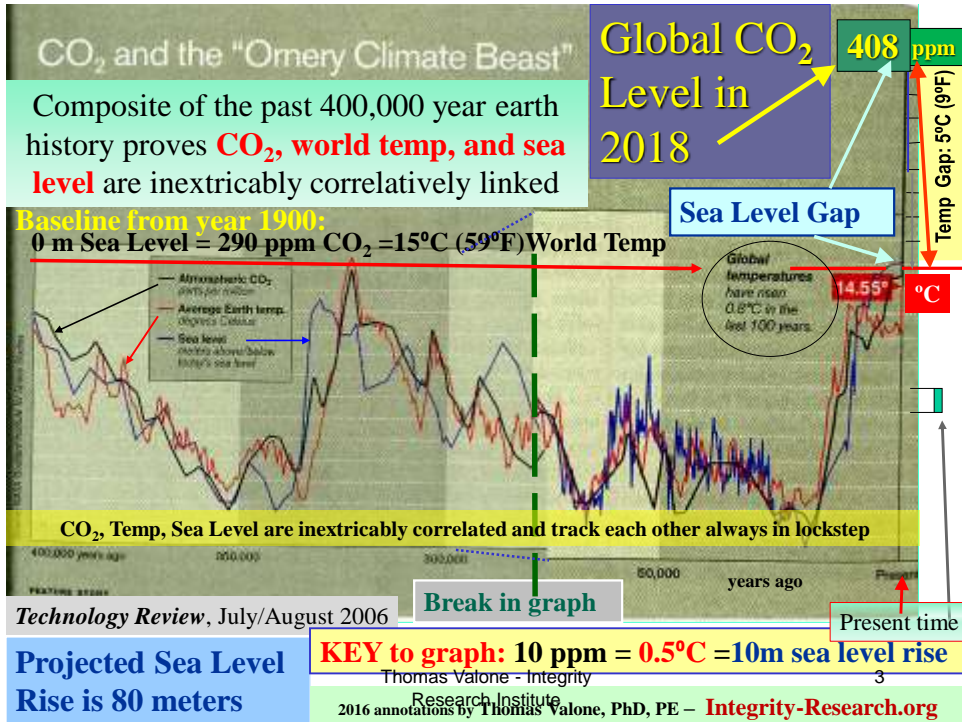
Measurements of carbon dioxide from instrumented and paleoclimate data show today's CO<sub>2</sub> levels at the highest concentrations in over 400,000 years.

CO<sub>2</sub> level in 2000: 369 ppm

Thomas Valone, Integrity Research Institute

Source: Modified from Barnola et al. (1999), A. Indermühle et al. (2000), D.M. Etheridge et al. (1998), C.D. Keeling et al. (1996)


**MIT's  
Technology  
Review**  
July/August, 2006



## WHAT CLEAN ENERGY BREAKTHROUGHS ARE READY TO MAKE A PUBLIC IMPACT?

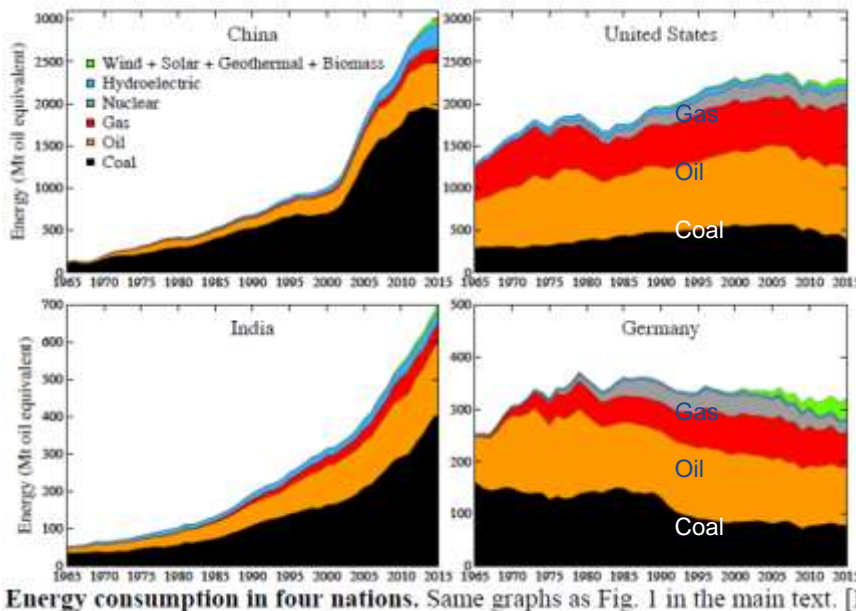
**Nuclear Power, Bacteria-Biomass Electricity, Solar Electric Plug-in Cars, Lithium-ion Batteries, Marine Turbines, Moisture Power, Osmotic Power, Tidal Power, Triboelectricity, Piezoelectric Panel Power, Distributed Solar PV, Net Zero Energy Communities, Energy Harvesting, Long Range Wireless Electricity**

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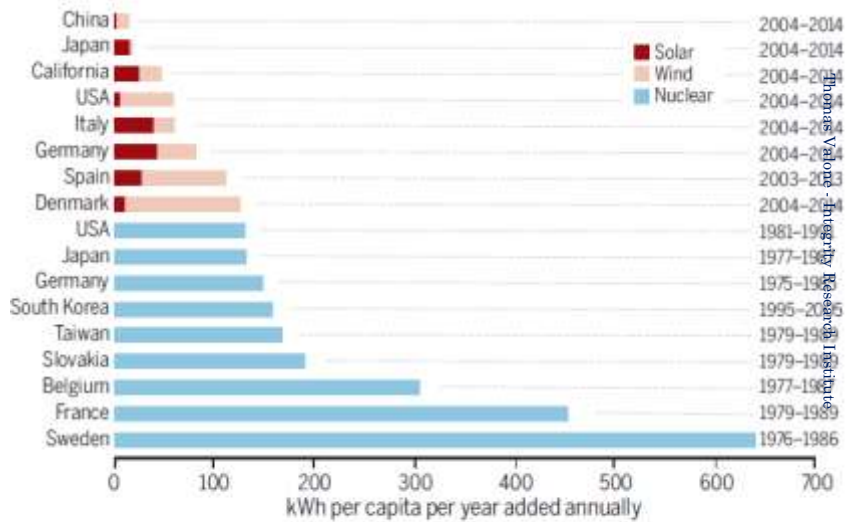
Energy consumption in four nations. Same graphs as Fig. 1 in the main text. [D

From China-US *Science* mag article





### Historical Annual Increase of Carbon-free Electricity per Capita during Peak – Note how Nuclear Power has Exceeded all other Renewable Energy Growth

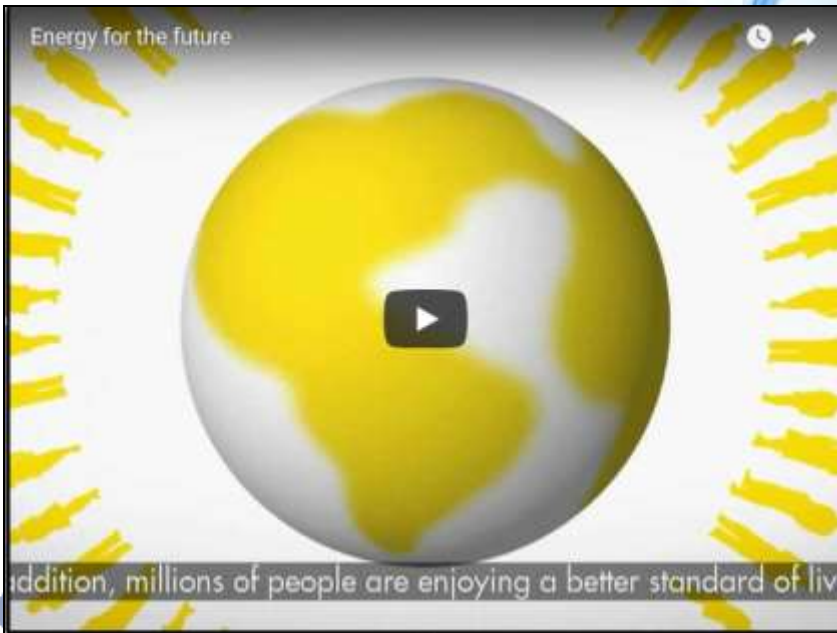


Average annual increase of carbon-free electricity per capita during decade of peak scale-up. Energy data from (6) except California renewables data from (7). Population data from (8). See supplementary materials.



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### SHELL OIL CORPORATION – 2050 PROJECTIONS



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“...projecting that a doubling to quadrupling of nuclear energy output is required in the next few decades”

“Nuclear scales up to 12x+ faster than solar/wind combined. Mass-manufacturing and coordinated approvals are key”



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# SOLAR ENERGY MODULES



Solar Illuminations lamp  
8 hours light with solar



Inflatable Solar Light  
\$15 from MPOWERD.COM



Distributed electricity that is failure-proof:

- solar lanterns
- networked solar rooftops



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## NET ZERO ENERGY DISTRICTS – FINANCIALLY ATTRACTIVE

- (1) Identify on-site **renewable energy capacity** and thus set the district's energy "budget";
- (2) Use **superefficient** district geothermal heating and cooling;
- (3) Set design standards to drive load up to **75 percent below code**; and
- (4) Iterate between steps 1 and 3, optimizing based on the net present value of the life-cycle cost until net zero energy is achieved.

These four steps must be done in a way that makes the project **financially attractive** to developers, tenants, and investors.

Developed for a 180-acre site in a Mid-size US city



Ft. Collins CO – Insight Brief from RMI.org



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**BIG IDEA**

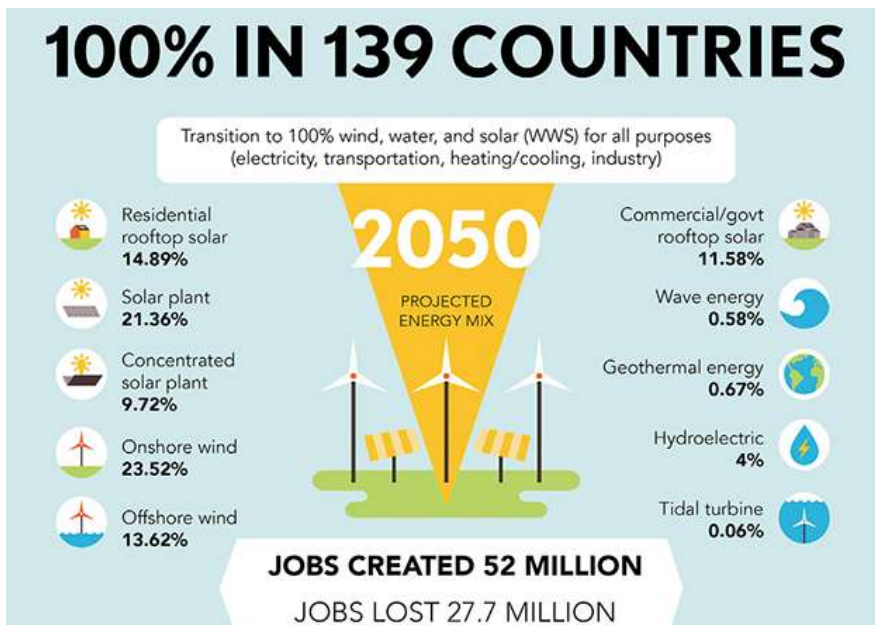
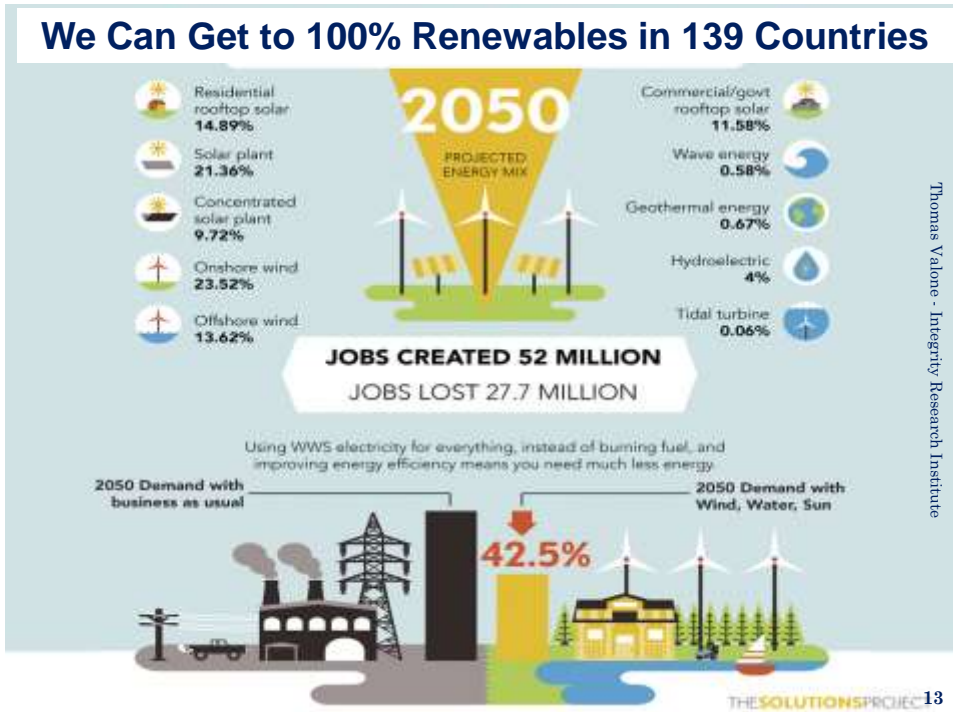
### Buildings that power themselves

Want to glimpse a city of the future? Look no farther than Astana, in oil-rich Kazakhstan, where a new development is rising to host Expo 2017, a global conference on clean energy. Using solar panels and wind turbines, the 430-acre (174 hectare) campus will produce a quarter of its own electricity, eventually cutting its CO<sub>2</sub> emissions by more than 6,000 tons per year. Its buildings are also designed to be über-sustainable, featuring roofs angled for maximum sun exposure and curved facades that repel snow. "It's not an experiment," says architect Gordon Gill, whose Chicago-based firm conceived the project. "It's real." —Julie Shapiro



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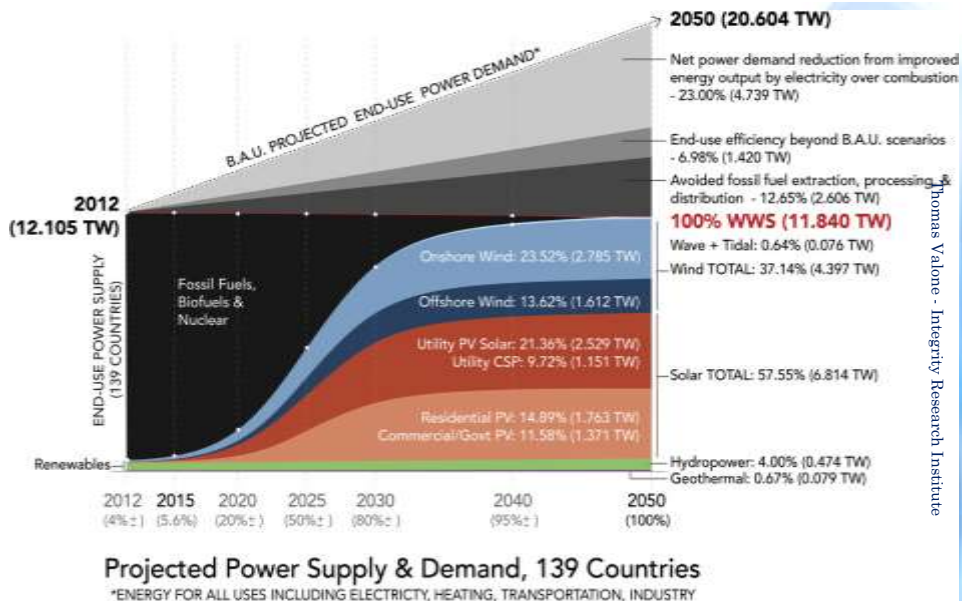
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**Mark Z. Jacobson, director of Stanford University's Atmosphere and Energy Program – Jule, 2017**







**“100% Clean and Renewable Wind, Water, and Sunlight All-Sector Energy Roadmaps for 139 Countries of the World” – *Joule*, V.1, N.1, p. 108, 9/6,17**



## ROAD MAP TO 100 PERCENT RENEWABLE ENERGY IN 139 COUNTRIES BY 2050 (VIDEO)

**Mark Z Jacobson Explains the Energy Transition Timeline for 139 Countries to 100% Wind, Water and Solar for all Purposes by 2050.**





# THERMOELECTRIC GENERATORS (TEGs) CAPTURE WASTE HEAT INTO ELECTRICITY



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Three minute video: <https://youtu.be/DudsKeB39p8>

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## U.S. Geothermal Power

Over 2,800 megawatts of electricity from geothermal power plants are supplying about 4 million people in the U.S.

Geothermal power plants have no smoky emissions. They emit water vapor.



**Jan. 22, 2007  
MIT Panel Backs  
Geothermal as a  
KEY US Energy  
Source – report:  
mit.edu**

Growth in U.S. Geothermal Power



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TECHNOLOGY NEWS 27 July 2016 *New Scientist*

# Bacteria made to turn sewage into clean water – and electricity

A self-powered waste water treatment plant using microbes has just passed its biggest test, bringing household-level water recycling a step closer.



**BioVolt** microbial fuel cell uses GMO *Geobacter* strains which generate electricity, grow slowly and do not create microbe cake – **Cambrian Innovation** tested at Naval Surface Warfare in MD – scaling up from 2000 liters/day to 20,000 liters/day



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## CHICKEN DROPPINGS TO ELECTRICITY

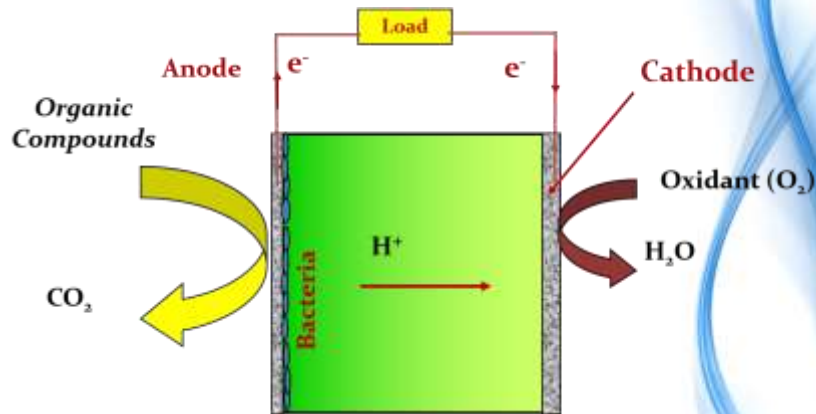


University of Maryland and Penn State University both engaged in biomass electricity



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## BACTERIA GENERATE ELECTRICITY AND PURIFY WASTE WATER



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Also Craig Venter Institute testing 600 liters/day pig waste at local farm in Escondido CA and Penn State University generates kilowatts from human waste



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## PENN STATE U GENERATES 0.94 kWh/KG INSTEAD OF CONSUMING THE SAME AMOUNT

The researchers say they generated 0.94 kilowatt-hours per kilogram of waste material. Conventional treatment processes—such as activated sludge—consume 1.2 kilowatt-hours per kilo of waste. To put those figures into perspective: Brooklyn's Newton Creek wastewater treatment plant consumes about 700,000 kilowatt-hours of per day. Based on Cusick's estimates, if fitted with an MRC system, the plant could generate roughly 350,000 kilowatt-hours a day instead. "That's enough energy for about 11,000 people per day," he says.

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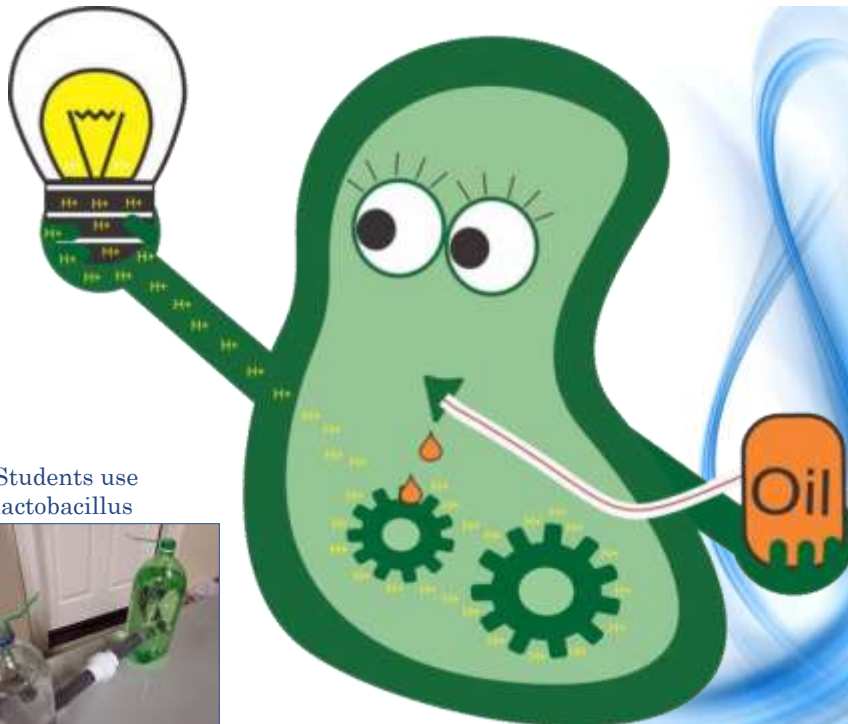
# Nation's Capital D.C. Water Harnesses Electricity from Every Flush



Uses Norway's "THERMAL HYDROLYSIS" to convert sludge left over from sewage (with microbes) into 13 MW of electricity

Thomas Valone - Integrity Research Institute

Dairy farms are a big market since only four current use digesters out of hundreds of farms that use digesters  
- Dr. Lansing



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Students use lactobacillus





# Energy Harvesting = \$7B Market



## Energy Harvesting: Off-Grid Microwatt to Megawatt 2017-2027

Applications, technologies, forecasts including regeneration

By Dr Peter Harrop and Dr Harry Zervas

Reports Published by **IDtechEx.com**



## Triboelectric Energy Harvesting (TENG) 2017-2027

Commercialisation: Interviews, Forecasts, Materials Opportunities

Brand new for August 2016  
Harvests electrostatic energy with polymers for self-powered systems

Triboelectric energy harvesting transducers will be a \$400 million market in 2027

### Solar cell captures CO2 and sunlight, produces burnable fuel




Researchers at the University of Illinois at Chicago have engineered a potentially game-changing solar cell that cheaply and efficiently converts atmospheric carbon dioxide gas into a liquid fuel that can be used in a wide range of applications.

This market will reach over \$1.1 billion by 2025

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## THE UNIVERSITY OF TEXAS AT DALLAS

### RESEARCH

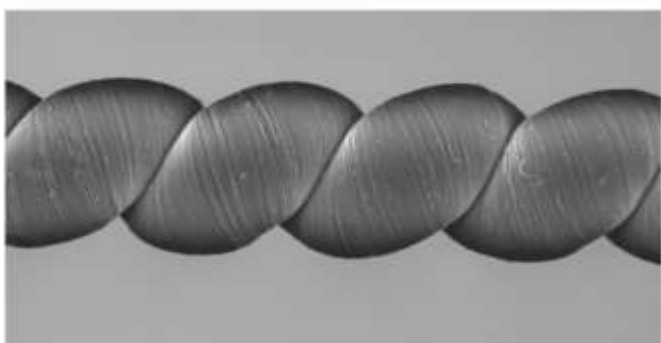
Text size:

### No Batteries Required: Energy-Harvesting Yarns Generate Electricity

Aug. 25, 2017

"If our twistron harvesters could be made less expensively, they might ultimately be able to harvest the enormous amount of energy available from ocean waves."

Dr. Ray Boughman, director of the NanoTech Institute and a corresponding author of the study



Coiled carbon nanotube yarns, created at The University of Texas at Dallas and imaged here with a scanning electron microscope, generate electrical energy when stretched or twisted.

Stretching the nanotube yarn 30 times a second generated 250 watts per kilogram of peak electrical power

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# Potential for widespread electrification of personal vehicle travel in the United States

Zachary A. Needell<sup>1,2</sup>, James McNerney<sup>1</sup>, Michael T. Chang<sup>1</sup> and Jessika E. Trancik<sup>1,3\*</sup>

Electric vehicles can contribute to climate change mitigation if coupled with decarbonized electricity, but only if vehicle range matches travellers' needs. Evaluating electric vehicle range against a population's needs is challenging because detailed driving behaviour must be taken into account. Here we develop a model to combine information from coarse-grained but expansive travel surveys with high-resolution GPS data to estimate the energy requirements of personal vehicle trips across the US. We find that the energy requirements of 87% of vehicle-days could be met by an existing, affordable electric vehicle. This percentage is markedly similar across diverse cities, even when per capita gasoline consumption differs significantly. We also find that for the highest-energy days, other vehicle technologies are likely to be needed even as batteries improve and charging infrastructure expands. Car sharing or other means to serve this small number of high-energy days could play an important role in the electrification and decarbonization of transportation.

**“We find that the energy requirements of 87% of vehicle-days could be met by an existing, affordable electric vehicle.”**



DOI: 10.1038/NENERGY.2016.112

Energy

### Why Range Anxiety for Electric Cars Is Overblown

A new study says that today's electric vehicles can handle almost 90 percent of all car travel in the U.S.

by Catherine Caruso August 16, 2016 *New Scientist* 37

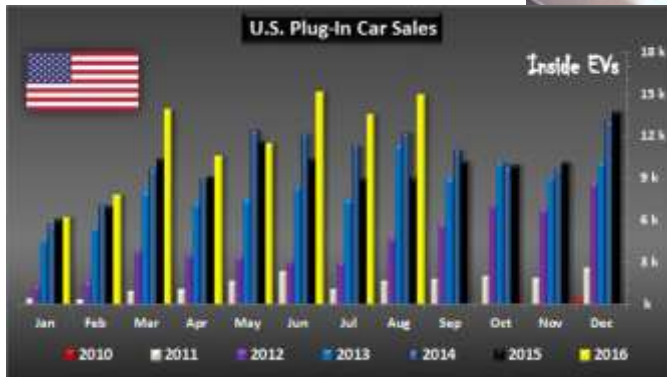
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## ELECTRIC PLUG-IN CAR BOOM

“Within three years we expect 150 to 200 miles to become the new normal for all-electric cars priced at \$30,000 to \$45,000, perhaps lower” – *Green Car Reports*, February, 2016



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**Electric Vehicles to be 35% of global new car sales by 2040**

“Continuing reduction in battery prices will bring the total cost of ownership of EVs below that for conventional-fuel vehicles by 2025, even with low oil prices.”

*Bloomberg New Energy Finance* – Feb 25, 2016  
<https://about.bnef.com>

## 24M LITHIUM-ION BATTERY BREAKTHROUGH

Dr. Chiang's innovation, which was developed in his MIT lab, is an electrode formed by mixing powders with a liquid electrolyte to make a gooey slurry. The design enables 24M to increase the amount of energy-storing material in a battery and **give it 15 to 25 percent more capacity than conventional lithium-ion batteries of the same size.**

- No coat, dry, cut, or compress electrode
- 1/5 time to manufacture
- **Less than \$100 per kWh\***
- 24M scaling up factory for high-volume by 2018

<http://24-m.com>

\* \$350/kWh last year

*MIT Tech Review,  
June 21, 2016*



Semisolid electrode  
"safest lithium-ion  
battery ever made"



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## HANERGY.COM SOLAR ELECTRIC VEHICLE

July, 2016



Solar-powered car travels **80 km (50 miles)** on a **5 to 6 hour charge** in the sun. Can also be plugged in. Hanergy outfits RVs, buses, trucks with solar PV affixed to body.

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# AQUANTIS BUILDING UNDERSEA TURBINES

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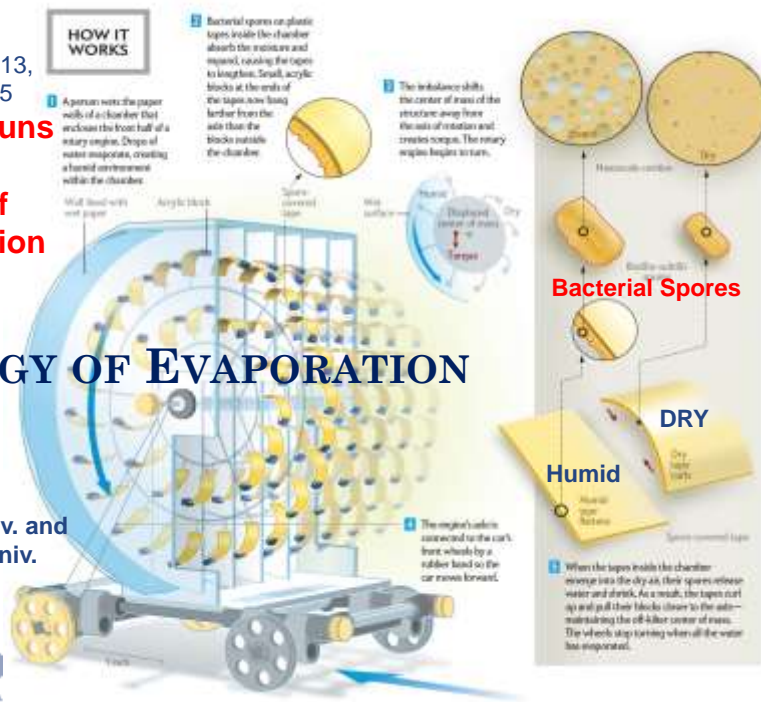
With turbines already in production and being **distributed to Wales and the Isle of Wight in 2018**, the start of something big could be just around the corner. Soon after the first turbines have been erected, the biggest will be at a site in the **Gulf Stream in 2019/2020** and will consist of a **200 MW field of marine turbines**. **Department of Energy grants have already been awarded to the team, and even Mitsubishi Heavy Industries has claimed a little piece of investment.**



*Sci. Amer.* 313,  
26, Aug. 2015  
**Toy car runs on the energy of evaporation**

## ENERGY OF EVAPORATION

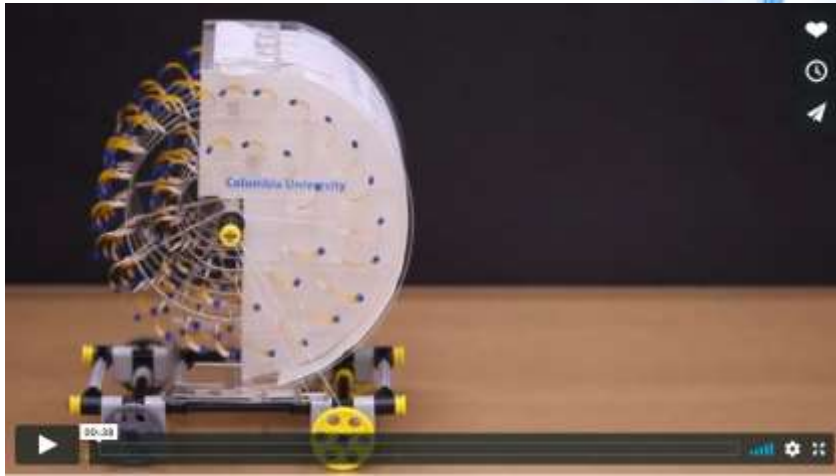
Harvard Univ. and Columbia Univ.



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## WATER-POWERED CAR – COLUMBIA UNIVERSITY



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<https://vimeo.com/235801232>



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 Columbia University in the City of New York

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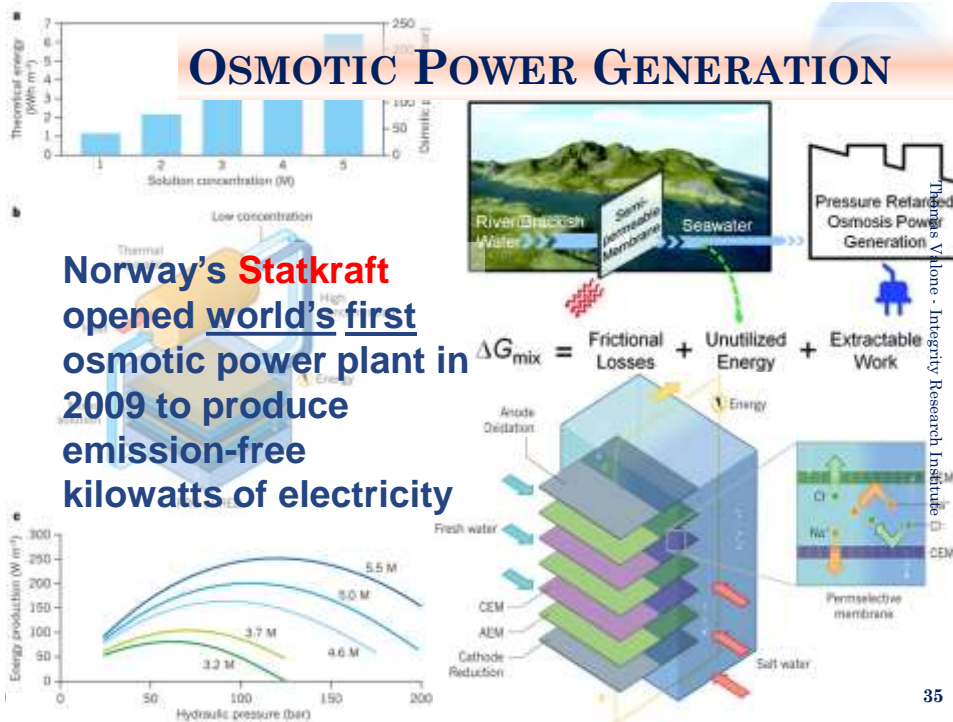
## Energy Harvested from Evaporation Could Power Much of U.S., Says Study

September 26, 2017



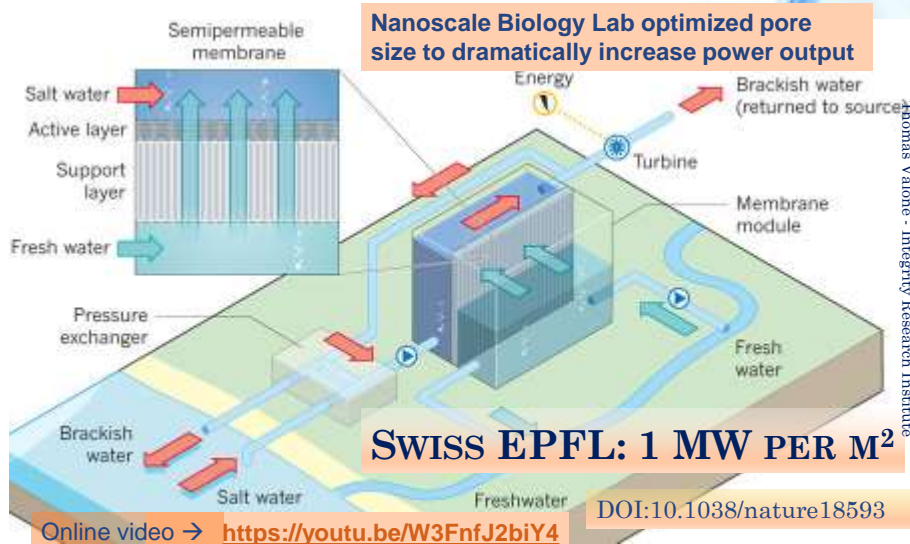
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Norway's **Statkraft** opened world's first osmotic power plant in 2009 to produce emission-free kilowatts of electricity

“Osmotically induced current”–*Nature*, July, 2016



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## Innowattech – 500 kW per km

- Piezoelectric panels for roadways and train tracks
- Generates electricity from passing vehicles
- Game changing invention ready for installation
- Should be developed in this country as well
- Advocated by IRI in *Future Energy Annual 2017*

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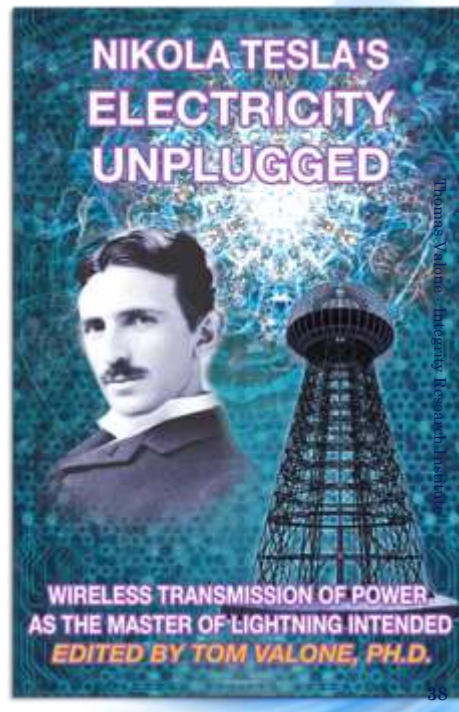
Piezo panels ready for insert

## WIRELESS POWER BECOMES AVAILABLE

From short range to long range, the latest wireless solutions are in a 450-page illustrated book → Long range wireless power transmission uses Zenneck Surface Waves, being demonstrated by Texzon Technologies (Texzont.com)



**ABC** History Channel



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