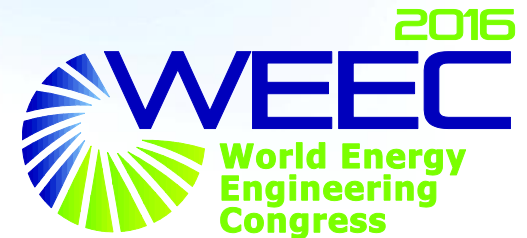


RENEWABLE ENERGY & SUSTAINABLE DEVELOPMENT

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

SEPTEMBER 22, 2016
THOMAS F. VALONE, PHD, PE
INTEGRITY RESEARCH INSTITUTE
BELTSVILLE MD



Earth's Last 400,000 Year Climate History

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

CO₂ and the "Ornery Climate Beast"

How might today's human-caused increases in atmospheric concentrations of carbon dioxide and other greenhouse gases change the planet? The past provides clues. Geological records show that in the past 400,000

years, atmospheric concentrations of carbon dioxide, average Earth temperature, and sea levels have risen and fallen roughly in tandem, in 100,000-year cycles paced by slight oscillations in Earth's orbit. These oscillations

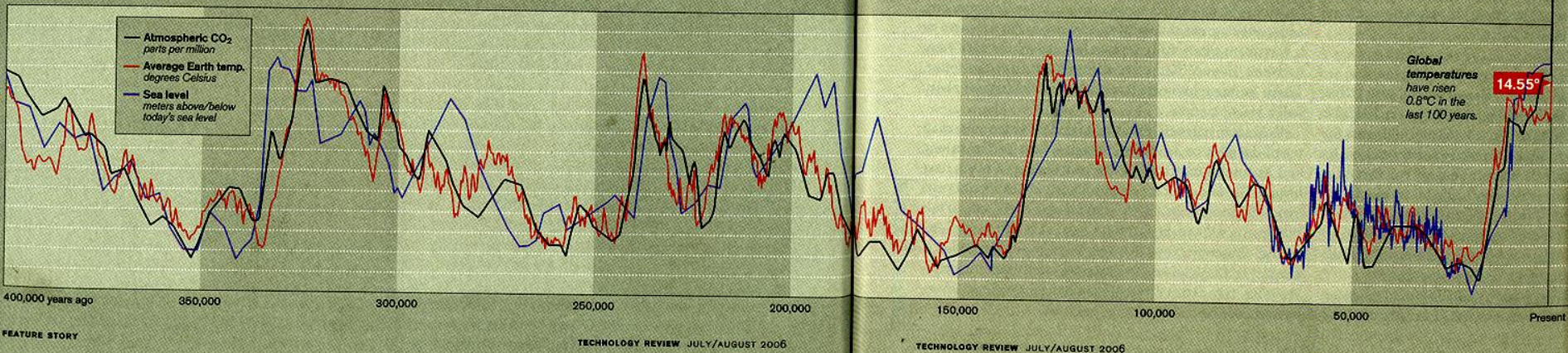
affect the distribution of sunlight, hardly affecting the total amount reaching Earth; yet, scientists believe, this has been enough to set in motion chains of events that raise and lower temperatures, launch and end ice ages, and trigger vast changes in sea level.

What's coming next? Carbon dioxide—the number one greenhouse gas—has

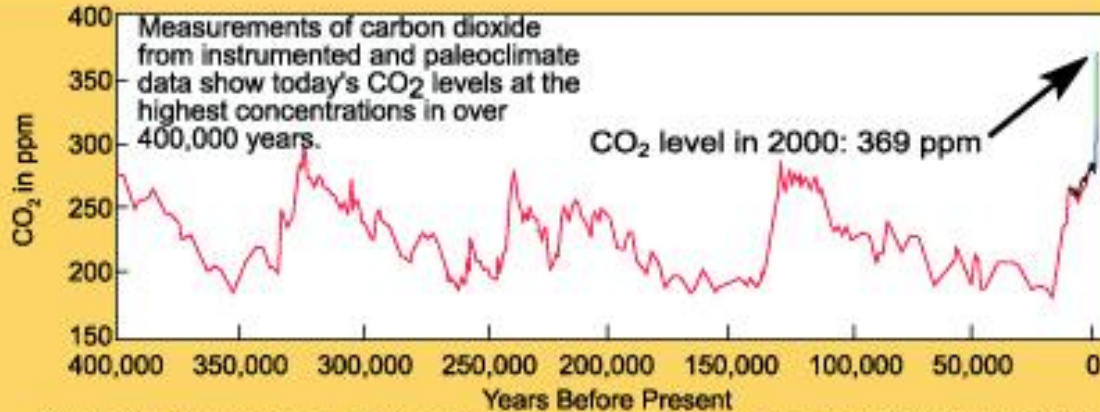
much more power to affect Earth's temperature than the orbital changes do. And in just the past 150 years, humankind has boosted carbon dioxide concentrations by 32 percent. NASA planetary scientist Jim Hansen says that if we continue to increase greenhouse-gas emissions, temperatures will rise between 2 and 3 °C this century, making

Earth as warm as it was three million years ago, when seas were between 15 and 35 meters higher than they are today. His predictions bear weight partly because he can verify his methods: using geological records, he has calculated past temperatures, and his results closely match the measured temperatures shown here. **DAVID TALBOT**

377



ncdc.
noaa.
gov



Source: Modified from Barnola et al. (1999), A. Indemihle et al. (2000), D.M. Etheridge et al. (1998), C.D. Keeling et al. (1995)

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

CO₂ and the "Ornery Climate Beast"

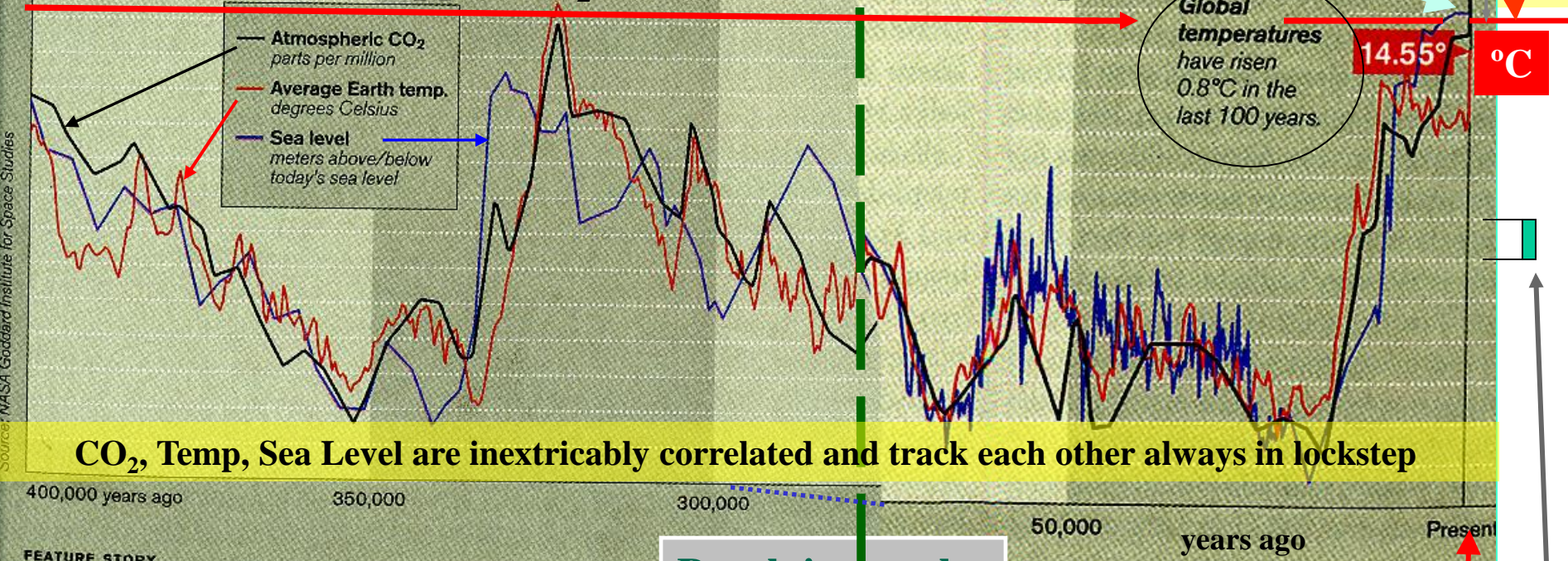
Composite of the past 400,000 year earth history proves **CO₂, world temp, and sea level** are inextricably correlatively linked

Global CO₂ Level in 2016 **402 ppm**

Sea Level Gap

Temp Gap: 5°C (9°F)

Baseline from year 1900:
0 m Sea Level = 290 ppm CO₂ = 15°C (59°F) World Temp



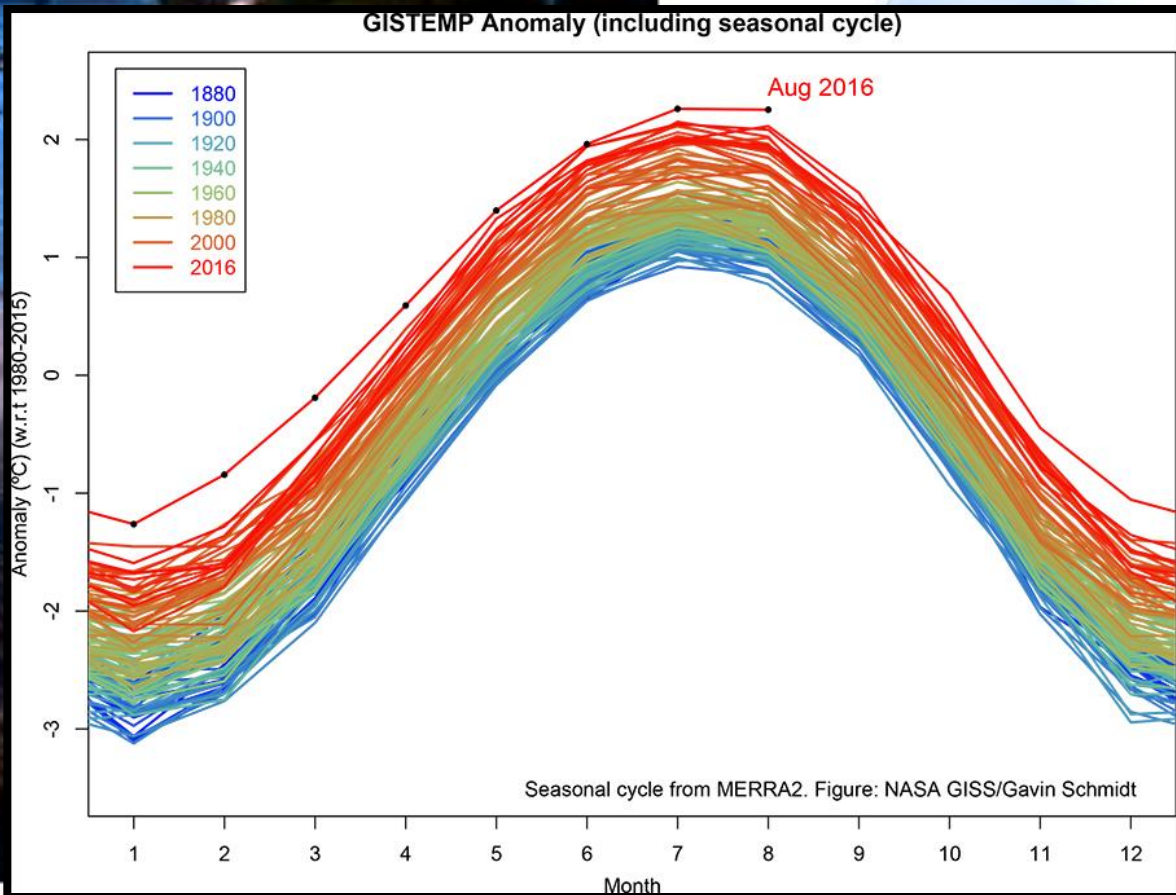
Source: NASA Goddard Institute for Space Studies

CO₂, Temp, Sea Level are inextricably correlated and track each other always in lockstep

Technology Review, July/August 2006

Projected Sea Level Rise is 80 meters

KEY to graph: 10 ppm = 0.5°C = 10m sea level rise

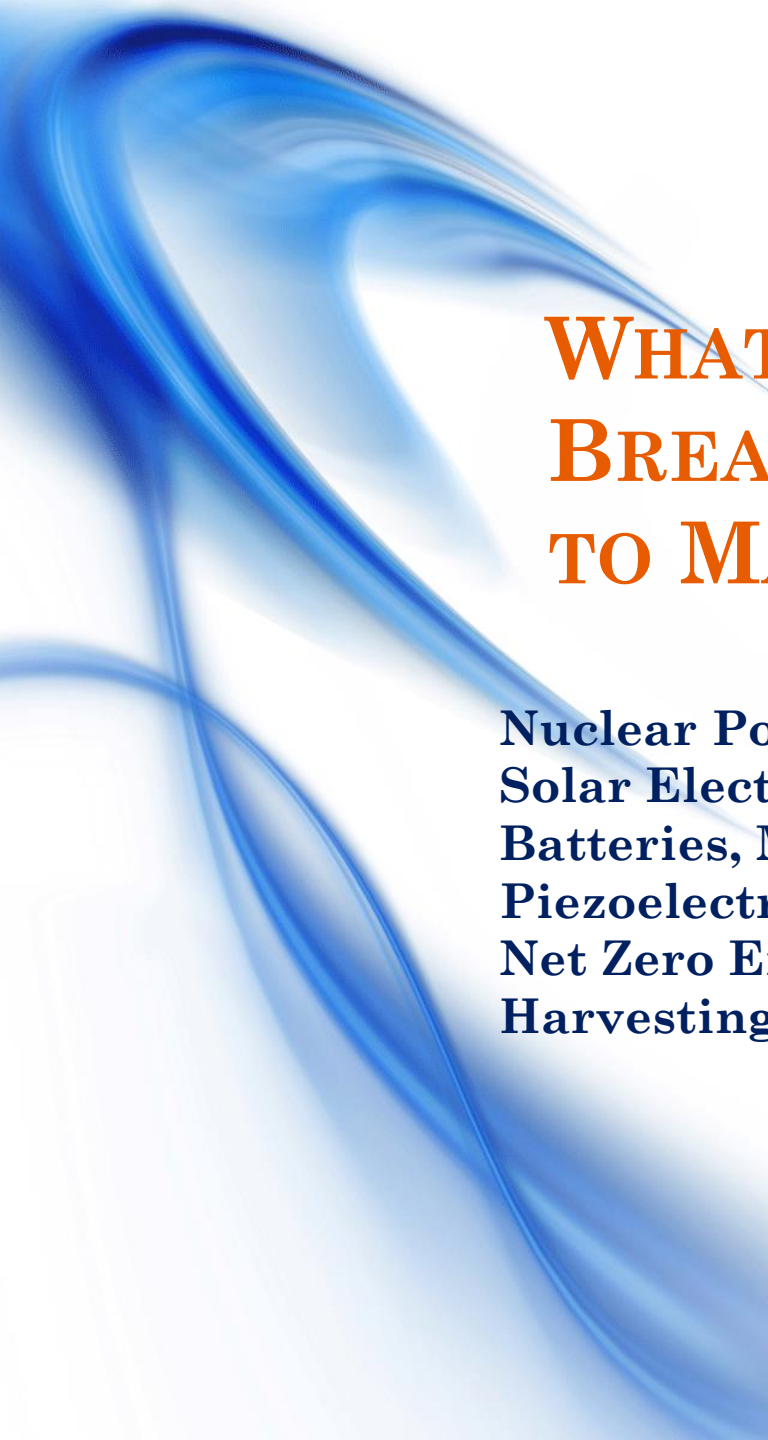


land, Ga., in June. High tides are forcing the road to close several times a year.

Flooding of the U.S. Coastline, Caused by Global Warming, Has Already Begun

**AUGUST
2016 was the
hottest
August ever
recorded**



A large, abstract graphic on the left side of the slide, consisting of flowing, translucent blue lines that create a sense of movement and energy. The lines are thicker in some areas and thinner in others, creating a dynamic, organic shape.

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,
Piezoelectric Panel Power, Distributed Solar PV,
Net Zero Energy Communities, Energy
Harvesting, Long Range Wireless Electricity**





CNN

Moneyline 2002

LOU DOBBS



TOM VALONE

PRES., INTEGRITY RESEARCH INST.

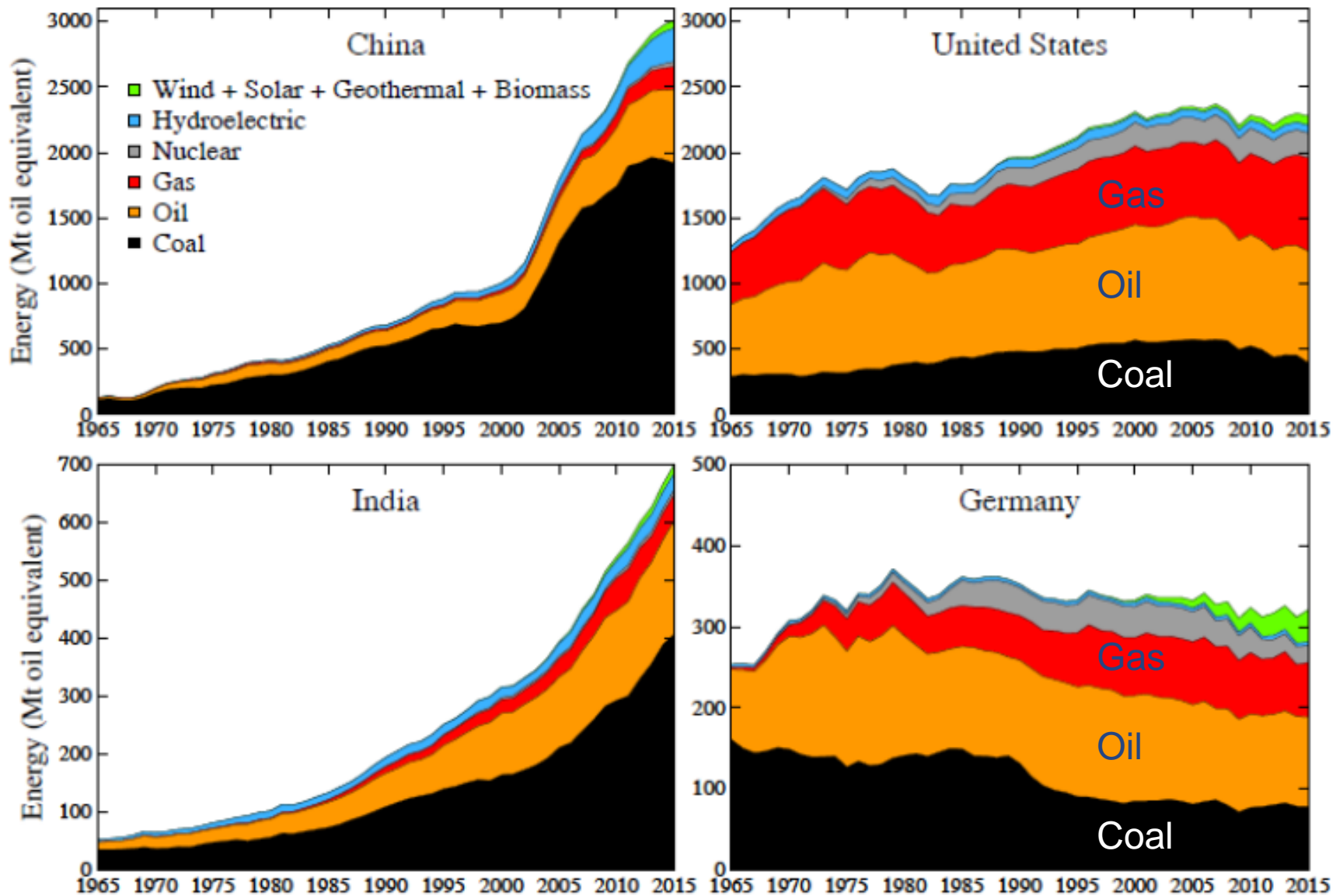
5:31p ET

OF HOLLYWOOD WALK OF FAME



ROUNDBALL REJE

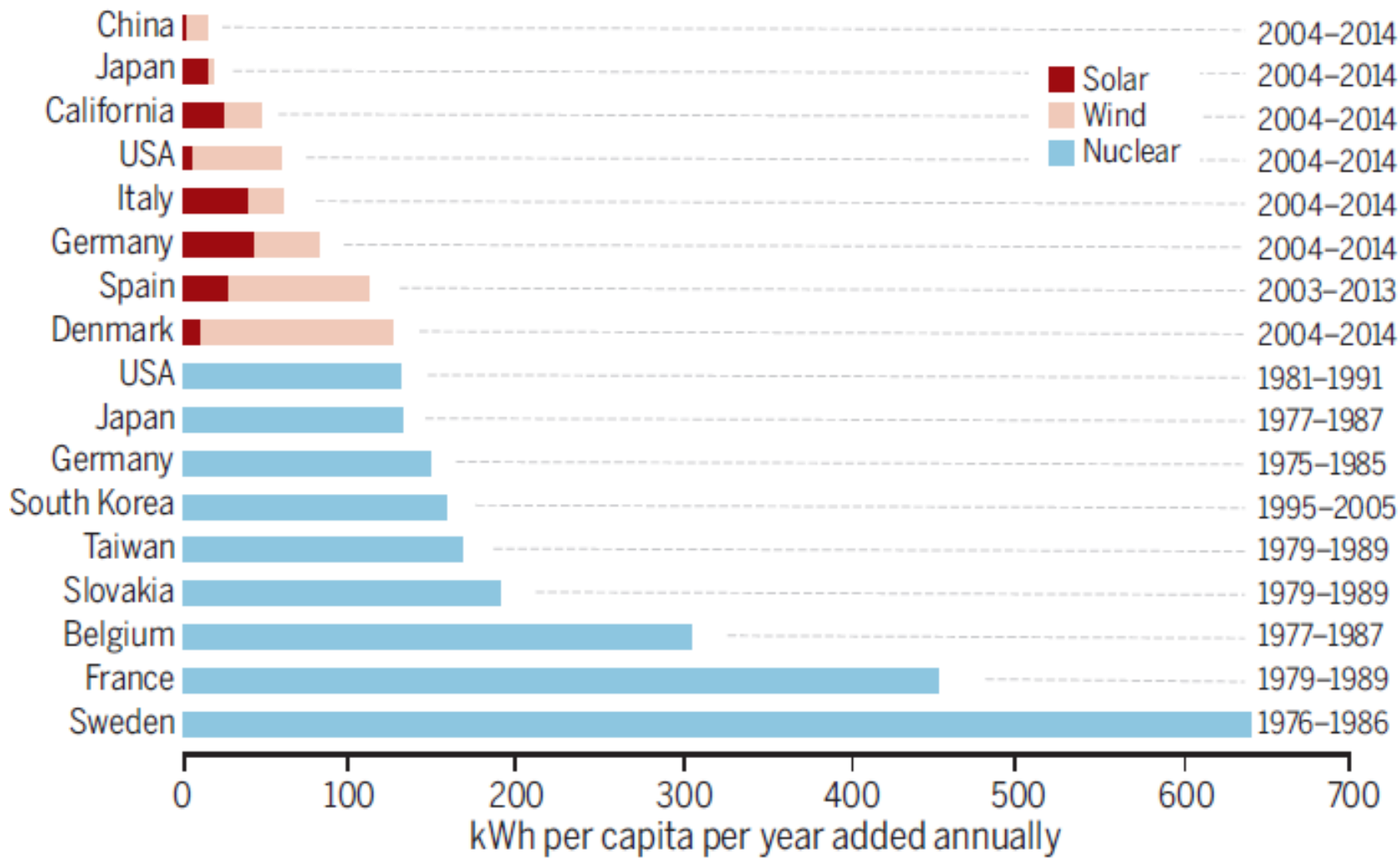




Energy consumption in four nations. Same graphs as Fig. 1 in the main text. [D

From China-US *Science* mag article





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.

SHARE

POLICY FORUM | NUCLEAR ENERGY

China-U.S. cooperation to advance nuclear power

Aug. 5, 2016

Junji Cao¹, Armond Cohen², James Hansen^{3,*}, Richard Lester⁴, Per Peterson⁵, Hongjie Xu⁶

+ Author Affiliations

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Science 05 Aug 2016:
Vol. 353, Issue 6299, pp. 547-548
DOI: [10.1126/science.aaf7131](https://doi.org/10.1126/science.aaf7131)

“...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”**

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



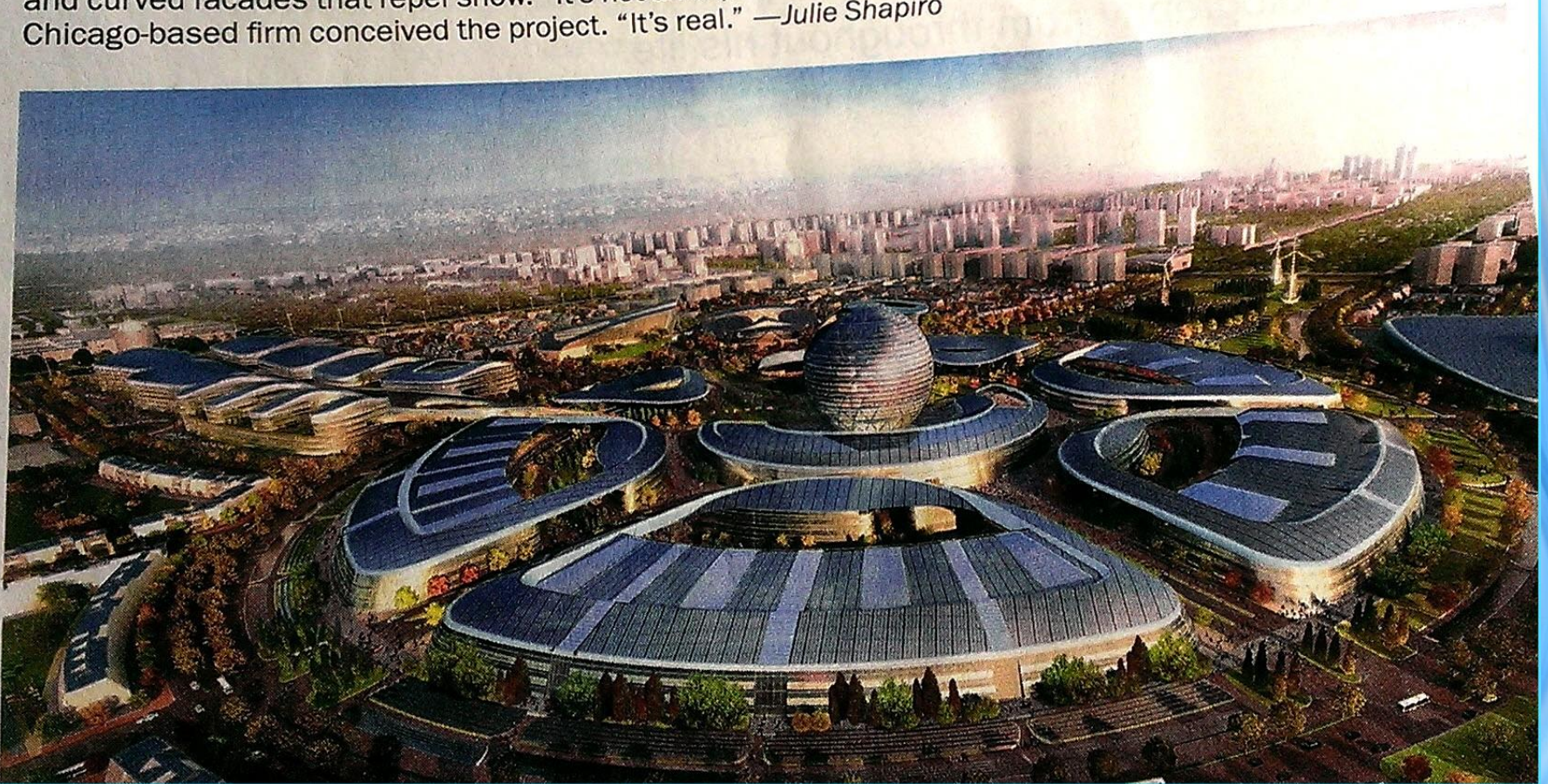
Ft. Collins CO – Insight Brief from RMI.org



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 CO₂ 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



How Tesla could change the solar power game

THE dream of a solar-powered society has tantalised us for decades. But the costs involved in piping the sun's energy into the electricity grid remain prohibitively high. Now, solar power could get the efficiency boost it needs - thanks to a corporate takeover. Last week, Tesla, which makes batteries big enough to power your home - and also happens to make the biggest-selling electric car - announced that it is buying SolarCity, the leading installer of solar panels in the US. Backed by Tesla CEO Elon Musk, who co-founded both SolarCity and the combined expertise of the two companies, the deal is a breakthrough for the solar industry needs. Solar panels have fallen in price by more than 50% in the last decade, but the cost of just plugging in solar power generators need a lot of energy to produce during the day. Solar panels are not as efficient as they used to be. The cost of solar power is still too high in many places. In Bend, Oregon, solar power is still too expensive to be a viable option.

into huge vats of salt, which is good at absorbing heat. When the energy is required, piping water through the salt causes it to boil and produce steam that drives a turbine. In Texas, a giant array of batteries backs up the Notrees wind farm, keeping energy flowing when the wind dies. Both projects turn unreliable renewable resources into dependable power plants - but at a cost. "While deployment of storage is increasing, it is not widespread," says Matt Kramer, who leads the SunDial project at the Fraunhofer Institute for Sustainable Energy Systems in Boston. Simply plugging solar panels into a battery isn't enough, says Aminul Huque at the Electric Power Research Institute in Palo Alto, California. Batteries get stressed every charging cycle and die quickly if they aren't carefully managed. To get round this, firms are turning to software. Kromer says SunDial taps into data on electricity prices, weather forecasts, solar panel and storage software uses all this information to make better decisions about when to charge and discharge batteries, increasing their lifespan. Tesla and SolarCity could do the same. With batteries in cars and homes that can store solar power when it's needed, Tesla can smooth the supply of solar power to the grid. A similar approach is already being tested in pilot schemes around the US. Arizona Public Service - the utility that serves the Phoenix area and plugs into the Solana plant - is in the midst of deploying solar panels and batteries to 1500 households. Even though the panels and storage are spread across many rooftops, they are effectively roped together into a single 10-megawatt power plant that APS can control. The SunDial project is planning a pilot in Massachusetts in which 2 megawatts of solar power and storage are controlled by the local utility company. This kind of integration is exactly what the tie-up between Tesla and SolarCity promises - but on a much grander scale. There might soon be a power plant on every roof. Hal Hodson ■

"Batteries that can store solar power until it's needed will smooth the supply to the grid"



**Inflatable Solar Light
\$10 from MPOWERD.COM**

Distributed electricity that is failure-proof:

- solar lanterns
- networked solar rooftops

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



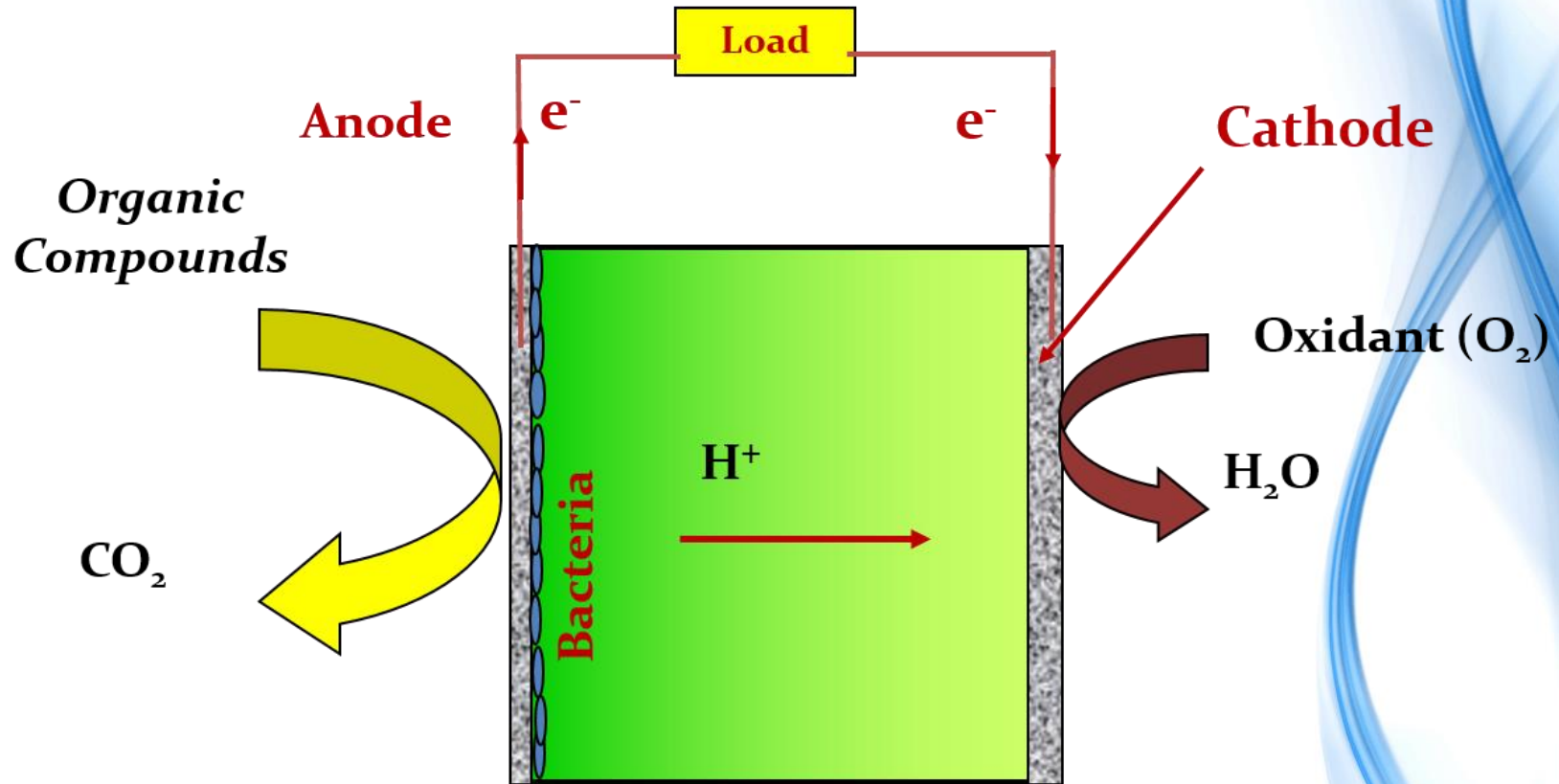
CHICKEN DROPPINGS TO ELECTRICITY



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



BACTERIA GENERATE ELECTRICITY AND PURIFY WASTE WATER



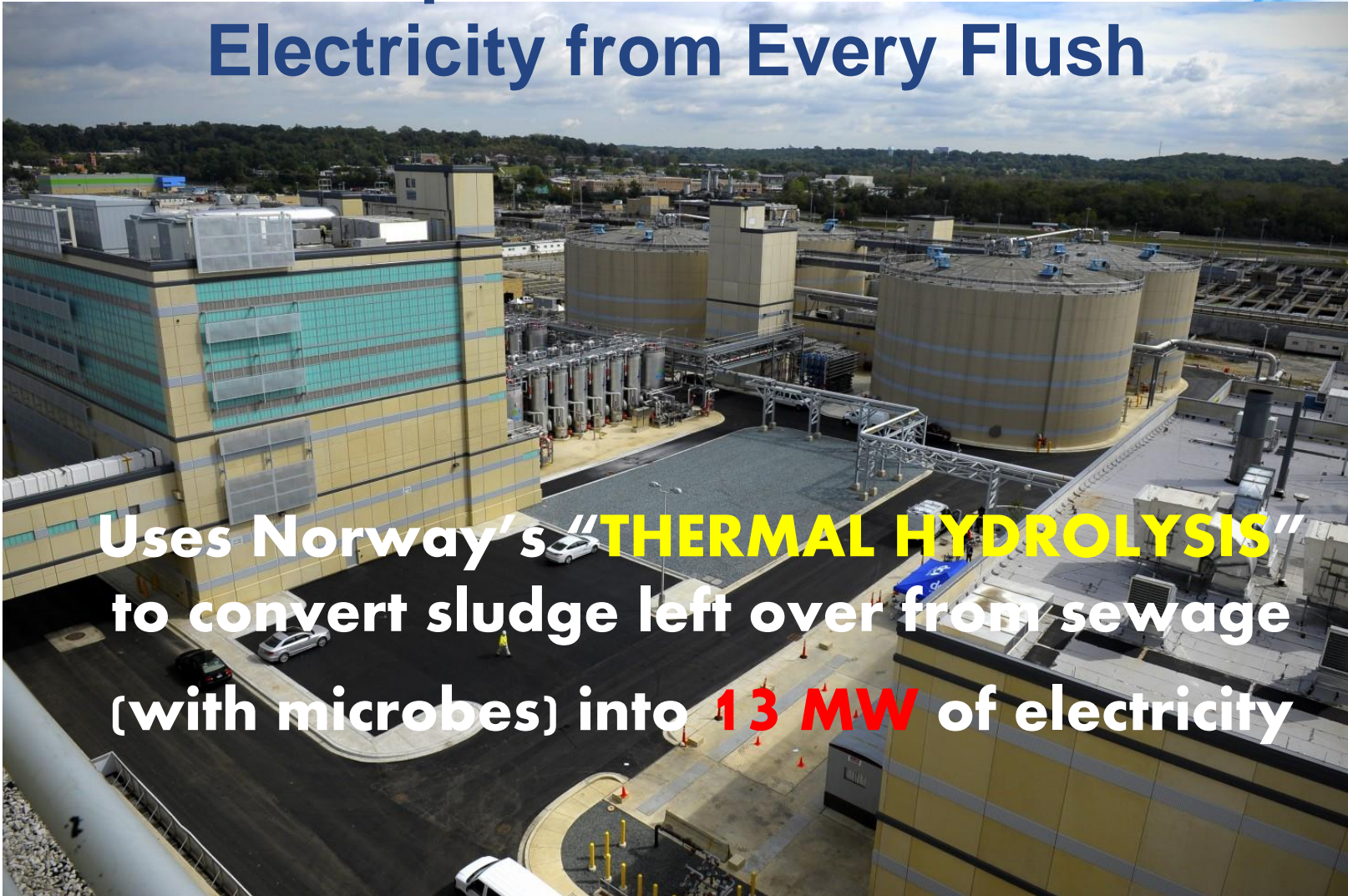
Also Craig Venter Institute testing 600 liters/day pig waste at local farm in Escondido CA and Penn State University generates kilowatts from human waste

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 kilo-watt hours a day instead. "That's enough energy for about 11,000 people per day," he says.



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

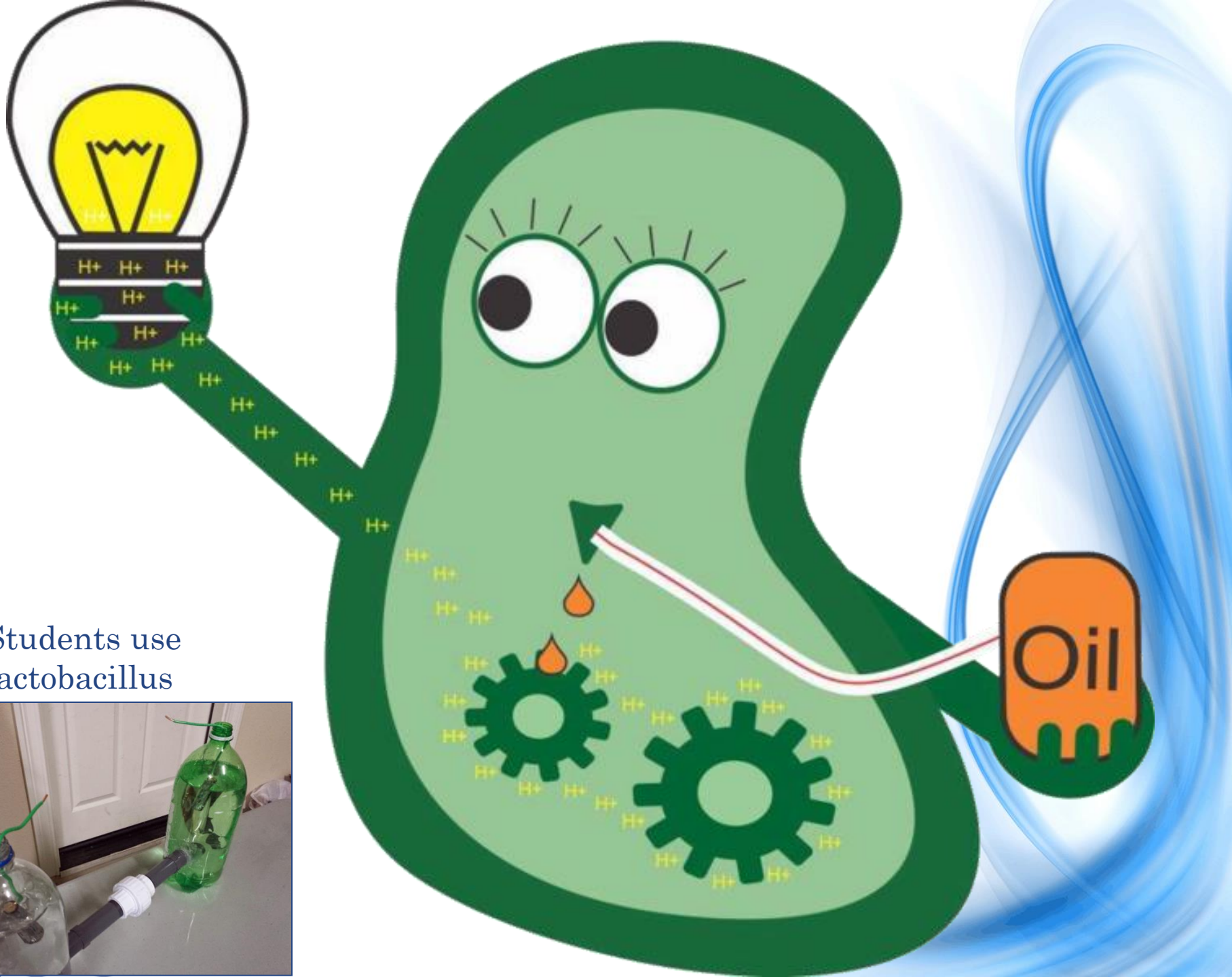


Uses Norway's "**THERMAL HYDROLYSIS**"
to convert sludge left over from sewage
(with microbes) into **13 MW** of electricity

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

– Dr. Lansing





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 Zervos](#)

Reports Published by **IDtechEx.com**



Triboelectric Energy Harvesting (TENG) 2017-2027

Commercialisation: Interviews,
Forecasts, Materials Opportunities

Brand new for August 2016

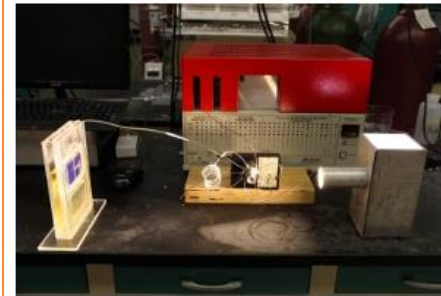
Harvests electrostatic energy with
polymers for self-powered systems

By [Dr Peter Harrop](#)

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

Posted on August 10, 2016

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

gyharvestingjournal.com/articles/9812/solar-cell-captures-co2-and-sunlight-...

"This market
will reach over
\$1.1 billion by
2026"

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

Zachary A. Needell^{1,2}, James McNerney¹, Michael T. Chang¹ and Jessika E. Trancik^{1,3*}

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.”

Energy

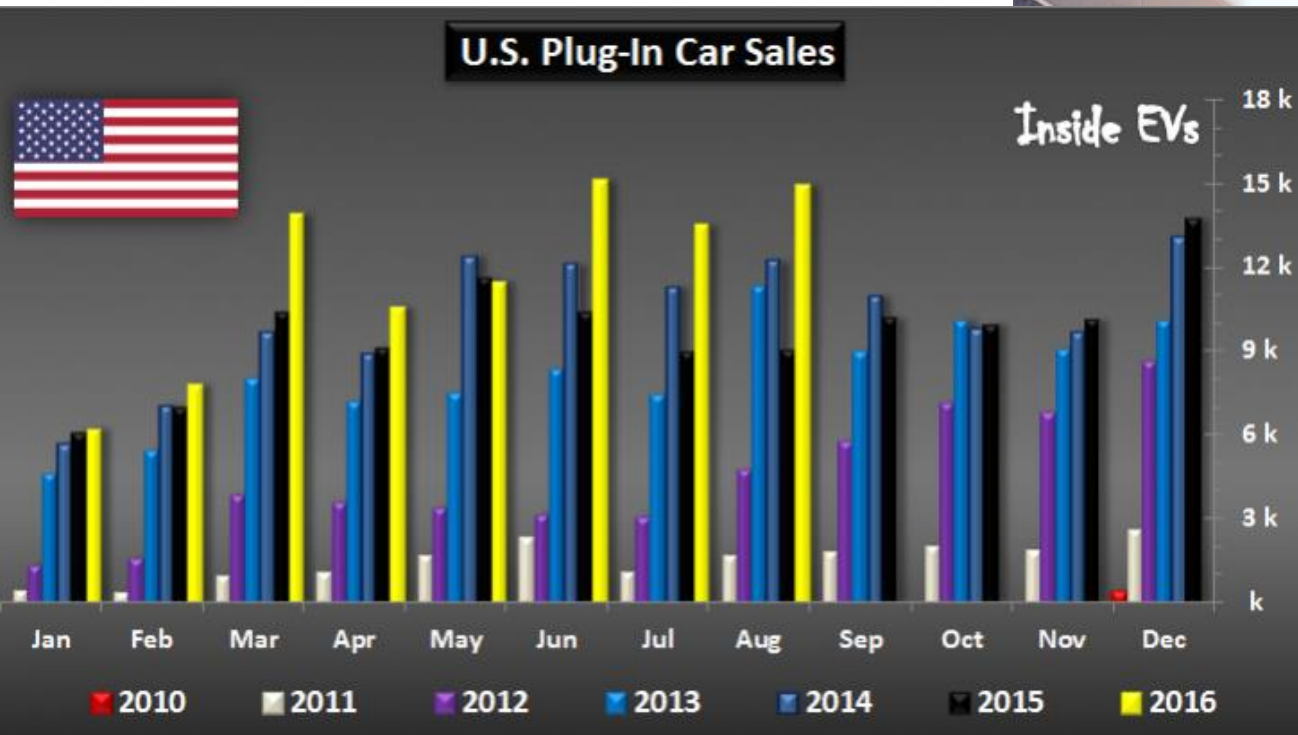
Why Range Anxiety for Electric Cars Is Overblown

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 15, 2016 *New Scientist*

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



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

“Continuing reductions 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”**



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.

AQUANTIS BUILDING UNDERSEA TURBINES



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**

HOW IT WORKS

1 A person wets the paper walls of a chamber that encloses the front half of a rotary engine. Drops of water evaporate, creating a humid environment within the chamber.

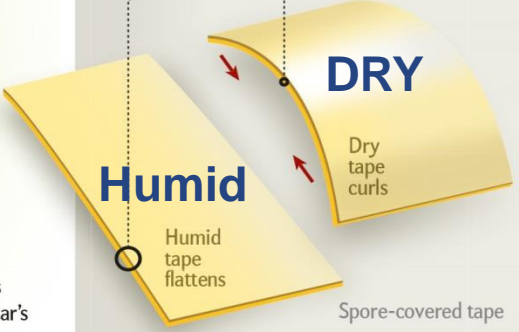
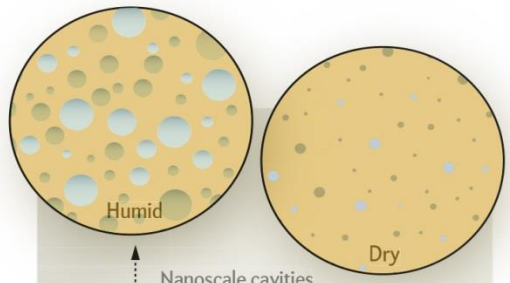
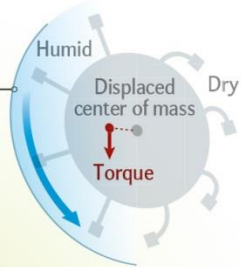
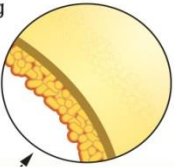
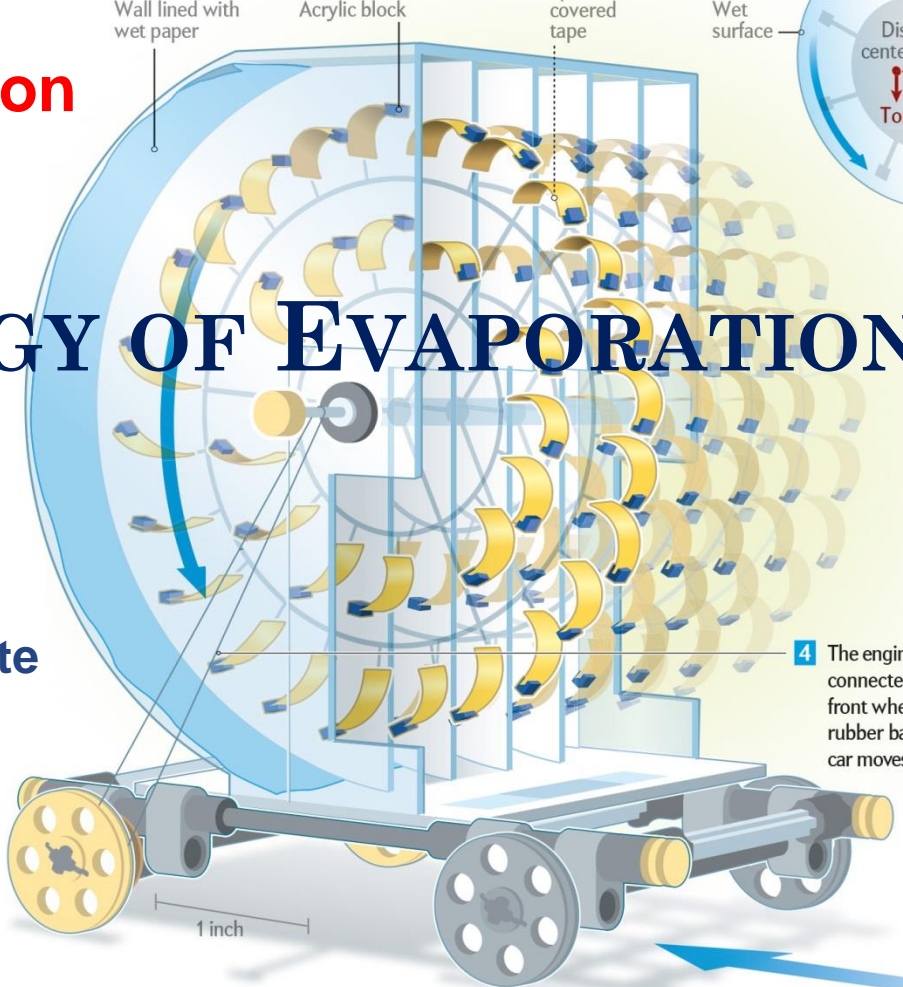
2 Bacterial spores on plastic tapes inside the chamber absorb the moisture and expand, causing the tapes to lengthen. Small, acrylic blocks at the ends of the tapes now hang farther from the axle than the blocks outside the chamber.

3 The imbalance shifts the center of mass of the structure away from the axis of rotation and creates torque. The rotary engine begins to turn.

4 The engine's axle is connected to the car's front wheels by a rubber band so the car moves forward.

5 When the tapes inside the chamber emerge into the dry air, their spores release water and shrink. As a result, the tapes curl up and pull their blocks closer to the axle—maintaining the off-kilter center of mass. The wheels stop turning when all the water has evaporated.

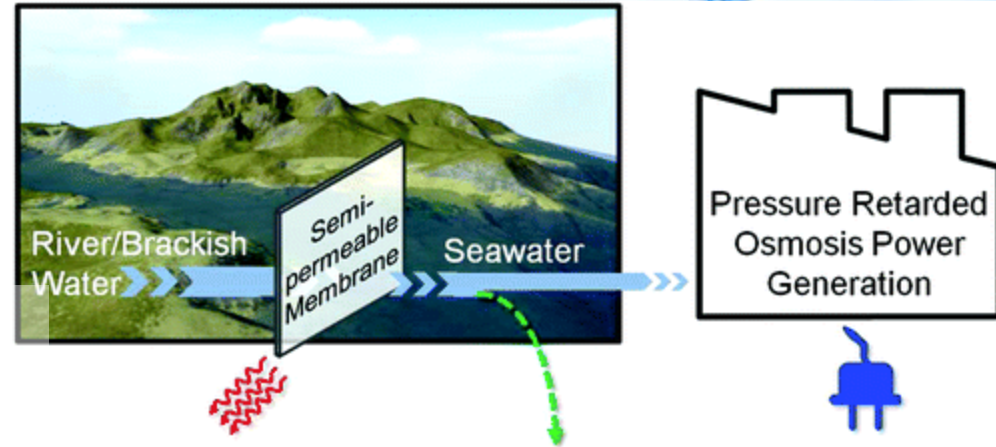
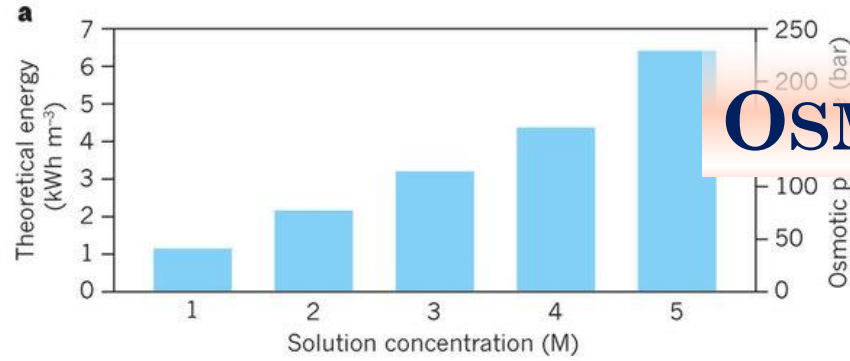
ENERGY OF EVAPORATION



**Wyss Institute
Harvard Univ.**

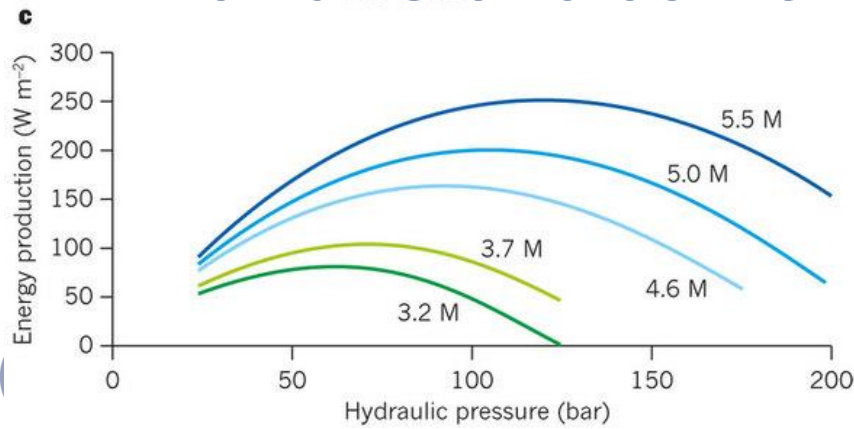
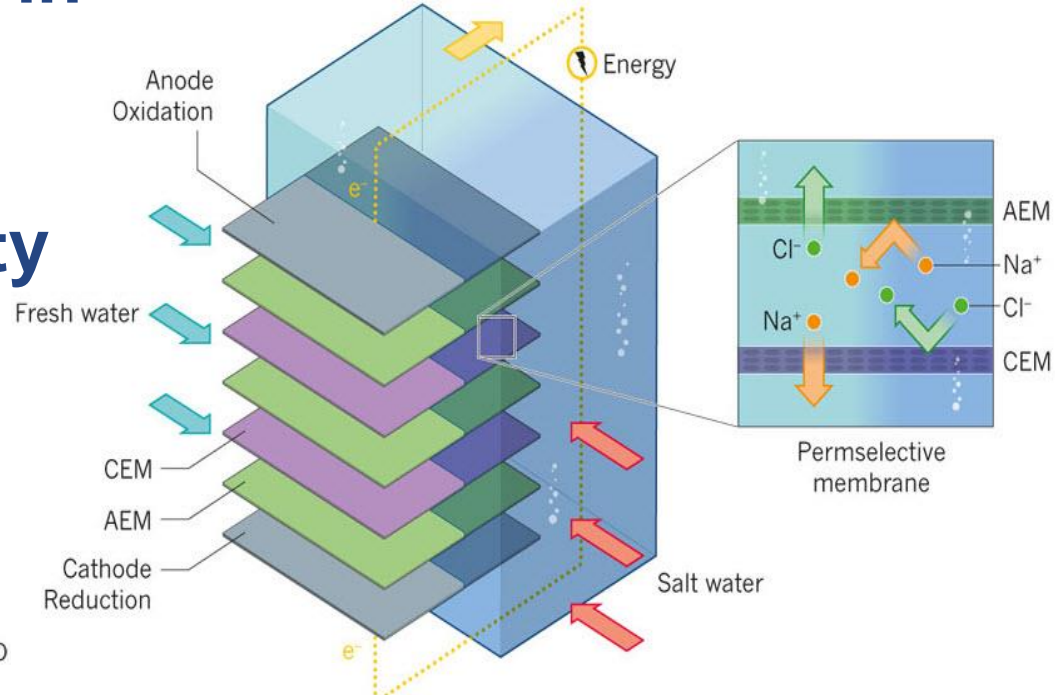


OSMOTIC POWER GENERATION



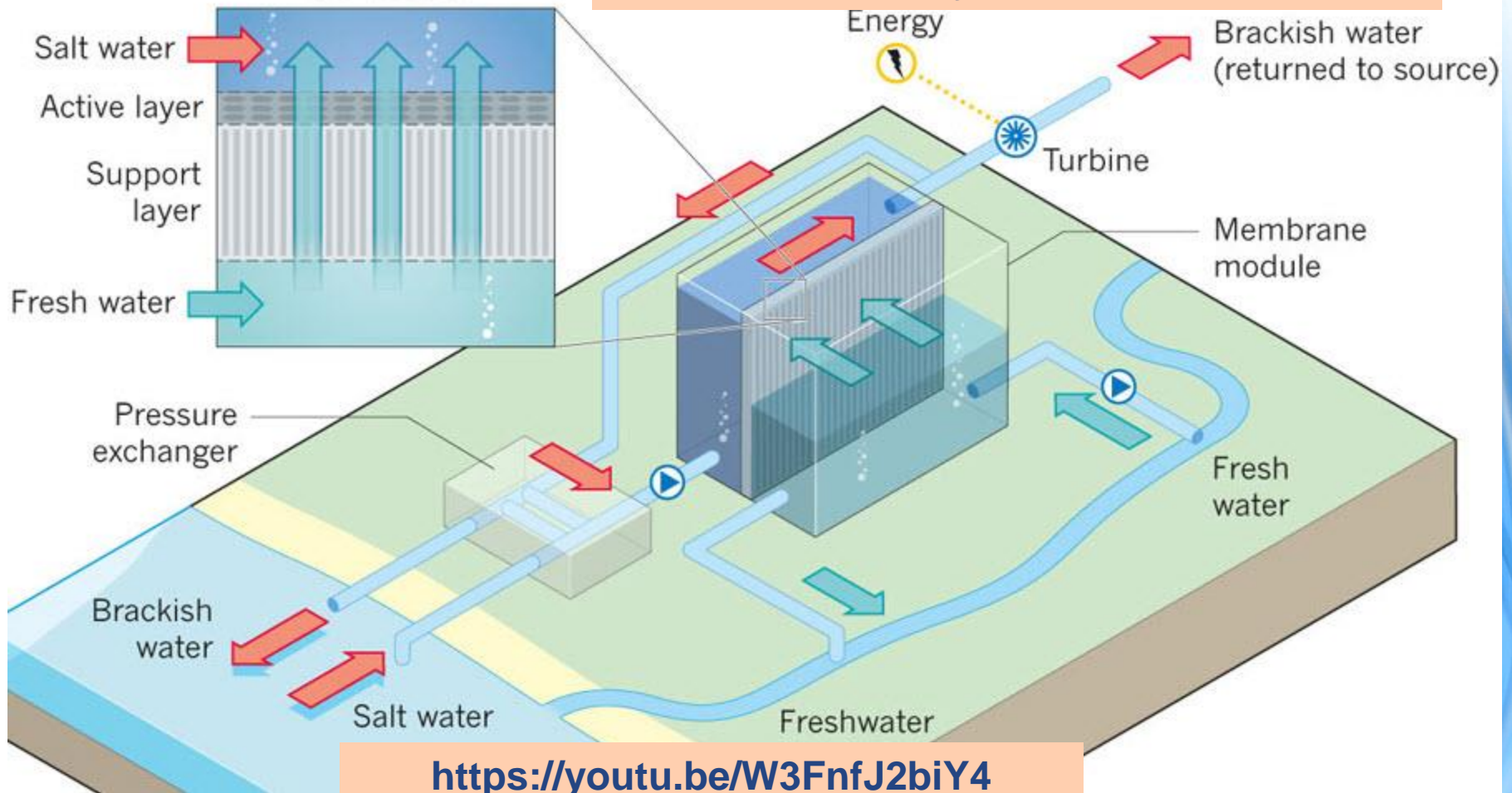
Norway's **Statkraft** opened world's first osmotic power plant in 2009 to produce emission-free kilowatts of electricity

$$\Delta G_{\text{mix}} = \text{Frictional Losses} + \text{Unutilized Energy} + \text{Extractable Work}$$



SWISS EPFL: 1 MW PER M² “BLUE ENERGY”

Nanoscale Biology Lab optimized pore size to dramatically increase power output



“Osmotically induced current” – *Nature*, July, 2016
DOI: 10.1038/nature18593

**B
R
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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 2012*



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)

