

Chemical Engineers: Current and Future Challenges

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May 3, 2017

AICHE – UIS, Bucaramanga, Colombia

Chemical Engineering:

Involved in of all engineering products&processes



Refrigerator

© McGraw-Hill Education, Jill Braaten



Boats

© Doug Menezes/Getty Images RF



Aircraft and spacecraft

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Power plants

© Malcolm Fife/Getty Images RF



Human body

© Ryan McVay/Getty Images RF



Cars

© Mark Evans/Getty Images RF



Wind turbines

© F. Schussler/PhotoLink/Getty



Food processing

Glow Images RF



A piping network in an industrial facility.

Courtesy of UMDE Engineering Contracting

WHAT IS ENGINEERING?

ENGINEERING = INNOVATION (Ingenuity)



ENGINEERING: CHANGE and PROGRESS

- The world is **fast-changing**. There is continual demand for the **better**.
- **Science&Technology** is the engine of this change. The only thing that will not change is **change itself**.
- In a **changing environment**, those who do not change actually **go backward**.
- Change **cannot be stopped**; it can only be redirected.



AGE OF INFORMATION and KNOWLEDGE SOCIETY

AGRICULTURAL Society (... – 1712, Invention of Steam Engine,

Newcomen) Occupations (farming, crafts) passed from father to son.

- **Speed of Change:** Low
- **Required skills/competencies:** Simple

INDUSTRIAL Society (1712 – 1948, invention of transistor, Bell Labs)

- Farming didn't disappear; it mechanized. Mechanization became the measure of competitiveness in Ag. Working class; new vocations.
- **Speed of Change:** Medium
- **Required skills/competencies:** Mechanical (robotic)

KNOWLEDGE Society (1948 – ...)

- Industrialization continues, but is knowledge-based. Routine tasks are left to robots. Arena of competition: New knowledge and technology developed.
- **Speed of Change:** High; **Product life:** Short; **Life of occupation:** Short
- **Required skills/competencies:** Complex and variable

Industrial Age: Drop in Employment Rate in Agriculture (USA)

1900: %35



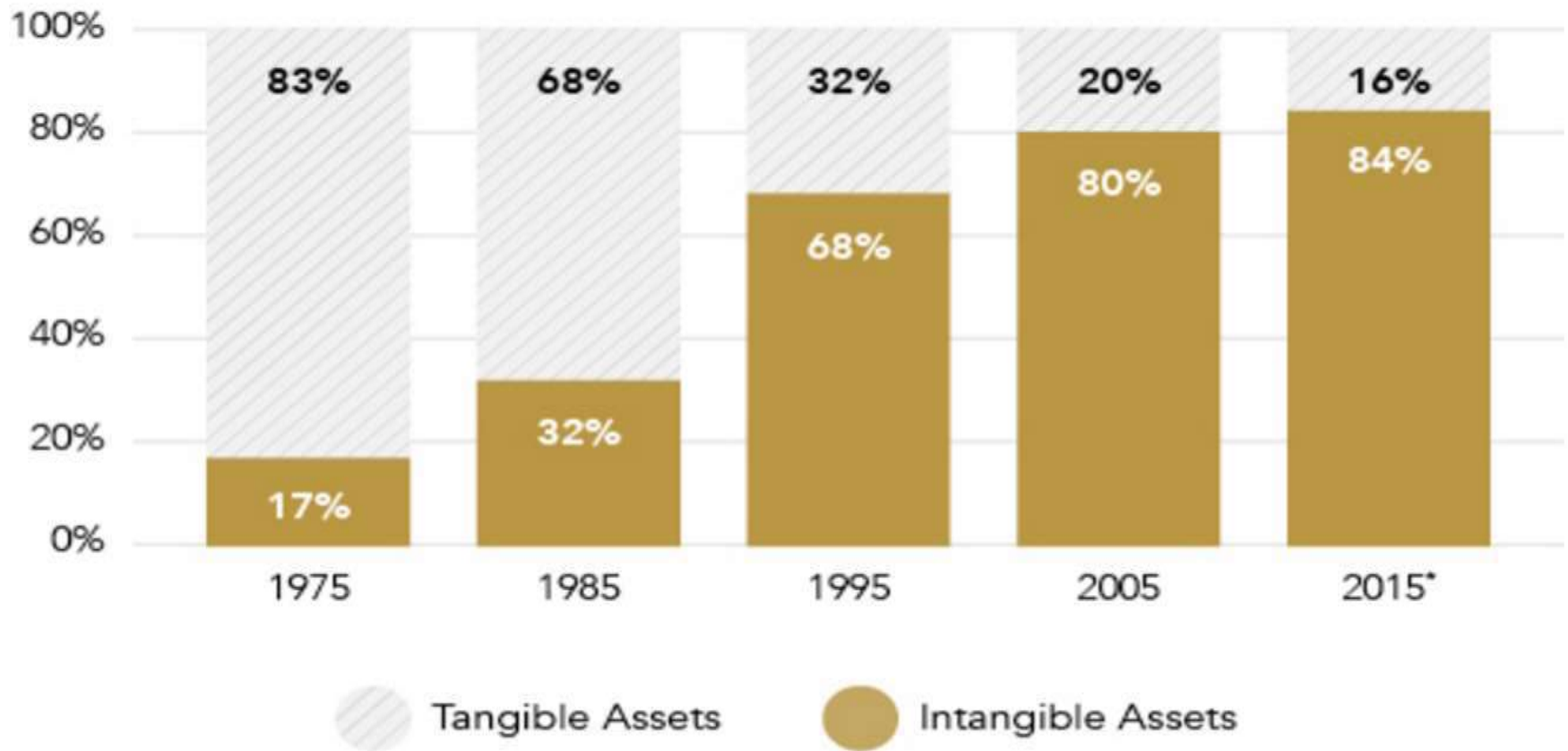
2000: %2



- Employment in the **manufacturing sector in the US** dropped from 30% in 1950s to under 10% today.
- Employment in **service sector** rose from under 50% to 70% during the same period.
- Secretaries are being replaced by computer programmers and web designers.

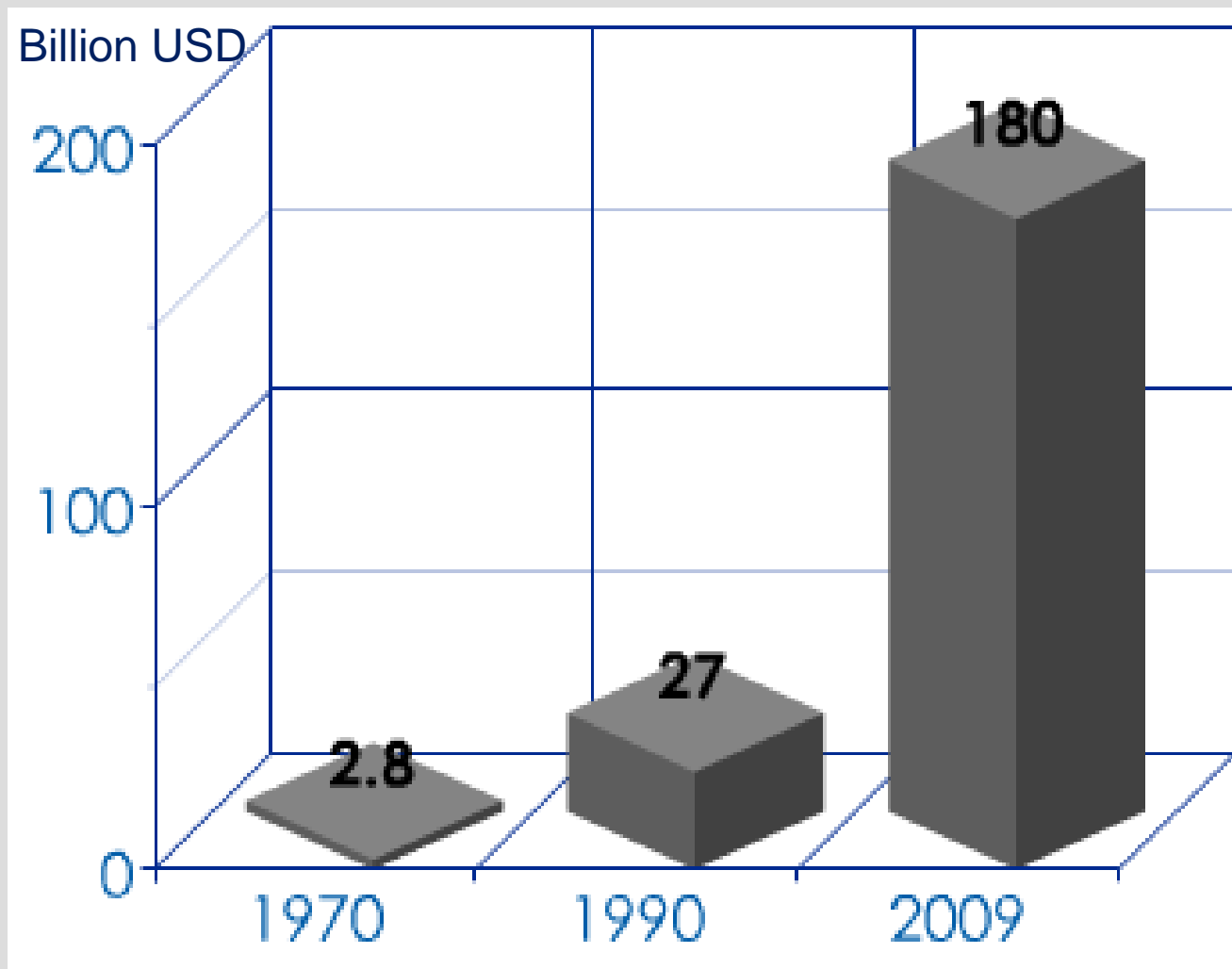
An Indicator of Knowledge-Based Economy: Fraction of Intellectual Property: 84%

COMPONENTS *of* S&P 500 MARKET VALUE



SOURCE: OCEAN TOMO, LLC
*JANUARY 1, 2015

Cross-border Licensing and Royalty Income



Source: WIPO (World Intellectual Property Organization)

A Rough Measure of Knowledge Economy: Average price of exported goods, \$/kg



A High-Value Added Product: Satellites

Satellite = Matter {copper, iron, plastic, ...} + **Non-matter** {imagination, innovation, knowledge, skills, ...}



Price of GOLD:
\$45,000/kg

TURKSAT 4A and 4B
Mitsubishi Electric, Japan
2013 and 2014

Total mass and price:
7700 kg
\$571 million

Unit cost:
\$74,000/kg

Raw materials:
\$10/kg?

High-Value Added Technology Products



Car: \$20/kg



Tablet: \$500/kg



Erythropoietin (A hormone that controls red cell production in blood; a biotechnology product used in the treatment of leukemia)

\$27 billion/kg

Source: Prof. Cezmi Akdis, *Director of Swiss Institute of Allergy and Asthma Research (SIAF)*;

A Measure of Technological Advancement: PATENTS

No. of patents granted by countries (2011)

Rank ↕	Country ↕	No. of Patents Granted			
1	 Japan	238,323	11	 France	10,213
2	 United States	224,505	12	 United Kingdom	7,173
3	 China	172,113	13	 Italy	6,380
4	 South Korea	94,720	14	 North Korea	6,290
5	European Patent Office	62,112	15	 Singapore	5,949
6	 Russia	29,999	16	 South Africa	5,296
7	 Canada	20,762	17	 India	5,168
8	 Australia	17,877	18	 Israel	5,104
9	 Germany	11,719	19	 Hong Kong	5,050
10	 Mexico	11,485	20	 New Zealand	4,710

No. of domestic patents granted by Turkish Patent Institute in 2011: 847.

No. given to foreign applicants in 2011: 5720 (%87)

Source: http://en.wikipedia.org/wiki/List_of_countries_by_patents and Turkish Patent Institute

Firms with Most US Patents in 2012 (Top 25)

No.	No. Patents	Firm	Country
1	6478	International Business Machines Corp, IBM	United States
2	5081	Samsung Electronics Co Ltd KR	Korea
3	3174	Canon K K JP	Japan
4	3032	Sony Corp JP	Japan
5	2769	Panasonic Corp JP	Japan
6	2613	Microsoft Corp	United States
7	2447	Toshiba Corp JP	Japan
8	2013	Hon Hai Precision Industry Co Ltd TW	Taiwan
9	1652	General Electric Co	United States
10	1624	LG Electronics Inc KR	Korea
11	1535	Fujitsu Ltd JP	Japan
12	1461	Seiko Epson Corp JP	Japan
13	1436	Hitachi Ltd JP	Japan
14	1410	Ricoh Co Ltd JP	Japan
15	1394	Hewlett-Packard Development Co L P	United States
16	1377	GM Global Technology Operations LLC	United States
17	1292	QUALCOMM Inc	United States
18	1290	Intel Corp	United States
19	1285	Toyota Jidosha K K JP	Japan
20	1157	Broadcom Corp	United States
21	1151	Google Inc	United States
22	1136	Apple Inc	United States
23	1132	Honda Motor Co Ltd JP	Japan
24	1118	Sharp K K JP	Japan
25	1050	Xerox Corp	United States

Apple: The Most Innovative Company

	Company	R&D Spending		
		2011, \$US Bil.	Rank	As % of Sales (Intensity)
1	Apple	\$2.4	53	2.2%
2	Google	\$5.2	26	13.6%
3	3M	\$1.6	86	5.3%
4	Samsung	\$9.0	6	6.0%
5	GE	\$4.6	30	3.2%
6	Microsoft	\$9.0	5	12.9%
7	Toyota	\$9.9	1	4.2%
8	P&G	\$2.0	72	2.4%
TIE 8	IBM	\$6.3	17	5.9%
10	Amazon	\$2.9	48	6.1%

Source: Bloomberg data, Booz & Company

- **Ross Rubin:** There are different kinds of innovation. “**Apple’s** innovation focuses on bringing together different parts of an ecosystem and tightly integrating them together with meticulous attention to detail.”
- **Samsung:** Incorporate the latest technologies into its products.
- **Dell:** Focus on relatively unglamorous innovation in process and manufacturing.
- **Google:** Innovation in prototypes and concepts.
- **Charles Golvin:** “A big distinction for Apple is the breadth of areas in which it innovates: hardware, industrial design, software, usability, retail.” Apple has come under criticism for its products being largely “evolutionary,” rather than “revolutionary”.

iPhone 5s: Major component suppliers

Manufacturer	Part Number	Description
		Display / Touch Screen Module - 4.0" Diagonal, 16.7M Color TFT, 1136 x 640 Pixels, 800:1 Contrast Ratio, 500cd/m2 Brightness, w/ In-Cell Multi-Touch
Toshiba Semiconductor	THGBX2G7B2JLA01	Flash - NAND, 16GB, MLC
Samsung Semiconductor	APL0898	A7 Application Processor - Dual-Core 64-Bit ARM Cortex CPU, Quad-Core GPU, PoP
Qualcomm	MDM9615M	Baseband Processor - Multi-Mode, Multi-Band, GSM/CDMA/EVDO RevB/HSPA+/LTE, 28nm
		Primary Camera Module - 8MP, 1.5-micron BSI CMOS, Auto Focus Lens
Elpida (Micron)	EDF8164A1PD-GD-F	SDRAM - Mobile DDR3, 1GB, PoP
		Fingerprint Sensor Module
Murata		BT / WLAN Module
		Battery - Li-Polymer
AT&S		10-Layer - FR4/RCP
Qualcomm	WTR1805L	RF Transceiver - Multi-Band, GLONASS
Dialog Semiconductor		Power Management IC
		Secondary Camera Module
Cirrus Logic		Audio Codec
Qualcomm	PM8018	Power Management IC
NXP	LPC18	Co-Processor
STMicroelectronics		Gyroscope - 3-Axis, Digital
Broadcom	BCM5976	Touchscreen Controller
Skyworks	SKY77572-18	Transmit Module
Avago	A792503	Transmit Module - Band 3/20, w/ Duplexer

Total cost for Parts&Manufacturing

32-GB: **Cost: \$208; Price \$749**

64-GB : **Cost: \$218; Price: \$849**

Profit: Over 50%

(S&P 500 Automotive: 4%)

CPU (A7): SAMSUNG

DISPLAY: JAPAN DISPLAY, LG, SHARP

BATTERY: SONY

CHIPS: TOSHIBA, SanDisk, ELPIDA,..

RF TRANSCEIVER: QUALCOMM

iOS (Software): APPLE

MAKER of iPhone: FOXCONN (China)

An Example of 'Apple Model' in Turkey: **AirTies**



DSL Modemler



Kablosuz Ağ
Geniřleticiler



Kablosuz ve Powerline
Adaptörler

*'Designed in
Turkey,
Manufactured in
China'*



Set-Top Boxlar



Ethernet Switchler

Bilim ve Sanayi Bakanlığı Ar-Ge merkezi
2012 yılı performans Endeksi Deęerlendirme
sonuçlarına göre sektör bazında;

En Başarılı Ar-Ge Merkezi

ödölünü almaktan gurur duyuyoruz.



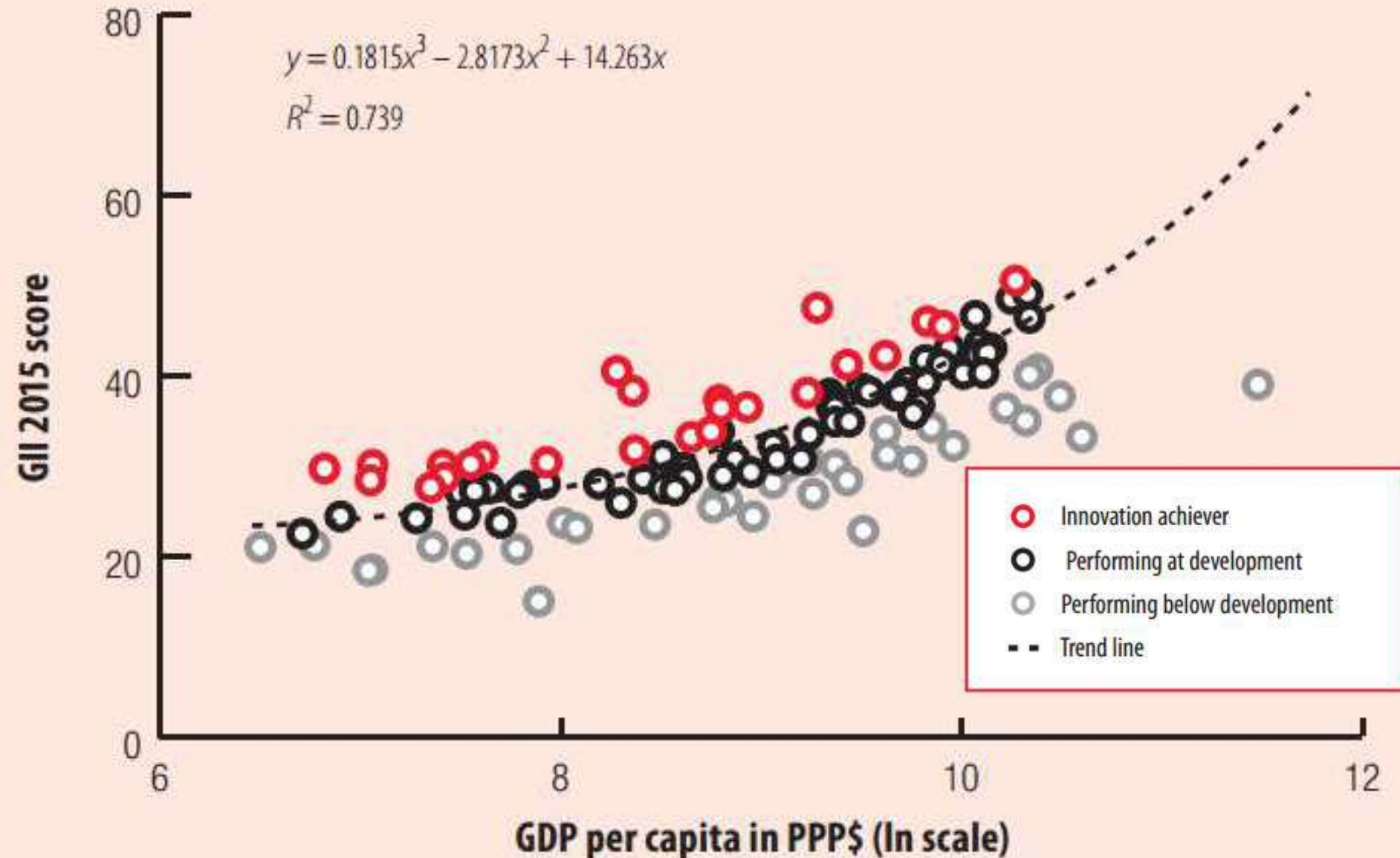
- R&D and Design in Turkey,
- Patents from US,
- Manufacturing in China,
- Worldwide sales (%50+ export)



**Bülent Çelebi, Founder
(Founded: 2004)**

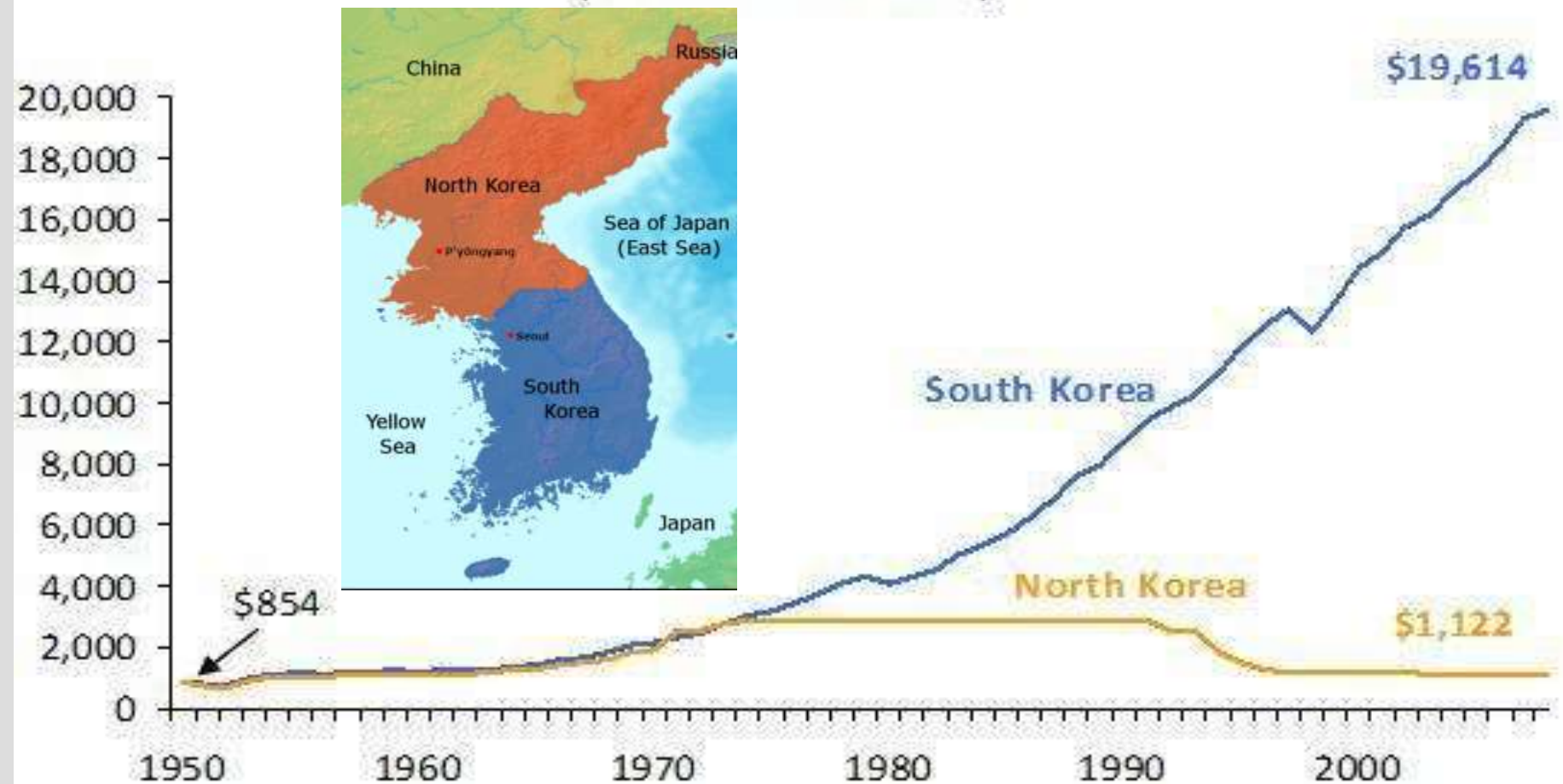
Innovation vs. GDP per capita:

Distribution of innovation performance in the GII 2015



South Korea vs. North Korea: Innovation brings wealth and prestige

**Institutions Matter:
Real Per Capita GDP in North and South Korea
(1990 International Dollars)**



Nobel Prizes in Sciences (by country of birth, 1945-2014)

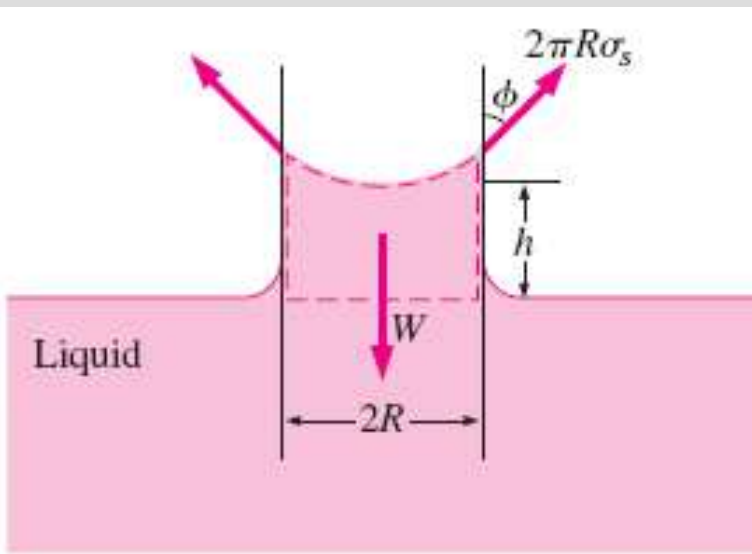
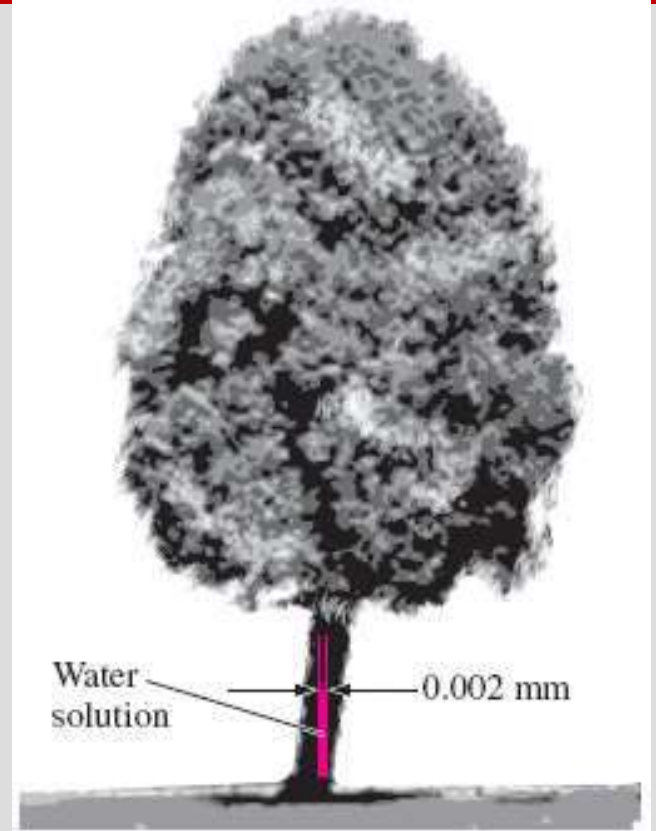
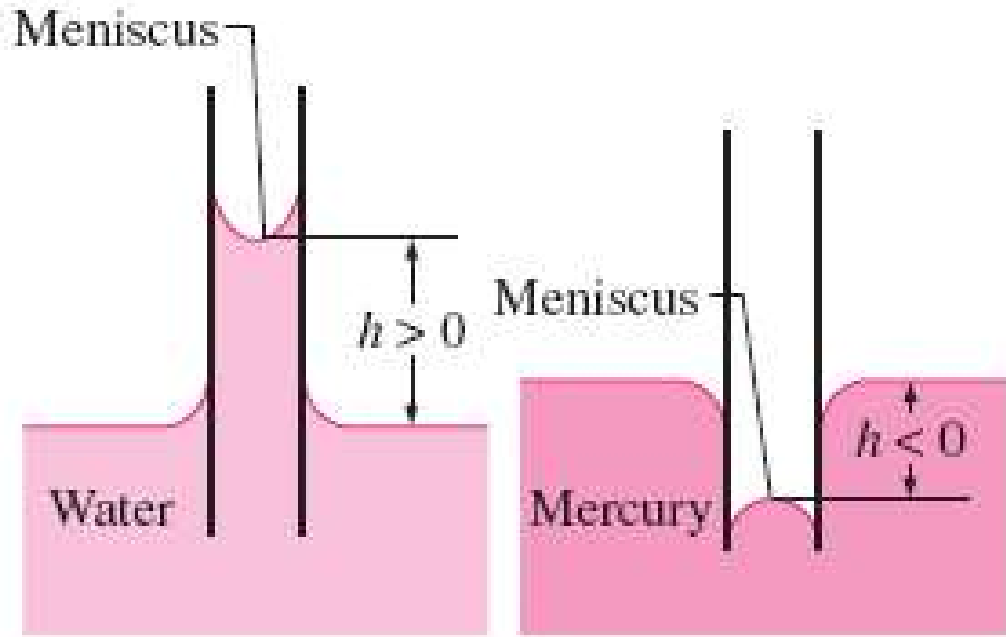
Country	Number of Nobel Prizes (1945-2014)			
	TOTAL	Physics	Chemistry	Medicine/Physiol.
United States	171	61	47	63
United Kingdom	49	11	18	20
Germany	39	15	12	12
Japan	18	10	6	2
Russia	13	10	2	1
Canada	10	3	4	3
Switzerland	10	3	2	5
Australia	9	1	1	7
Sweden	9	2	1	6
Italy	8	3	1	4

Proper climate for scientific development:

Democratic regime, Personal rights and freedoms

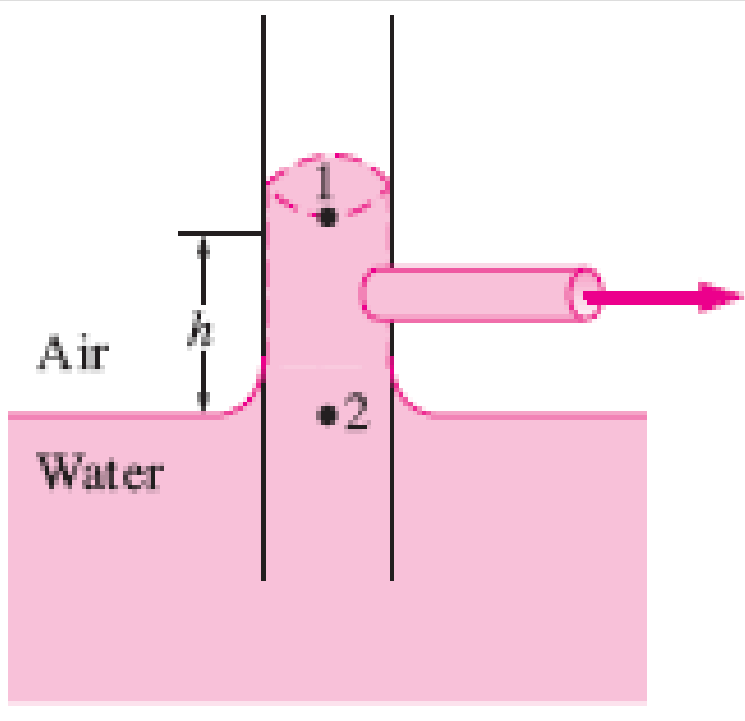
High quality of living (center of attraction), Culture of high tech creativity

Capillary Effect



$$h = \frac{2\sigma_s}{\rho g R} \cos \phi$$

Rise of Water due to Capillary Effect



Water rises a distance h from the free surface under the influence of surface tension. Now a hole is drilled and a small tube is inserted at a distance $h/2$ from the free surface, as shown in the figure. Circle the right answer about what will happen as a result.

- a) **Water will leak out** through the horizontal tube.
- b) **Air will leak in** through the horizontal tube.
- c) **Neither water will leak out not air will leak in** through the horizontal tube.

INNOVATION:

A New Product,

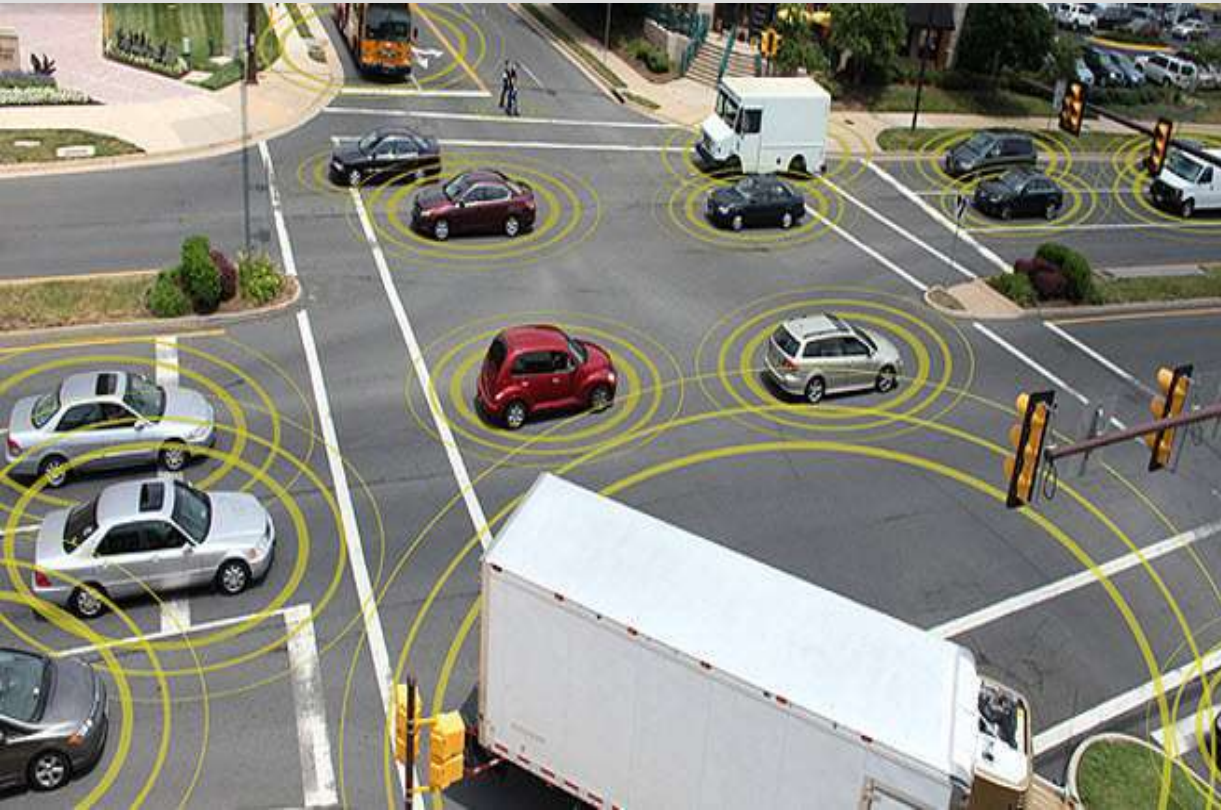
A New Process,

A New Business Model,

A New Service

IEEE: 75% of Cars Will Be Autonomous By 2040

- General Motors' Cadillac division expects to produce **partially autonomous** cars at a large scale **by 2015**, and the automaker also predicts it will have fully autonomous cars available by the end of the decade.
- The Institute of Electrical and Electronics Engineers recently released predictions that autonomous cars will account for up to **75%** of vehicles on the road **by 2040**.
- IEEE went even further, forecasting how **infrastructure, society and attitudes** could change when self-driving cars become the norm around the middle of the century."



Source:

<http://www.wired.com/autopia/2012/09/ieee-autonomous-2040/>

(18 Sep 2012)

Mirrorless Cars: Side Mirrors out; Cameras in

- **Side mirrors** create drag (2 to 7%), increase fuel consumption, cause blind spots and generate noise.
- Auto parts supplier 'Continental' developed **digital mirrors** (video systems) with **significant noise reduction** and **reduced fuel consumption**.
- There is also **increased field of view**.
- Interior screens on the left- and right side of dashboard show side and rear views. Makes parking easier.



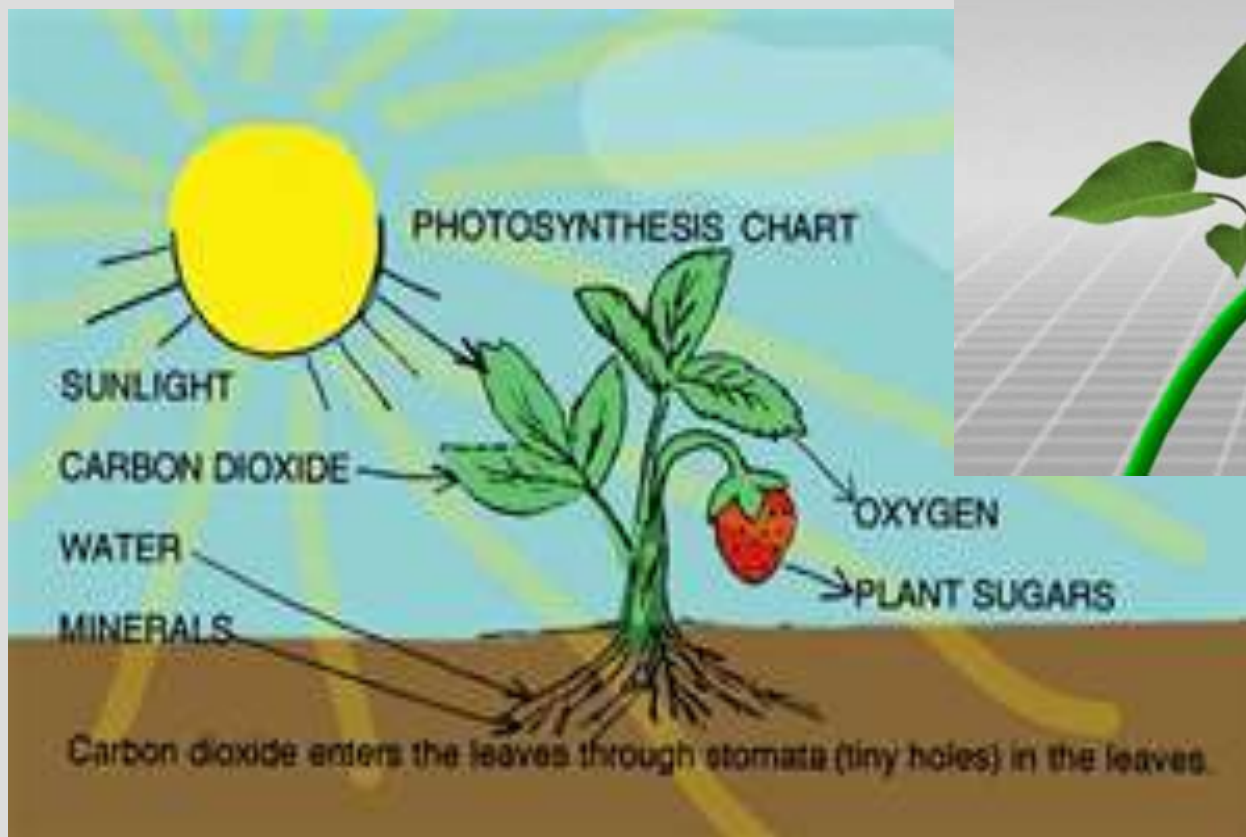
(Feb. 4, 2016)

ARTIFICIAL LEAVES

Liquid Fuel from Solar Energy via Artificial Leaves

Science: **Natural Leaf** (Photosynthesis)

Sun → Energy (sugar) + O₂ ▲



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Scientists Have Figured Out a Way to Convert Solar Energy Into Liquid Fuel

12 Feb 2015

TECHNOLOGY: **Artificial Leaf**

Sun → Energy (liquid fuel) + O₂

Artificial Leaves with Genetically Engineered Bacteria

(29 May 2016)

MAY 29, 2016 @ 12:01 AM 5,412 VIEWS

Harvard Scientist Engineers Superbug That Inhales CO₂, Produces Energy



Jeff McMahon
CONTRIBUTOR

I cover green technology, energy and the environment from Chicago.

[FULL BIO >](#)

Opinions expressed by Forbes Contributors are their own.



Harvard chemist Daniel Nocera at the University of Chicago (Photo courtesy of University of Chicago).

The chemist who gave us the artificial leaf has genetically engineered bacteria to absorb hydrogen and carbon dioxide and convert them into alcohol fuel.

“His bug converts **10% of sunlight** to alcohol fuel - 10 times more efficiently than plants.”

Carbon-neutral artificial photosynthesis:

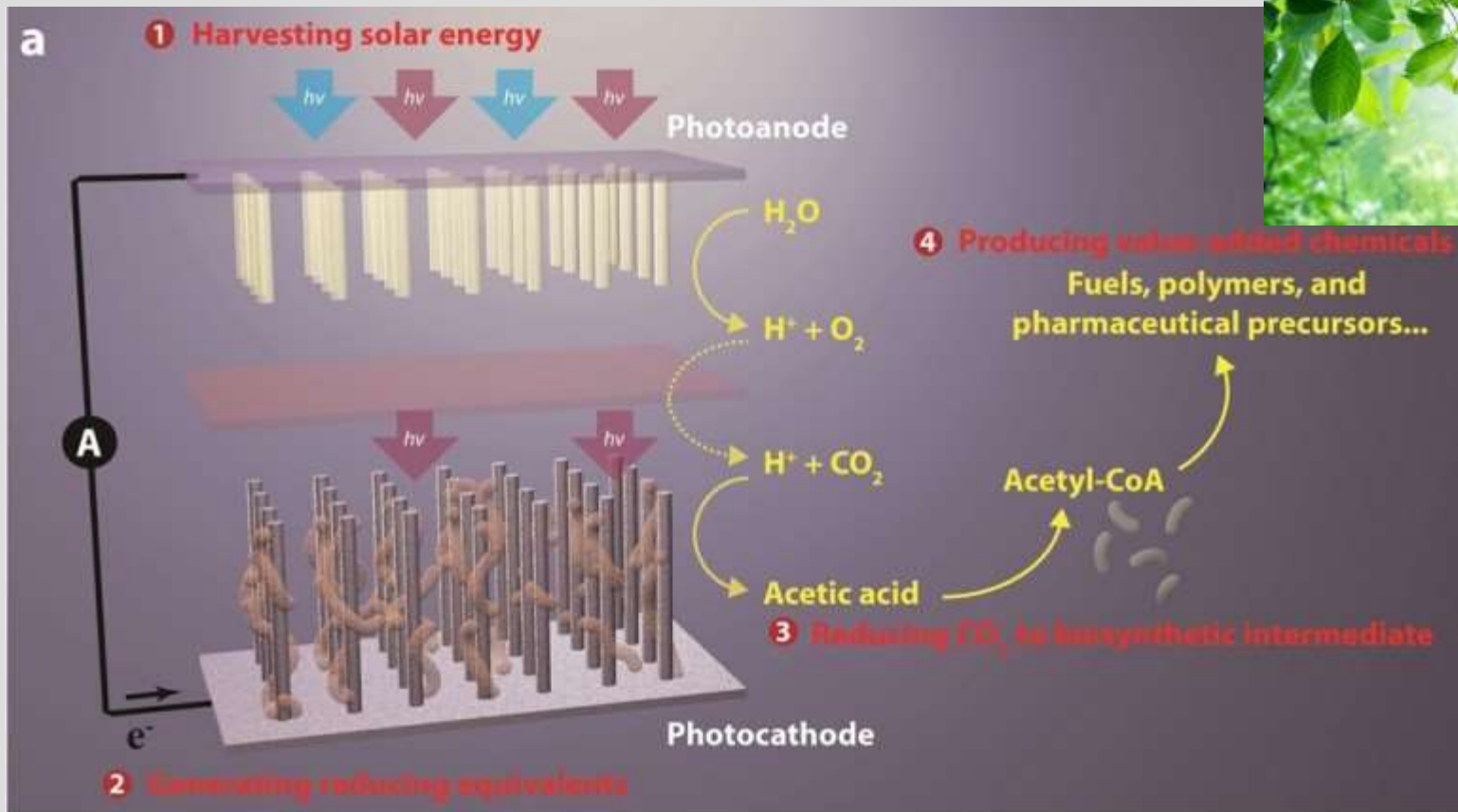
Solar-powered molecule converts CO₂ into CO as fuel

- Inspired by the leaf, researchers at Indiana Univ have developed a **molecule** that uses sunlight to convert CO₂ into CO, which can be used to make other fuels.
- The technique is the **most energy-efficient** way to create CO. The molecule is made of **nanographene** (absorbs the sunlight) and **rhenium** (acts like an "engine" that reduces CO₂ to CO).



Artificial photosynthesis breakthrough: CO2 emissions turned into plastics and biofuel

- Taking inspiration from Mother Nature, scientists devised a system that uses **sunlight** and H₂O to convert CO₂ into a wide range of useful chemicals.
- New approach could be a **game changer** because of its versatility and the **high yields** it produces.



(23 April 2015)

Color-changing roof tiles



2009 Wharton Energy Conference

GENERATION ENERGY

Friday, October 30, 2009 | The Union League of Philadelphia



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FRIDAY, OCTOBER 9, 2009

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[Green Building](#) | Jeff St. John | October 9, 2009

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3 Comments

MIT Team Invents Color-Changing Roof Tiles

A team of MIT students says they've made a roof tile that turns white in hot weather and black in cold weather, capturing the best of both colors.

Energy Secretary Steven Chu says painting all the nation's black roofs a heat-reflecting white could cut global warming.

But white isn't that popular a color for rooftops. And what about wintertime, when black roofs help cut home heating bills by absorbing the sun's heat?

A team of graduate students at the Massachusetts Institute of Technology think they might have an answer – the [Thermalene](#)



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ELECTRIC CARS (EV) & BATTERIES

AUDI: Game-changer in Electric Cars



Range: 500+ km per charge.

Charge time: Less than 1 h

Motor: All wheel drive.

Mass production: 2018

Acceleration from 0 to 100 km/h: 4.6 s.

Capacity: 95 kWh

(19 September 2015)

Chevrolet BOLT EV : 350 km range (in 2017)

BMW i3 EMiniCar: Extended range (in 2017)

Nissan (ve Renault) LEAF: 350 km (in 2018)

Hot Pursuit in Elektrik Cars:

FORD to Invest \$4.5 Billion by 2020 in Electric Cars

- Focus will be on **plug-in hybrid systems** - which allow drivers to operate part of the time on batteries recharged from the grid, and part of the time on gasoline.
- The batteries for plug-in hybrids are not as heavy or expensive as those required to deliver 200-mile or more range in an all-electric vehicle.
- All new vehicle platforms will come equipped with **engine- and battery-powered** capabilities.



- FORD plans to add 13 electric, plug-in models in 5 years.
- The plan includes an electric Ford Focus with a 160-km range and **30 minute battery recharge**.
- Such vehicles to rise to 40% of lineup from 13% now.

(Dec. 12, 2015)

Samsung EV battery (2021): 600-km range, 20-min fast charge



(9 January 2017)

Hot Pursuit in Elektrik Cars:

Mercedes plans to sell 100,000 EV/yıl in 2020

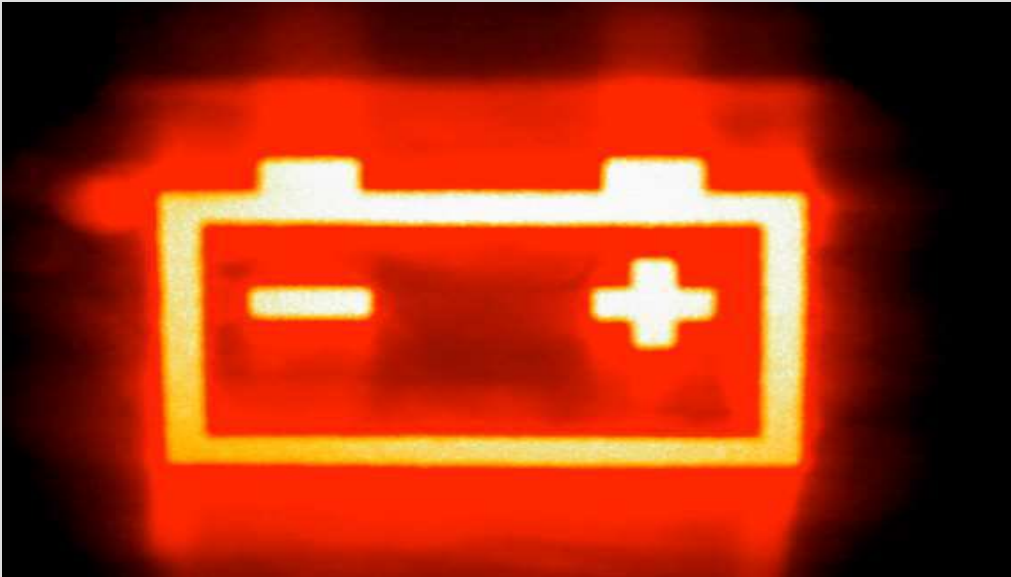
- Daimler plans to invest over **\$8 billion** in green technologies over the next two years alone.
- As part of the plan, Mercedes-Benz will eventually electrify every single model series of its passenger vehicles.
- It will also unveil a new EV with **300-mile range** at the Paris Motor Show this fall.



(June 13, 2016

Boosting lithium-ion capacity 7X by adding cobalt

- Researchers from the **University of Tokyo** have found a way to develop a lithium-based battery with **7 times the energy density** of current lithium-ion batteries, according to [Nikkei Technology](#).
- It also has each of the major benefits — **lower cost, greater capacity and increased safety**.
- The team have used a **new material** on the positive electrode in the battery, formed by **adding cobalt to the lithium oxide crystal structure**. This aids an oxidation-reduction reaction during which peroxides are produced, and electrical energy is generated.

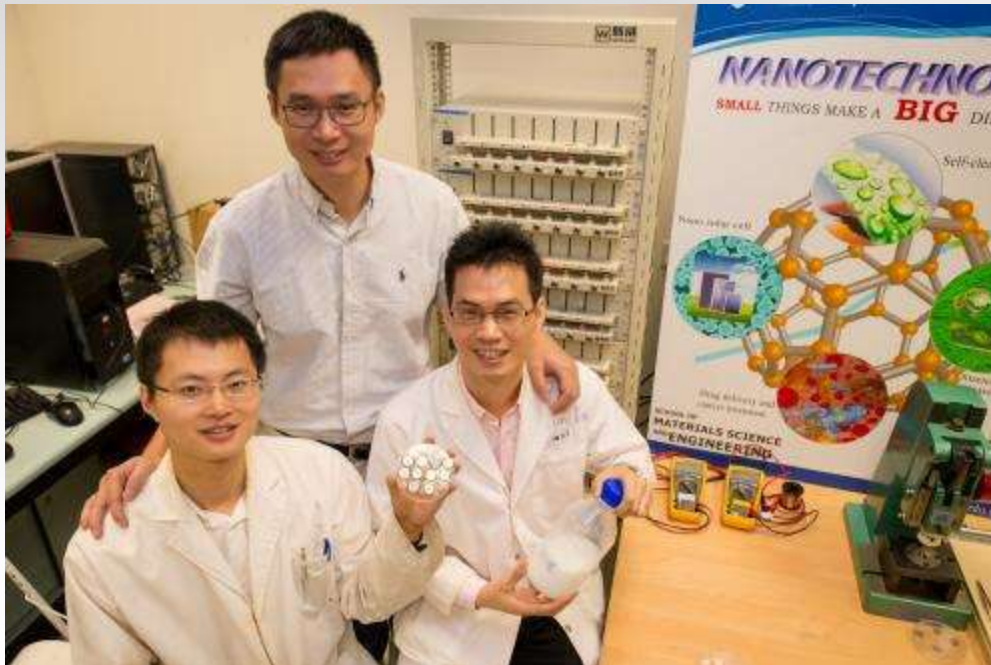


The researchers claim energy density of 2,570 Wh/kg. (The theoretical density of lithium-air technology is 3,460 Wh/kg.) But as a sealed design it's more stable (and thus safer) than lithium-air.

(27 July 2014)

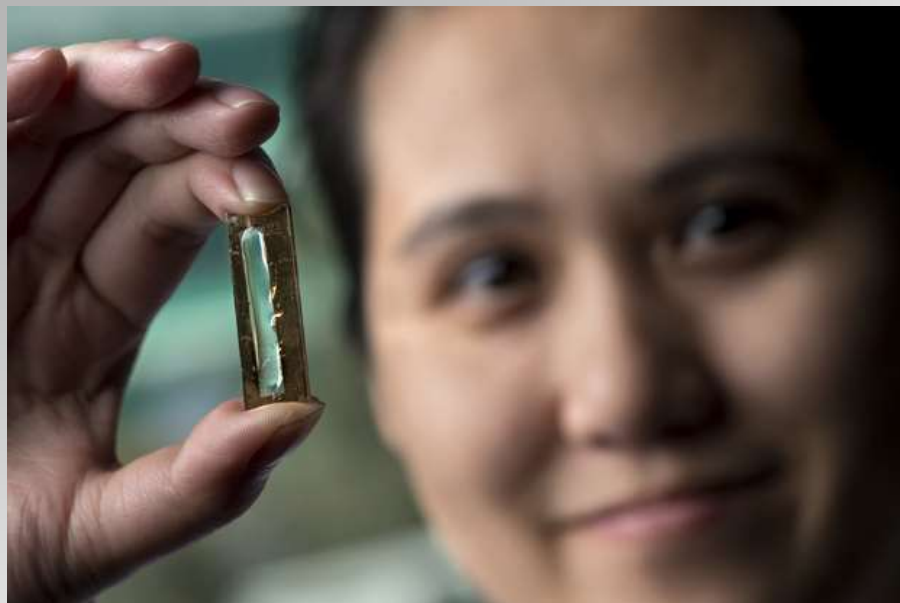
Ultra-fast charging batteries recharge 70% in 2 minutes

- Nanyang Technological University (NTU Singapore) Scientists have developed a new battery that can be **recharged up to 70% in 2 minutes**.
- The battery will also have a longer **lifespan of over 20 years**.
- New battery will be able to endure more than **10,000 charging cycles** – 20 times more than the current 500 cycles of today's batteries.
- New technology uses a **cheap titanium dioxide gel** in the form of nanostructures instead of the traditional graphite.

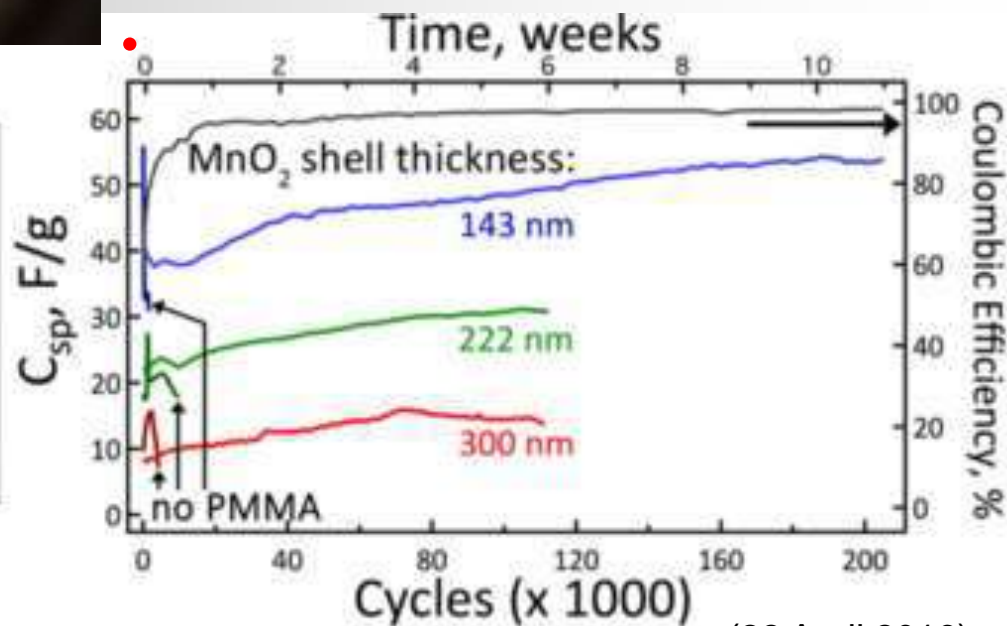
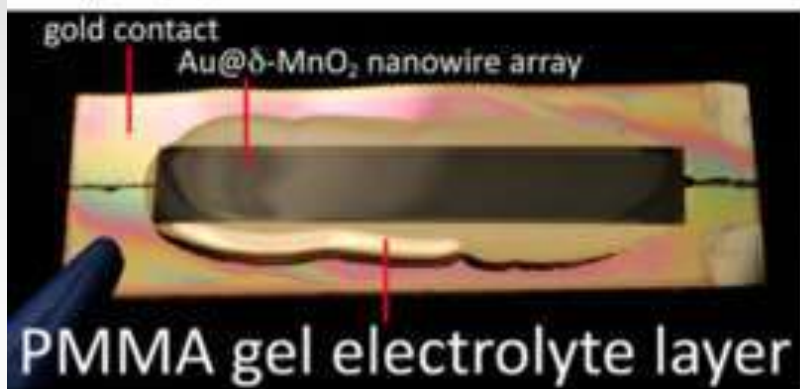


(13 October 2014)

Extending the Life of Lithium-ion batteries to infinity



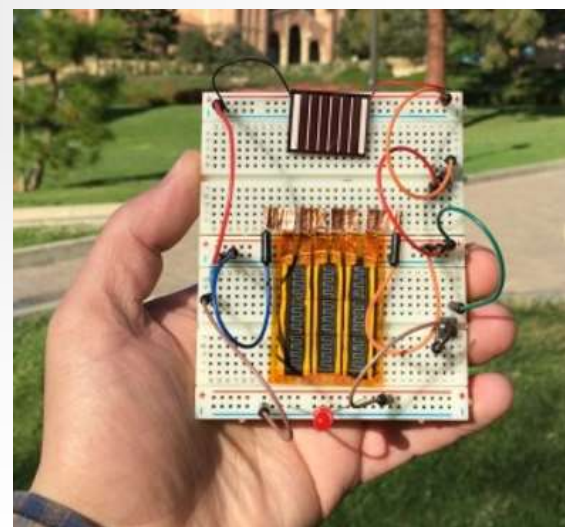
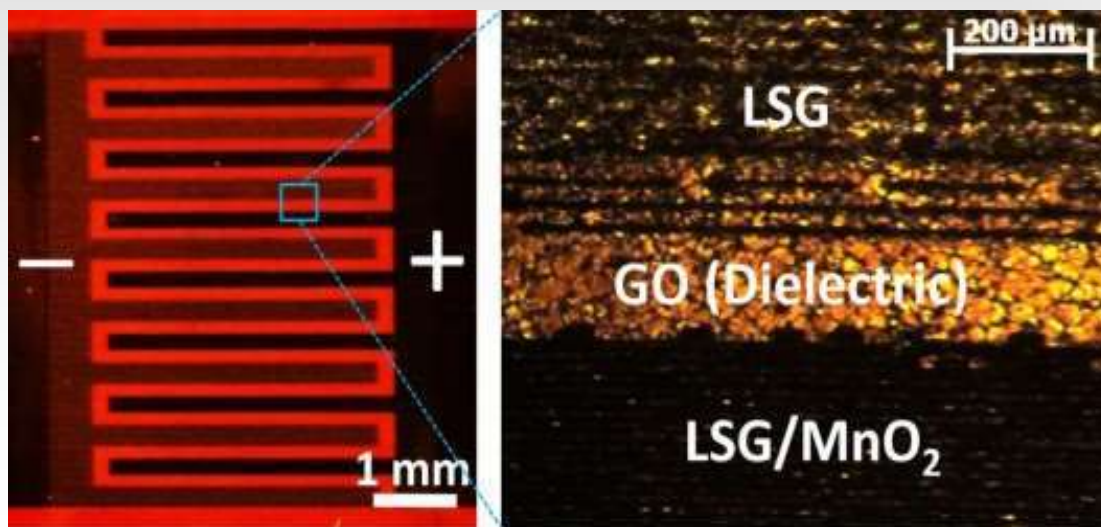
- Brittleness is solved by coating a gold nanowire in a MnO_2 shell and encasing it in an electrolyte made of a plexiglas-like gel.
- The combination is reliable and resistant to failure, lasting 100,000+ cycles instead of just 5000 without losing any capacity.



(22 April 2016)

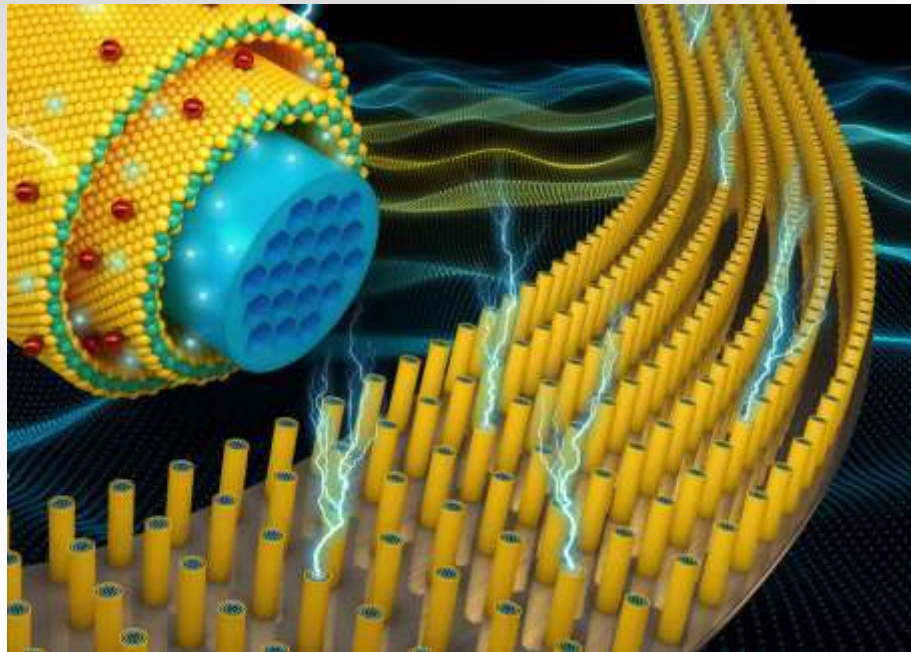
High Capacity (6x) + Fast Charge (UCLA) in Batteries

- **UCLA** Researchers developed a new hybrid supercapacitor that combines the **high energy densities of batteries** and the **quick charge/discharge rates of supercapacitors**.
- It can reach energy densities of up to 42 Wh/l, compared with 7 Wh/l for state of the art commercial carbon-based supercapacitors.
- The LSG–manganese-dioxide capacitors can store as much electrical charge as a lead acid battery per unit volume, yet can be **recharged in seconds**, and they **store about 6 times the capacity** of state-of-the-art commercially available supercapacitors.



Supercapacitor battery: High-capacity, instant charge

- Works like new even after being recharged 30,000 times.
- Supercapacitors can be charged quickly because they store electricity statically on the surface of a material, rather than using chemical reactions like batteries. That requires 2-D material sheets with large surface areas to hold lots of electrons.



Hybrid energy storage technology: Supercapacitor+Lithium-ion Battery

- The **hybrid** energy storage technology developed by Korea's KAIST research team combines **pros** of **lithium-ion batteries** and **supercapacitors**.
- **Higher energy capacity; 100 times faster charging.**
- **Lithium-ion batteries** have relatively high energy storage density of 185 Wh/kg, and low charging speed and output of 200 W/kg.
- **Supercapacitor** has high charging speed and output of 20 kW/kg but low energy density.
- **Hybrid energy storage** technology with 275 Wh/kg energy density (1.5 times that of the lithium ion battery) and 23 kW/kg charging and output property (100 times higher than that of the lithium ion battery).

Safer Alternative to Lithium-Ion Batteries:

Solid-state design; Non-flammable electrolyte

- Uses **sodium** rather than lithium.
- 3 times more **energy dense**.
- **Better performance, lower cost**.
- **Noncombustible** due to the solid-state design, which replaces the flammable liquid electrolyte used in lithium-ion battery cells with a solid material (glass).
- Glass-electrolyte solid-state battery can **charge and discharge faster** and will have a **longer lifespan** than current lithium-ion designs.
- Developed by John Goodenough from the University of Texas Austin, the co-inventor of the lithium-ion cell.



(March 4, 2017)

Large scale Battery storage: Up from 80 MW in 2008 to 580 MW in 2015 in US

- U.S. homes and businesses, mostly utilities (85%), installed storage systems with 221 megawatts of capacity in 2015.
- Large-scale energy-storage systems is key to integrating solar and wind power into electric grids.
- US expected to have 4,000 megawatts of battery storage capacity by 2020.
- Global battery storage capacity is expected to reach 40 GW by 2022.



(Mar. 3, 2016)

2000 MW, \$5 billion Solar thermal plant (CSP): 24-h electric production with molten salt storage

Energy | Oct. 12, 2016 10:07AM EST

World's Largest Solar Project Would Generate Electricity 24 Hours a Day, Power 1 Million U.S. Homes



Lorraine Chow

- Planned for Nevada, USA.
- Involves at least 100,000 mirrored heliostats
- 10 towers equipped with a molten salt energy storage system.
- Molten salt is heated to over 600°C
- 6500 hectare area

(Oct. 12, 2016)

HYDROGEN CARS

Toyota's hydrogen-powered Mirai



Japan Times, December 15, 2014

Toyota has become the world's first automaker to market a hydrogen-powered car. The fuel-cell vehicle will be the U.S. and European markets.

<http://www.japantimes.co.jp/news/2014/12/15/business/toyotas-hydrogen-powered-mirai-goes-sale-japan/#.VJHtGq39nb0>

Hydrogen Cars (Fuel Cell): Hydrogen-powered Honda Clarity: **589 km range**

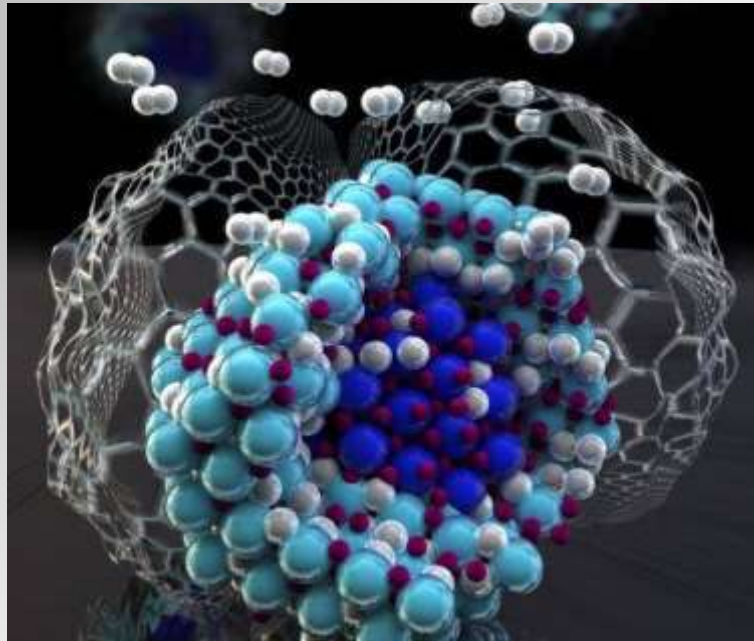
October 26, 2016



- Longest-range zero-emissions vehicle on the market (Nov. 2016).
- Price: \$60,000. Refuels in 3-5 minutes.
- There is a growing network of hydrogen stations.
- 130 kW (174 hp); new smaller and more energy dense fuel cell stack
- Can also be used as an emergency electric generator - can power the average home for around a week.

Hydrogen-Sucking Sponge For Fuel Cell EVs

Feb. 28, 2017



- **Nanotechnology** based.
- Involves **inserting metals and nitrogen** into **particles of carbon**.
- **Lithium nitride** acts like a chemical “sponge” to absorb and release hydrogen.
- Modified carbon particles **release/absorb hydrogen** in only **one step** and **more rapidly** than bulk material.

(Research at Sandia, Lawrence Livermore National Lab, NIST and Thailand’s Mahidol University.)

HYDROGEN CARS

NEWS & ANALYSIS ▾

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POPULAR:

Ultrathin Layers of Platinum Could Help Make Hydrogen Cars Affordable

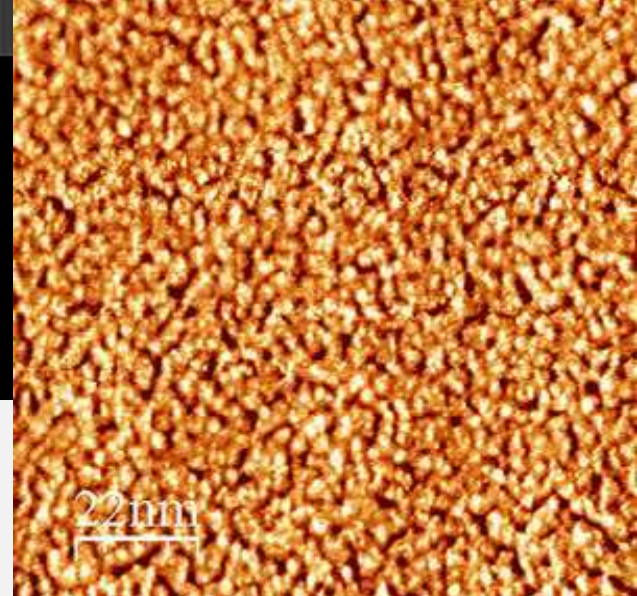
A fast and easy way to deposit platinum could reduce the amount of the precious metal needed for fuel cells.

By Kevin Bullis on December 6, 2012

A new method for quickly and cheaply depositing ultrathin layers of platinum might make it practical to reduce the amount of platinum used in fuel cells, thereby lowering the cost of fuel cells significantly.

Current methods for applying atom-thick layers of platinum are slow and complicated. The new approach is said to be incredibly cheap and easy to implement (NIST).

The researchers "showed that platinum dissolved in a solution can be deposited on a gold surface in one-atom thick layers by alternately applying a positive and negative voltage. The negative voltage causes two things: first, an atom-thick layer of platinum forms; and second, once those atoms are in place, a layer of hydrogen forms, thus preventing any more platinum from accumulating.



An electron microscope image shows platinum accumulated on a layer of gold

Joint R&D in Hydrogen Cars by Ford, Daimler, Nissan

San Francisco Chronicle
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<http://www.sfgate.com/business/energy/article/Ford-Daimler-Nissan-to-research-hydrogen-cars-4228722.php>

SFGate

January 27, 2013 (change)

Tuesday Jan 29, 2013 5:50 AM PT



Today
48/61



Wed.
48/63

5 Day Forecast



sfgate.com

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Ford, Daimler, Nissan to research hydrogen cars

By TOM KRISHER, AP Auto Writer

Updated 6:57 am, Monday, January 28, 2013



Comments (0) Email This

DETROIT (AP) — Ford is joining with Daimler and Renault-Nissan to speed development of cars that run on hydrogen, with hopes of bringing a vehicle to market in as little as four years.

Ford is joining with Daimler and Renault-Nissan to speed development of cars that run on hydrogen, with hopes of bringing a vehicle to market in 4 years – by 2017.

- Each company will invest equally in the technology. The companies will use the common fuel cell system developed to power their own vehicles.
- Ford: "Working together will significantly help speed this technology to market at a more affordable cost to our customers."
- "We will all benefit from this relationship, as the resulting solution will be better than any one company working alone."

GENETIC TECHNOLOGIES IN ENERGY

Yeast to Convert Wood Sugar to Ethanol

Yeast Engineered To Convert Xylose Into Ethanol.

- The [AP](#) (6 Jan 2011) reports Professor Yong-Su Jin of the University of Illinois "says a yeast long used in brewing and baking has the potential to produce ethanol more quickly and efficiently."
- Jin engineered the yeast to create ethanol from xylose, also known as wood sugar.
- "Jin says the yeast normally would act on glucose and leave the xylose alone, unless an expensive enzyme is added.
- But he says he has been able to modify the yeast so the enzyme is not needed."

Electricity from Microbes

The New York Times Business Day
Technology

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Search Technology **Inside Technology** **Bits Blog »**
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The only phone with Office, Xbox LIVE and thousands of apps.   Windows Phone

[Replay](#)

Electricity From Microbes a Step Closer: Study

By REUTERS

Published: May 23, 2011 at 3:12 PM ET

OSLO (Reuters) - Microbes may be harnessed more easily to generate energy after a finding about how they naturally let off tiny electrical charges, scientists said on Monday.

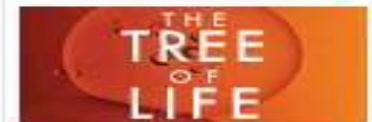


The bacteria, found to have microscopic "wires" sticking through their cell walls, might also be used to

clean up [oil spills](#) or uranium pollution, according to the report in the U.S. journal Proceedings of the National Academy of Sciences.

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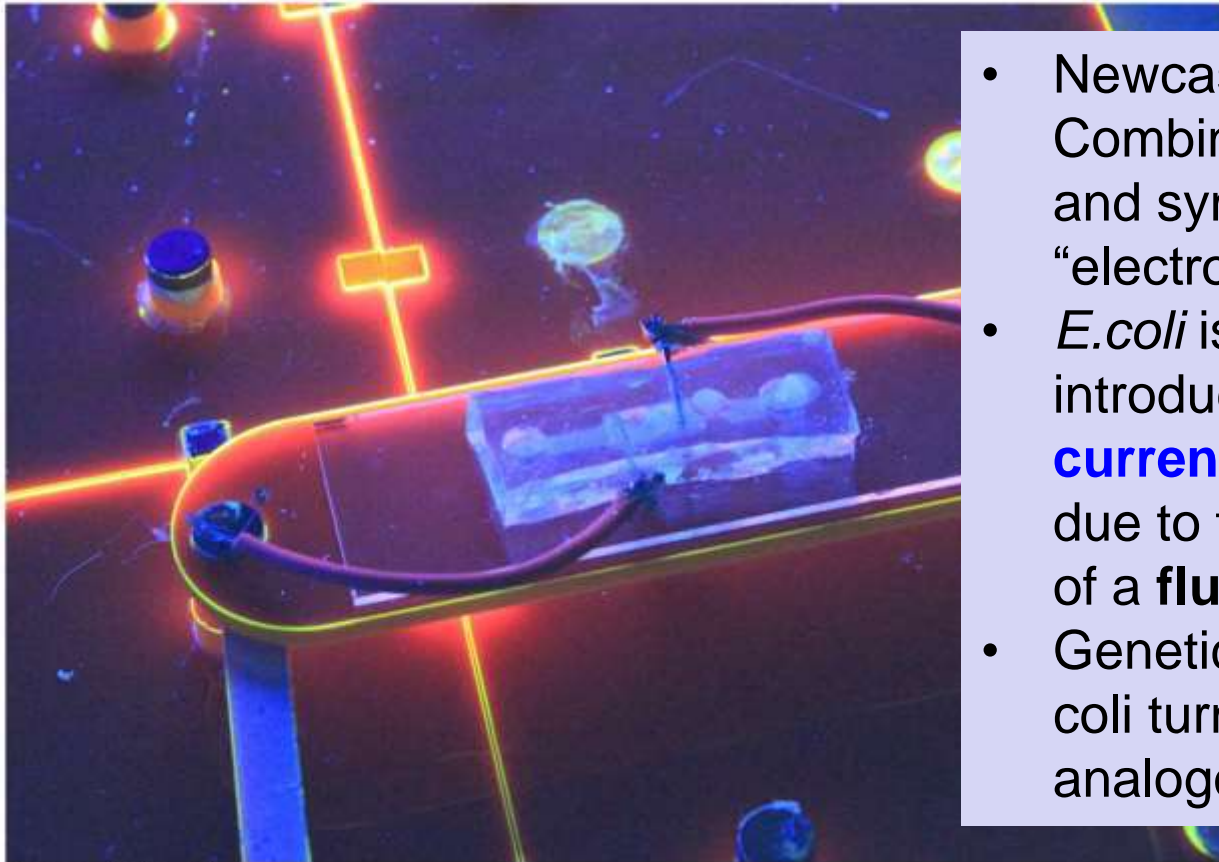
The discovery about the exact structure of the bacteria and their atom-sized wires would permit researchers to design electrodes with better contacts to pick up the charges, let off by the microbes to avoid a build-up of electricity.

<http://www.nytimes.com/reuters/2011/05/23/technology/tech-us-energy.html>

The emerging science of **Electrobiolology**: Light from genetically modified bacteria

(28 October 2016)

Lightbulb made of modified *E. coli* fuses biology and electronics



Made of modified *E. coli*
Ollie Burton/CultureShock

- Newcastle University (UK): Combined electronic engineering and synthetic biology to create “electro-biological” circuits.
- *E.coli* is designed to glow when introduced to an **electrical current** or a **heat source at 42°C** due to the increased expression of a **fluorescent gene**.
- Genetically modified glowing *E. coli* turned into something analogous to a light bulb.

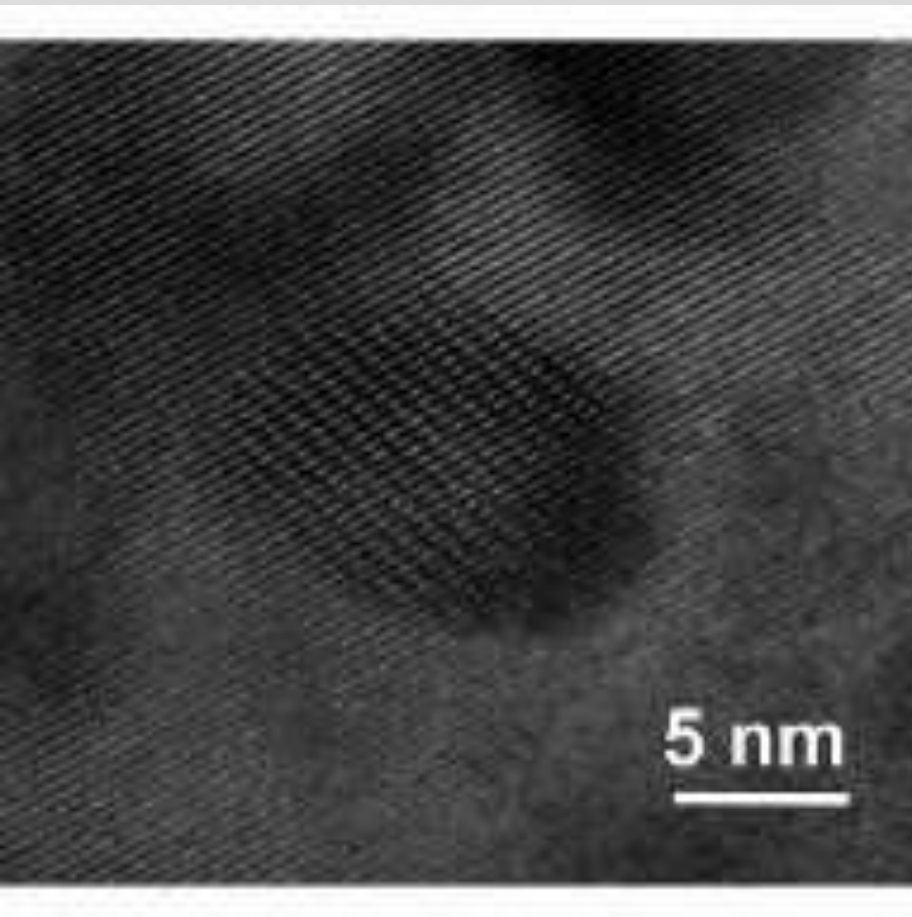
THERMOELECTRIC TECHNOLOGIES

New Material for Thermo-Electric Generation

Researchers at the U. of Houston created a new thermoelectric material: **germanium-doped magnesium stannide**, $\text{Mg}_2\text{Sn}_{0.75}\text{Ge}_{0.25}$



4 March 2015



- Researchers at the U. of Houston created a new thermoelectric material: **germanium-doped magnesium stannide**, $\text{Mg}_2\text{Sn}_{0.75}\text{Ge}_{0.25}$
- It is to be used to generate **electric power from waste heat** - from a vehicle tailpipe, for example, or an industrial smokestack - with greater efficiency.
- The new material has a peak power factor (or output power density) of 55, with a figure of merit (or efficiency) of **1.4**.

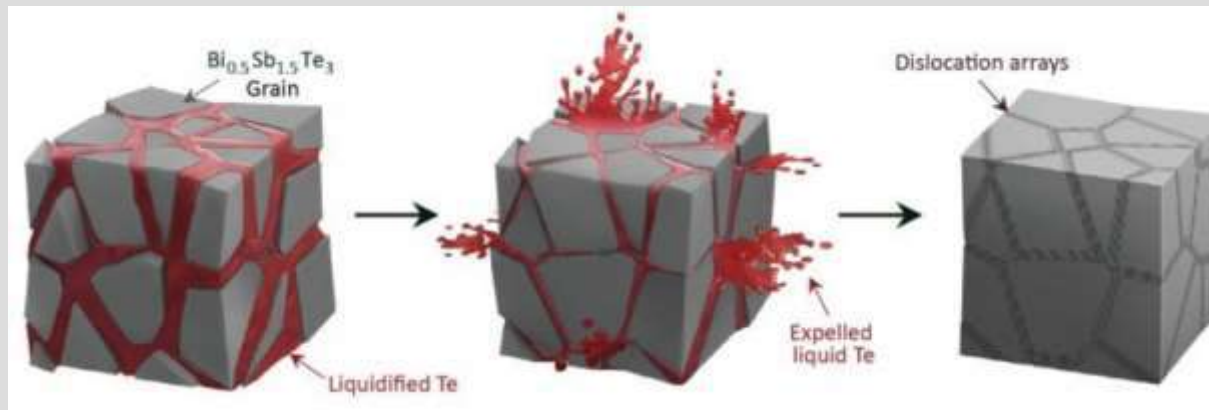
Doubling Thermo-Electric Refrigeration Efficiency

ScienceDaily[®]

Your source for the latest research news

2 Nisan 2015

The efficiency reached 2.01 at 320 K, nearly **doubling** the industry standard. The new material was able achieve a **temperature change of 81 K** at room temperature.

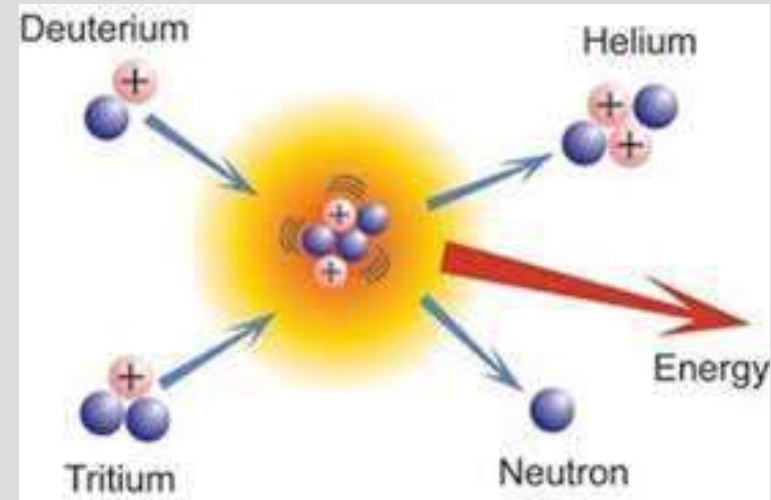
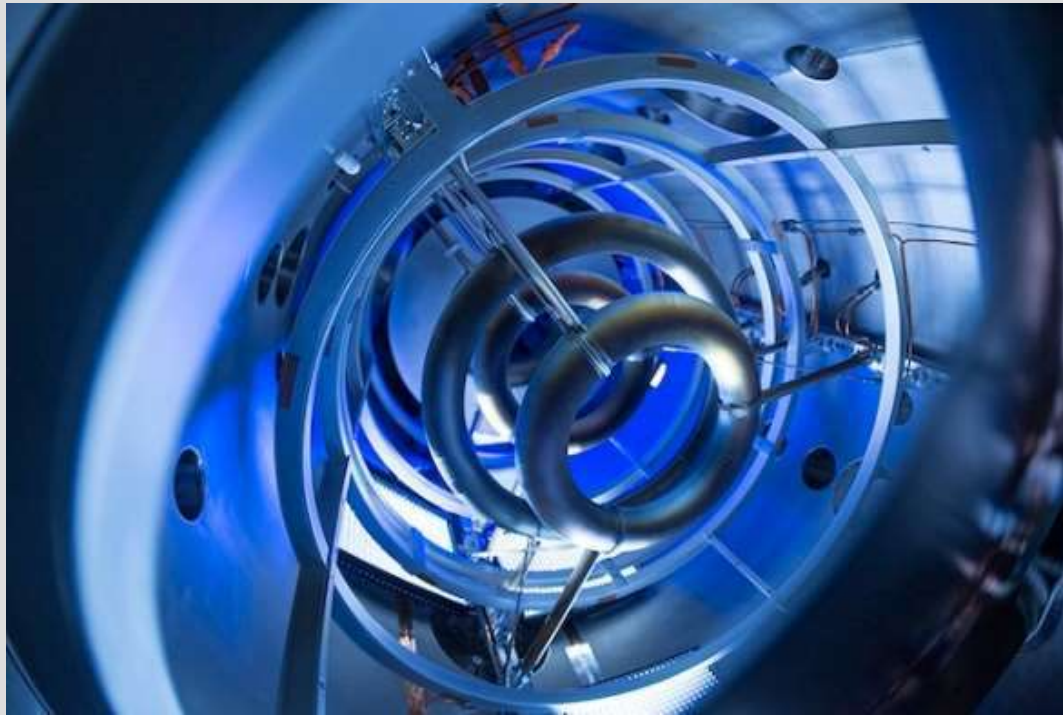


- Researchers in **South Korea** at IBS Center for Integrated Nanostructure Physics, Samsung Advanced Institute of Technology, Kangwon National University, Sungkyunkwan University, and California Institute of Technology, **USA** developed a new method for a much more efficient TE alloy.
- This new alloy is **nearly twice as efficient** as existing materials (2.0 vs. 1.1). Uses include refrigeration, consumer electronics, transportation, etc.
- These dislocation arrays **greatly reduce their thermal conduction**, leading to an enhancement of their thermoelectric conversion efficiency.

NUCLEAR FUSION

Nuclear Fusion: Lockheed Martin Claims Fusion Breakthrough

- Although nuclear fusion has been studied for decades, Lockheed is hoping to build a reactor **small enough to fit on the back of a truck within 10 years.**



Superconducting magnetic coils inside a compact fusion reactor.

Source: Lockheed Martin

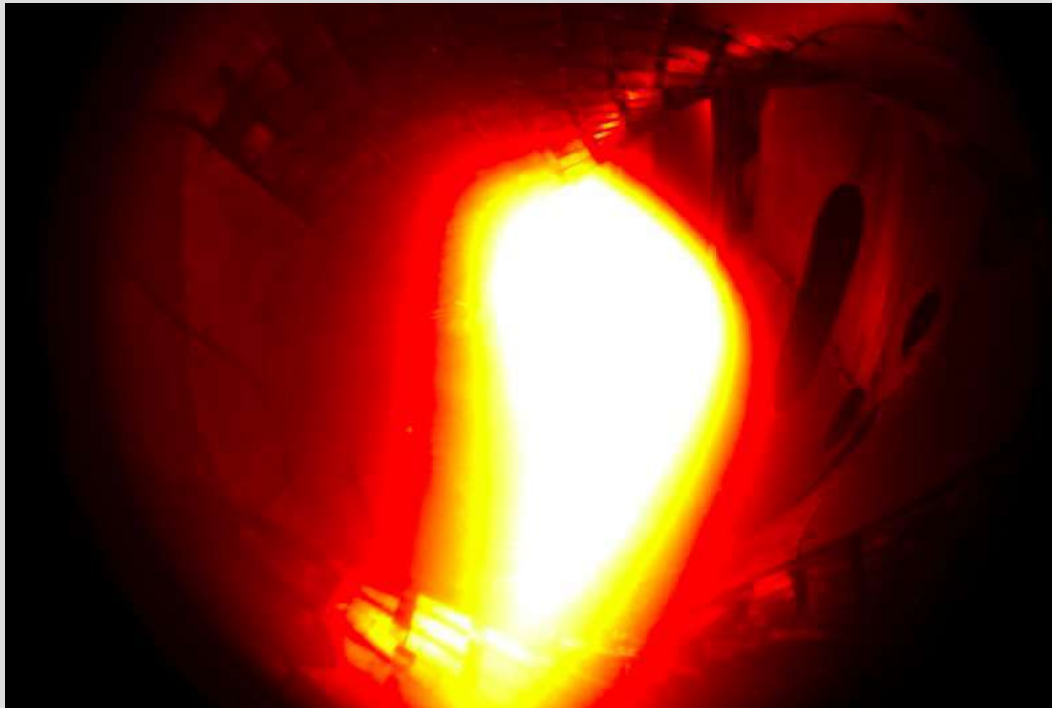
The Washington Post

http://www.washingtonpost.com/business/economy/lockheed-martin-is-building-a-compact-nuclear-fusion-reactor/2014/10/15/c2b13ff4-540e-11e4-892e-602188e70e9c_story.html?wprss=rss_national;

(15 October 2014)

Germany makes landmark fusion power achievement

- Researchers at **Max Planck Institute** in Greifswald switched on the [Wendelstein 7-X stellarator](#) for the very first time.
- With temperatures reaching **80 million degrees C**, the stellarator successfully generated its first hydrogen plasma.

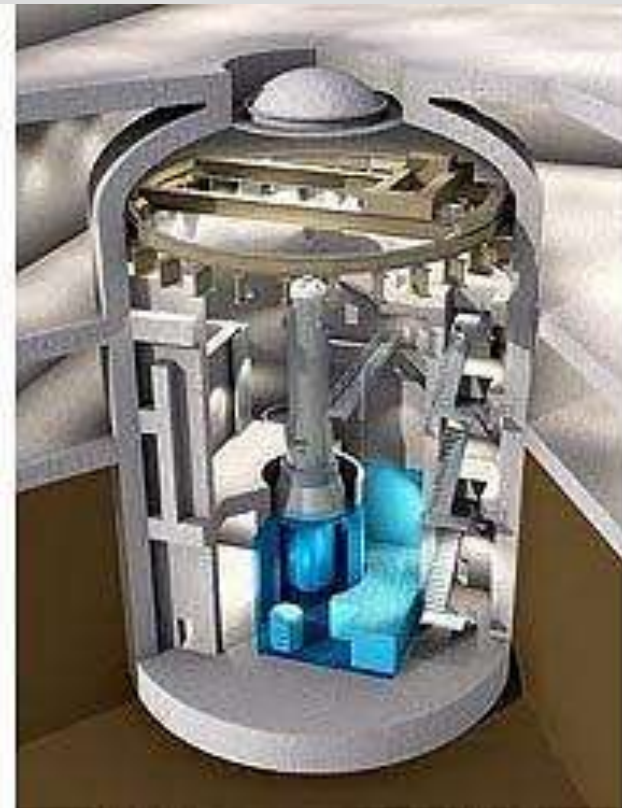


The European Commission announced in October 2014 a \$1 billion initiative to develop nuclear fusion as an energy source by 2020.

Small Modular Nuclear Reactors (SMR): US to develop 50-MW SMR's in next 10 years

(15 June 2015)

Modular: To be assembled from standardized, mass-produced subcomponents.



- SMRs are smaller, lower capital cost, factory produced units designed to provide electricity in the range of 50 to 300 MW.

- In 2012, the US Department of Energy launched a 6-year \$452-million SMR support program aimed at promoting the development and investment in US-based SMR projects.

- Uranium or thorium as fuel.

Detailed Report:

<http://trade.gov/publications/pdfs/the-commercial-outlook-for-us-small-modular-nuclear-reactors.pdf>

http://www.nuclearpowerdaily.com/reports/US_Anticipates_Small_Modular_Nuclear_Reactors_in_Next_Decade_999.html

Breakthrough in Nuclear Fusion: Plasma brought to 2 atm and 35 million C

(19 Oct 2016)

MIT Breaks a World Record For Nuclear Fusion

The record was broken on the day the reactor was scheduled to be shut down.



Bob Mumgaard/Plasma Science and Fusion Center



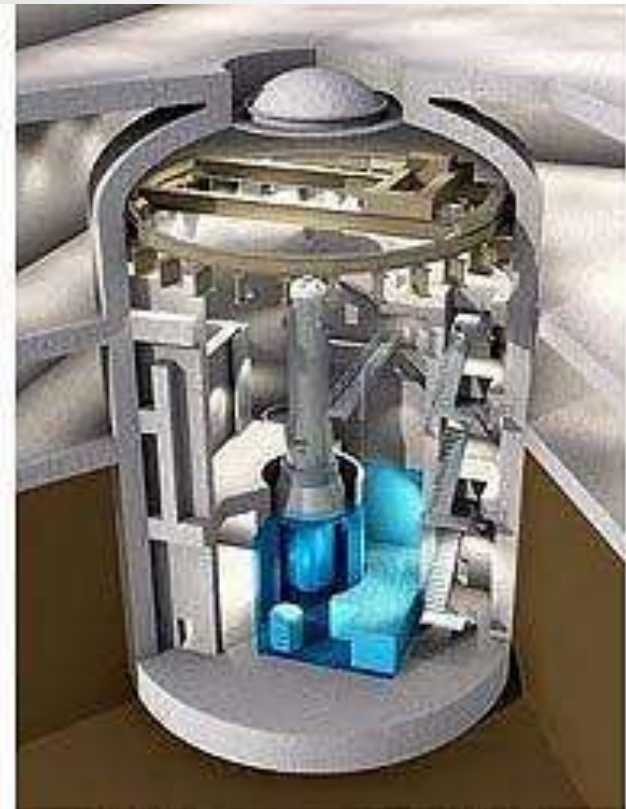
By Avery Thompson Oct 18, 2016

- Scientists working at MIT's Alcator C-Mod experimental fusion reactor have broken the world record for fusion pressure.
- This pressure brought the plasma to a temperature of 35 million C, close to the threshold of 50 million C needed commercial fusion power.

Small Modular Nuclear Reactors (SMR): US to develop 50-MW SMR's in next 10 years

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Detailed Report:

<http://trade.gov/publications/pdfs/the-commercial-outlook-for-us-small-modular-nuclear-reactors.pdf>

SOLAR PV TECHNOLOGIES

Increase in Solar PV Efficiency from 16% to 22%+: 40% more efficient PVs at lower cost

- **SolarCity** acquired: 1. '**Silevo**' (a start-up technology co.)
- '**Zep Solar**' (provider of solar panel mounting systems)
- '**Paramount Solar**' (a solar sales and marketing company)

The New York Times

(3 October 2015)



World record in PV module efficiency: 24.1%

27 June 2016



“SunPower's X-Series panel was tested by our lab. The module measured 11310.1 cm² (aperture area) and had a power of 272.5 W. We recorded 24.1% efficiency, which is a new record for silicon module efficiency.”

NREL, US DOE

- Crystalline silicon solar cells are said to have an **efficiency ceiling** of around 29%.
- Over the past year, **SolarCity, Panasonic and SunPower** have duked it over the efficiency crown with numbers in the **22% range**. (SunPower set the last mark at 22.8% earlier this year.)

<http://www.pv-tech.org/news/sunpower-lab-produced-solar-cells-used-in-24.1-module-efficiency-record>

<http://www.forbes.com/sites/michaelkanellos/2016/06/27/sunpowers-24-1-efficiency-mark-are-we-near-the-ceiling/#729581bc2be1>

PV tiles as roof:

Costs less than traditional roof

- “Looks better than a normal roof, lasts twice as long, costs less and generates electricity.”
- Made of textured glass and are virtually indistinguishable from high-end roofing products.



(Nov. 18, 2016)

Energy generating bendable glass: Skyscrapers as electricity generators

- Will turn skyscrapers into green 'vertical power generators'
- Super thin, bendable 'glass veneer' that can be applied to skyscrapers, cars, or planes to produce electricity.



(Jan. 18, 2017)

80% efficiency increase in PVs with 3-D Nanotubes



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William Pentland

CLEAN BETA



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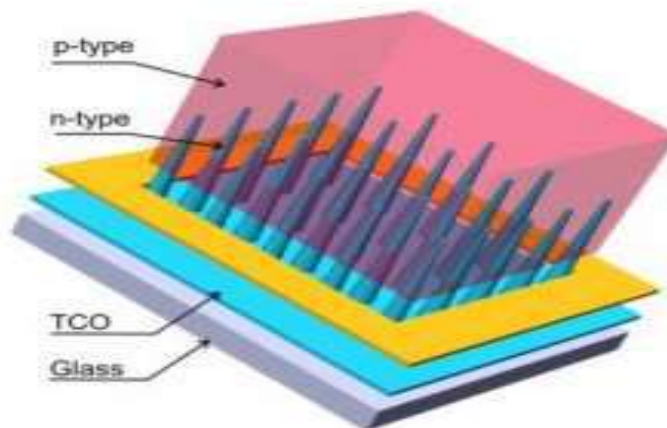
MY RSS FEED

ENERGY

Nanocone-Tips Take Solar Cell Efficiency to Next Level

May. 2 2011 - 3:58 pm | 1,751 views | 2 recommendations | 6 comments

Solar cells designed with 3-D nanocone tips can boost the light-to-power conversion efficiency of photovoltaics by a whopping 80%, according to research conducted at the U.S.



Department of Energy's [Oak Ridge National Laboratory](#).

50

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INNOVATION:

A New Product,
A New Process,
A New Business Model,
A New Service

SolarCity: A New Business Model to install PV

- There were more solar panels installed in the U.S. over the last 18 months than the last 30 years.
- NRG Energy wants to be as big or bigger than SolarCity in its residential solar financing and installation business, like that SolarCity founded in 2006.
- 2000 MW of solar power will be deployed by the end of 2014. SolarCity went public in 2012 at \$9.25 per share; now trading at about \$50 per share.

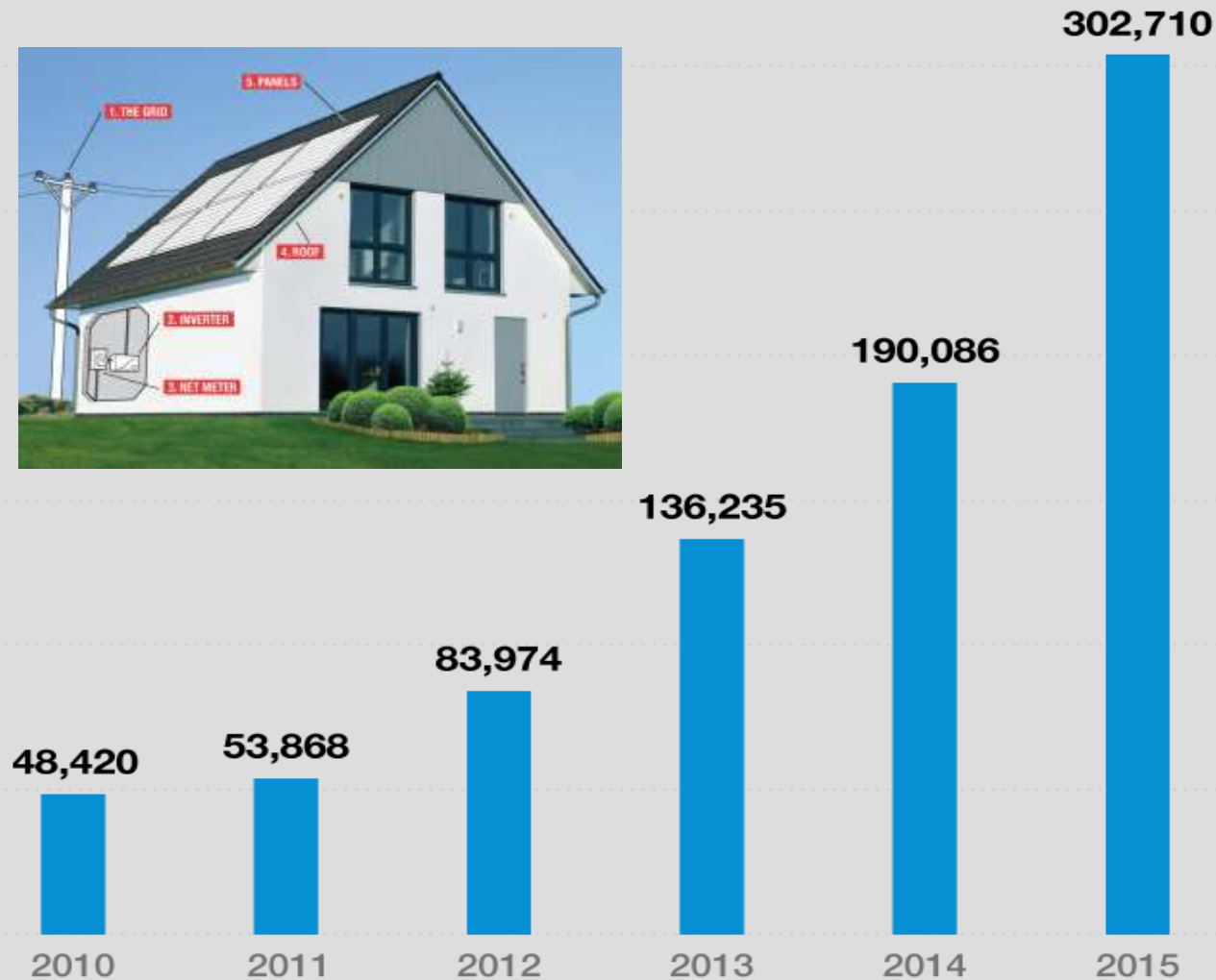


- SolarCity provides the upfront financing for the solar system; the customer doesn't have to put any money for the panels.
- Instead of paying 10s of thousands of dollars for a solar panel system, customer pays SolarCity for the cost of the solar energy monthly.

16 May 2014

Solar PV in the US: Rooftop Installations

ANNUAL U.S. RESIDENTIAL SOLAR PV INSTALLATIONS



30% Federal Tax break + State incentives.

Source: Source: Solar Energy Industries Association/GTM Research
© 2016 Consumer Reports. All rights reserved

Transformative (Disruptive) technologies: Home Electric Power Storage: Tesla Powerwall Battery

- **Backup power:** Store solar/wind/coal/nuclear electricity (on/off grid).
- **Load shifting:** Bank grid electricity from non-peak periods and use it during peak times to save money (California: \$0.35/kWh peak; \$0.08/kWh off-peak).
- **Balance grid load:** Charge up during non-peak energy usage hours, then provide energy during peak hours, serving as grid storage/balancing device.
- **Grid-independence:** Store excess solar power during daytime, use at night.
- **Emergencies:** Power homes during black-outs for a day or two.
- **GOAL:** To change the world (automotive industry, power sector, energy)
- **Energy storage industry:** Valued at \$200 million in 2012; expected to grow to \$19 billion by 2017.



Rechargeable lithium-ion battery

Size/weight: 130x86x18 cm; 100 kg

Storage: 7-10 kWh

Price: \$3000-\$3500

(Industrial: 100 kWh for \$25,000)

Installation: On walls

(inside/outside)

Charge/Discharge Efficiency: 90%?

IMAGINATION+TEAM FORMING+ENTREPRENEURSHIP= SUCCESS

Game Boy (Nintendo, Japan)+Tetris (USSR)+H.Rogers (USA)



THINKING BIG!

Game Boy w/Tetris sold 35 million units the 1st year (1989)

Flour+ Sugar + Oil ≠ Halva.

Need the **imagination** to visualize the HALVA in the ingredients + **entrepreneurship** to take the product to market place.

- In 1984, [Soviet Academy of Sciences](#) ([Alexey Pajitnov](#) et al) developed [Tetris](#) out of a desire to create a two-player puzzle game. In 1988 computer game publisher [Henk Rogers](#) noticed the game at the [Las Vegas Consumer Electronics Show](#).
- Rogers pursued the rights for the game, and knowing Nintendo planned to release the Game Boy, approached [Nintendo of America](#) with the suggestion that *Tetris* was the perfect title to be packaged with the handheld as it would sell it to everyone, not just young boys.

Video Games for Education

Wednesday, January 18, 2012



MIT to build educational video games with \$3M grant

By Michelle Lang

Sponsored Video



MSFT Wedding Tech?

The MIT Education Arcade plans to create a massively multiplayer online game (MMOG) as a tool to help high school students learn math and biology. The game is funded by a \$3 million grant from the Bill & Melinda Gates Foundation.

The MMOG is expected to use task-based assessment strategies that will show teachers what kind of progress a student is making on a given subject.

"This genre of games is uniquely suited to teaching the nature of science inquiry because they provide collaborative, self-directed learning situations," Eric Klopfer, MIT associate professor and director of the Education Arcade and the Scheller Teacher Education Program, said in a statement. "Players take on the roles of scientists, engineers and mathematicians to explore and explain a robust virtual world."

Klopfer, the creator of the StarLogo TNG gaming education platform, and his team will work with Wisconsin games production studio Filament Games to create the game. Some Boston students and teachers will conduct pilot testing of the game this spring, MIT noted in a press release.

Related News

[MIT Energy Lab founder David White dies](#) [January 19, 2012]

[Stryker Biotech agrees to pay \\$15M in federal lawsuit](#) [January 19, 2012]

INNOVATION:

A New Product,
A New Process,
A New Business Model,
A New Service

US Economy (World's Largest):

Impact of Service Industries (~80% of GDP & Labor)

- **GDP** (2014): \$17.7 trillion (1st in the world).
- **GDP per capita** (2013): \$53,000; 9th (nominal), 10th (PPP)
- **Average gross salary** (2012): \$55,050
- **Labor force by occupation** (2012):
- Goods-producing (except agriculture): 12.6
(**Manufacturing: 8.2**, Construction: 3.9, Mining: 0.6)
- **Services-providing: 79.9**
- Agriculture (+forestry, fishing, hunting): 1.5
(Nonagriculture self-employed+unpaid family worker: 6.1)
- **Exports** (2014): \$2.34 trillion;
- **Imports** (2014): \$2.74 trillion
- US is the world's **2nd largest manufacturer.**
- Ease of doing business rank (2014): 7th
(Turkey: 55th)

USA: GDP by sector (2013):

- Agriculture: 1.1%,
- Industry: 19.5%,
- **Services: 79.4%**

Colombia: GDP by sector:

- Agriculture: 7%,
- Industry: 34%,
- **Services: 59%**

Service sector or service-providing industry:

All industries except those in the goods-producing sector like agriculture, mining, construction, and manufacturing.

'Service' Innovation (alternative to sell SONGs): iTunes Music Store by Steve Jobs (2003)

iTunes Store, 2003 - 2013:

- 25 billion songs sold
- 40 billion downloads



- In 2003, the shift to digital music had started. But no solutions existed for users to drop their **CDs** and **pay for mp3s**. It was a complex world of **digital right management** and **limited online music portfolios**.
- **28 April 2003** – Apple launches the iTunes Music Store with **200,000 songs** at **99¢** each (after 1 year, it offered **over 1 million songs**).
- Over **1 million songs** are sold the first week.
- It changed the music industry and the way people get their music forever.

Innovation in Software: Facebook (A new service)

"Facebook Class" Helped Pioneer Lean Start-Up Model

- [New York Times](#) (May 7, 2011) reported on the "Facebook Class," a class of Stanford students in 2007 who were asked to design and market a Facebook app.
- Some of the projects were wildly successful and "almost overnight, the Facebook Class fired up the careers and fortunes of more than two dozen students and teachers."
- The class "also helped to pioneer a new model of entrepreneurship that has upturned the tech establishment: the lean start-up."
- Students learned, among other things, to keep their ideas simple and expedient, while venture capitalists began designing funds designed for this low-cost approach.
- Working in teams of three, the 75 students created apps that collectively had 16 million users in just 10 weeks. Many of those apps were sort of silly: Mr. De Lombaert's, for example, allowed users to send "hotness" points to Facebook friends. Yet during the term, the apps, free for users, generated roughly \$1 million in advertising revenue.

UBER (vs TAXI): Connecting Drivers w/Riders via Apps



- **Founded: 2009 in San Francisco (USA)**
- **Service: 60+ countries, 404 cities**
- **Value: \$62.5 billion (2015)**
- **Product: Apps for smartphones**
- **Rank: 48th Most Powerful company (2014)**
- **Revenues (in \$billions): 0.7b (2013), 2.9b (2014), 10b (2015)**

Redefining 'Shop' (A New Model for 'Service'): Amazon.com: World's Largest Shopping Center



Your Amazon.com Today's Deals Gift Cards Help

Shop by Department

Search All

Go

(E-commerce)

- **Founded:** 1994 (Seattle, USA)
- **Products:** Online retailing, Kindle, ...
- **Revenue (2013):** \$75 billion
- **Employees:** 117,000
- **Sales:** The World



Launch partners



kindle
paperwhite

The world's most advanced e-reader \$119 > [Order now](#)

Sports & Outdoors
Automotive & Industrial
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What Other Customers Are Looking At Right Now



Turkey's Largest Flowershop: Çiçek Sepeti



En Hızlı Çiçekçi Çiçek Sepeti

mizu

Artık Sizlerle...

Sipariş Takip

Üye Girişi

Üye Ol

İletişim



Facebook ile Bağlan

Arama



Gönderime Göre

Çiçek

Gurme

Hediye

Meyve

Takı

Şehir Seçiniz



**Biricik Aşkıınıza
Romantik Bir Sürpriz Yapın!**

Yazın Neşesi Kırmızı Gül



Kurumsal siparişleriniz



Innovative Business Model in Food: Yemeksepeti: The Largest 'Kitchen' of Turkey



Dünyanın en büyük online yemek sipariş platformu **Delivery Hero**, 2000'de kurulan **Yemeksepeti**'ni **\$589 milyona** satın aldı.

Delivery Hero (3 milyon euro sermaye ile 2001'de Berlin'de kuruldu):

- 28 ülkede faaliyet
- 100.000+ restoran network
- 1.500 çalışan

5 Mayıs 2015



INNOVATION IN FOOD ENGINEERING: KFC



- World's largest chain of fried chicken restaurants. 2nd largest restaurant chain after McDonalds's.
- Founder Colonel Harland Sanders first gave the world a taste of his most famous creation, Original Recipe Kentucky Fried Chicken, featuring a secret blend of 11 herbs and spices.
- After a lot of experimenting in 1939 with a pressure cooker by varying cooking time, pressure, shortening temperature and level, he developed a process to fry chicken quickly under pressure with great taste.

Founded: 1930 in Kentucky by Harland Sanders

Franchise: 1952, Utah

Number of locations: 17,000 in 105 countries

Employees: 455,000 (2010)

Revenue: US\$ 9.2 billion (2011)



HEALTH as an EXPORT COMMODITY (Turkey)

\$20 billion/year (2023)

Aksam.com.tr - 29.10.2012, 12:01

AKSAMLAR
GÜNCEL YAŞAM EKONOMİ DÜNYA SPOR MAGAZİN SAĞLIK EMLAK TEKNOLOJİ Dİ

Kaynak: <http://www.aksam.com.tr/yabancilar-sifa-icin-geliyor-yilda-1-milyar-lira-birakiyor--146684h.html>

29 Ekim 2012 Pazartesi - Akşam | EKONOMİ



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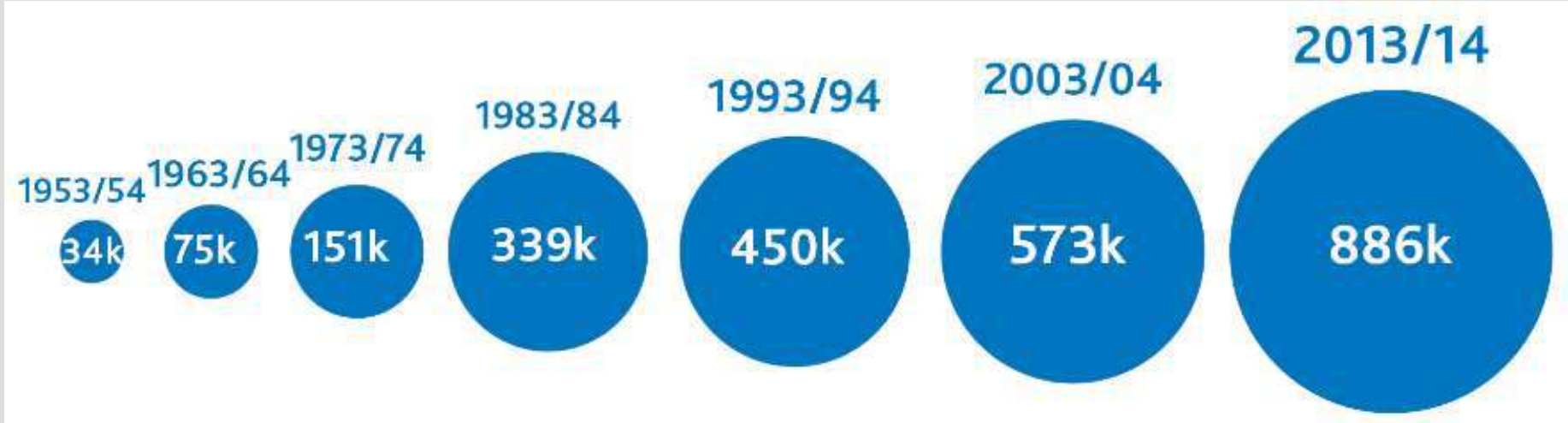
Yazdır

E-mail olarak gönder

Yabancılar 'şifa' için geliyor yılda 1 milyar lira bırakıyor

Sağlık Bakanlığı verilerine göre, Türkiye'ye gelen hasta sayısı 150 bine yükseldi, bunlardan yıllık elde edilen gelir, 1 milyar liranın üstüne çıktı. Türkiye'nin 2023 vizyonundaki hedef 1 milyon sağlık turisti ve 20 milyar dolar gelir...

EDUCATION as an EXPORT COMMODITY (USA)



USA, 2014-2015 Academic year:

1 million 130 thousand foreign students (4% of total univ students)
\$35 billion/year

In Turkey:

70,000 foreign students

- China (331,000), India (146,000) and S. Korea (87,000) account for half of foreign students in US.
- Univ. Southern California, Colombia U, New York U each had over 10,000 students.
- Americans studying abroad was 289,000. Most popular destinations: UK, Italy, Spain, France, China.
- US is the #1 choice of the world's 4.5 million international students (twice that of UK).

TEAM WORK

R&D Team to Improve Batteries for Electric/Hybrid Cars

Chicago Tribune
CHICAGOLAND

Home | News | Business | Sports | A&E | Lifestyles | Opinion | Real

December 1, 2012

Argonne National Laboratory selected to lead national research on super-efficient batteries



<http://www.car-battery-research-20121130,0,7799993.storychicagotribune.com/news/local/sns-ap-il-->

By Associated Press

3:04 a.m. CST, December 1, 2012

The US Department of Energy chose Argonne to lead the effort after a national competition. The lab will receive up to **\$120 million over 5 years.**

Other members for the new '**Joint Center for Energy Storage**' include:

- **5 universities** (Northwestern, U. Chicago, U. Illinois-Chicago, U. Illinois-Urbana Champaign, U. Michigan)
- **4 national labs** (Lawrence Berkeley, Pacific Northwest, Sandia, SLAC National Accelerator Lab)
- **4 industrial partners** (Dow Chemical, Applied Materials, Johnson Controls, Clean Energy Trust).
- **120 individuals** working on battery technology around the country will visit the Argonne hub on a regular basis.
- **Goal:** To **license the inventions** fostered there for commercialization.
- A breakthrough in battery technology would have **major implications for the auto, wind and solar** industries.

BMW, Toyota Partner On Next-Generation Batteries



The image is a screenshot of a Fox News website article. At the top left is the Fox News logo with the tagline 'Fair & Balanced'. To the right is a search bar and a '9a' logo. Below the search bar is the URL: <http://www.foxnews.com/leisure/2013/01/24/bmw-and-toyota-team-up-on-sports-cars-battery-development/>. A navigation menu includes 'Home', 'Video', 'Politics', 'U.S.', 'Opinion', 'Entertainment', 'Tech', 'Science', 'Health', and 'Travel'. Below the menu is the date 'January 24, 2013' and links for 'Real Estate' and 'Recipes'. The main headline reads 'BMW and Toyota team up on sports cars, battery development'. Below the headline is the publication information: 'Published January 24, 2013 / Associated Press'. At the bottom of the screenshot is a photograph of two men shaking hands in front of a backdrop featuring the logos for Toyota, BMW Group, BMW, MINI, and Rolls-Royce.

Toyota Motor Corp. and BMW Group are working together on next-generation batteries for green vehicles called 'lithium-air' as their collaboration, first announced in late 2011, moves ahead in fuel cells, sports vehicles and other fields."

Toyota and BMW "aim to complete a fuel-cell vehicle system by 2020, and a concept for a mid-size sports vehicle by the end of this year. They will also work together on developing lightweight technologies such as composites, which will help make cars greener.

Joint R&D in Hydrogen Cars by Ford, Daimler, Nissan

San Francisco Chronicle
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January 28, 2013

SFGate
Tuesday Jan 29, 2013 5:50 AM PT

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Mostly Cloudy
Today 48/61 Wed. 48/63 5 Day Forecast

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Ford, Daimler, Nissan to research hydrogen cars

By TOM KRISHER, AP Auto Writer
Updated 6:57 am, Monday, January 28, 2013

0 0 0

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DETROIT (AP) — Ford is joining with Daimler and Renault-Nissan to speed development of cars that run on hydrogen, with hopes of bringing a vehicle to market in as little as four years.

Ford is joining with Daimler and Renault-Nissan to speed development of cars that run on hydrogen, with hopes of bringing a vehicle to market in 4 years – by 2017.

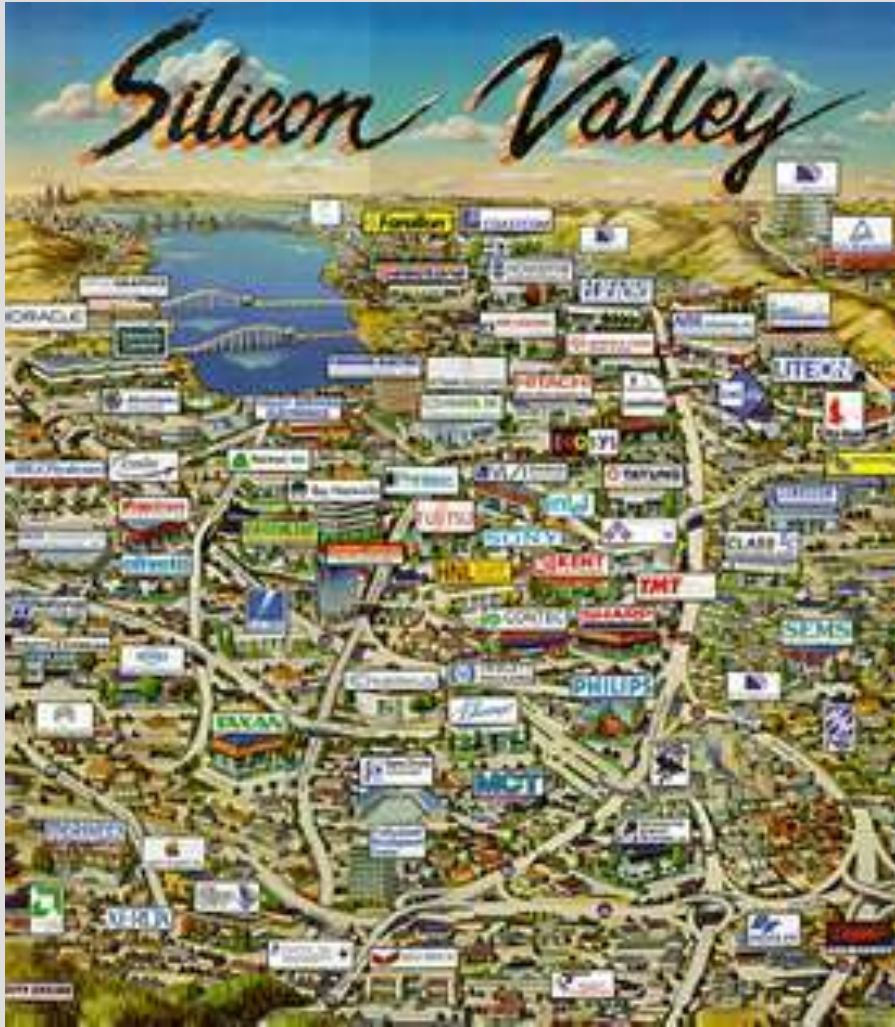
- Each company will invest equally in the technology. The companies will use the common fuel cell system developed to power their own vehicles.
- Ford: "Working together will significantly help speed this technology to market at a more affordable cost to our customers."
- "We will all benefit from this relationship, as the resulting solution will be better than any one company working alone."

Football Teams – No National Boundaries



ALTERNATIVE INNOVATION

BRAINPOWER FIRST: SILICON VALLEY



- **Silicon Valley** is just the ground of brain power and creative thinking, not the source.
- Silicon valley is merely the field where the **orchards of creativity** that blossomed in the garages of houses are **planted**.
- “Knowledge and skills now stand alone as only the source of comparative advantage. **Silicon Valley and Route 128** are where they are, simply because that is where the brain power is.”
 - Lester Thurow, MIT Economist

“In the U.S. immigrants have founded 52% of Silicon Valley’s companies and created millions of jobs.” ([Vivek Wadhwa](#), Washington Post, Oct. 4, 2011).

Going Where the Action is/Brains are: Samsung launches Silicon Valley incubator



<http://venturebeat.com/2013/07/12/samsung-launches-silicon-valley-incubator/>

July 11, 2013

- Samsung opened the doors of a **startup** and **entrepreneurship incubator/accelerator** nestled in the heart of **Silicon Valley**.
- Samsung will also open a new **Samsung Strategy and Innovation Center** in Palo Alto, and **incubators** in other **tech hubs** such as **New York, Austin, Boston, Russia, and Israel**. Samsung Ventures America is a \$1 billion fund.

Investing in Start-Up Companies: Samsung Invests \$18M in Israeli Firm on Fast-charging

Aug 19, 2015



- [StoreDot](#), an Israeli startup that makes ultra-fast charging batteries using bio-organic technology, has raised \$18 million for electric car batteries.
- StoreDot's goal is to build the "first ever instantly-charging car prototype" (**charging in 5 minutes**).
- Another goal: to fully charge a **smartphone in 30 seconds**.
- Samsung and LC Chem ARE EV Battery manufacturers.

Investing in Start-Up Companies: FORD invests \$1 billion in 'self-driving car' firm

Feb 10, 2017



- Ford is investing **\$1 billion over 5 years** in the artificial intelligence (AI) startup ARGO to further the development of **autonomous vehicle** technology.
- Ford working to develop a new software platform for its fully autonomous vehicle, expected in **2021**. It could **also license the software** to other carmakers.

Investing in where Brains are: Chinese Companies Invest in US R&D Labs



HUAWEI

ZTE TECHNOLOGIES



Humanwell

- In the US, there are over **800,000 people** with research doctoral degrees in science, engineering, and health.
- Annual flows of Chinese FDI into US was **\$14.3 billion in 2013** and **\$11.9 billion in 2014**,
- **Huawei** is a world leader in producing telecommunications equipment and has **6 U.S. research centers**.
- **German** companies extracted 1,416 patents in 2014 using U.S. researchers.
- Investment by Chinese companies in U.S. research labs is yielding a fast-growing trove of patents, part of a push to **mine America for ideas** to help China shift from being the **world's factory floor** to a **driver of innovation**.

June 22, 2015

A Short Cut to Becoming a World Brand-Name: BUY a World Brand (IBM); BECOME a World Brand (LENOVO)



- Founded (as Legend): 1984 (Beijing)
- Headquarters: Morrisville, NC (USA)
- Products: PC, Notebook, Tablet, ...
- Revenue (2013): \$34 billion
- Employees: 35,000
- Operations: 60+ countries
- Sales: 160 countries

- In 2013, Lenovo was the World's largest PC vendor by unit sales.
- Lenovo acquired IBM's Personal computer business in 2005 for \$1.8 billion; instantly became the world's 3rd largest computer maker.
- Entered the **smartphone** market in 2012; the largest vendor in China.
- Acquired the mobile phone maker Motorola Mobility from Google in 2014.
- 58% of Lenovo stock is held by the general public (2011).
- Lenovo's official language: English

Acquisitions: Quick Access to Technology

CNET › News › Microsoft › Microsoft to acquire Nokia's device and services ...

Microsoft to acquire Nokia's device and services division

As part of \$7.2 billion deal, Nokia CEO Stephen Elop will step down to become an executive vice president of the division.



by Steven Musil | September 2, 2013 8:25 PM PDT



- Microsoft will acquire Nokia's devices and services unit and license the company's mapping services in a deal worth \$7.2 billion in a bid to bolster the company's position in the smartphone market.
- The software giant will pay **\$5 billion** for "substantially all" of Nokia's phone unit and another **\$2.2 billion** to license its patents.

Quantum Computing: Performing calculations in Seconds instead of Years



- The quantum computers that can be bought today are made by **D-Wave Systems** Inc.(Canada).
- D-Wave has raised US\$130 million from Goldman Sachs and others.
- Quantum computers use **qubits** as their most basic element. Instead of **zero-or-one bits**, a qubit can be 0, 1 or inbetween.

- Quantum computers, an **emerging technology** that aims to exploit the properties of subatomic particles to make **extremely complex calculations at unprecedented speeds**, attract the attention of major investors.
- **Goldman Sachs** Group Inc., **Royal Bank of Scotland** Group Plc, **CME Group** Inc. and **Guggenheim Partners** are evaluating quantum computing.
- **Microsoft and IBM** are developing quantum technologies to speed up software. China's Alibaba is forming a quantum computing lab.

Adding a Research Base in a US University

Toyota Teams up with U Michigan on Driverless Cars

April 2016



- In 2015 Toyota announced a **\$1 billion Advanced Projects Lab** in Silicon Valley to expand its research in autonomous driving and AI.
- **Univ of Michigan** is Toyota's 3rd university collaboration in the US after **Stanford** and **MIT** to try to advance its efforts in autonomous driving.
- Toyota also bought the **entire staff of Jaybridge Robotics** in Cambridge.

Toyota funds AI research for autonomous cars

\$50 million over 5 years to Stanford and MIT

Feb 2017



- Toyota is partnering with Stanford University and the Massachusetts Institute of Technology to research artificial intelligence and robotics in order to bring greater autonomy to Toyota cars.

Draining Brain from Top Research Universities: UBER Lures 40 Researchers from Carnegie Mellon U

May 2015



- Carnegie Mellon's **National Robotics Engineering Center NREC** is in crisis after 40 of its researchers and scientists have left to join Uber, as the car-hailing service aims to develop **driverless car technology**.
- **With no in-house capability**, the \$62-billion San Francisco company UBER went to the one place with enough talent **to build a team instantly**: NREC.
- Offered **double salaries** and **hundreds of thousands \$ in bonuses**.

Instant Presence in Worldwide Automotive Market: China Acquired VOLVO in 2010 for \$1.9b

- By acquiring Volvo, China's Geely got **instant presence in the U.S. market** as well as **decades' worth of engineering and manufacturing expertise** to use in its own cars.
- Geely focused on **increasing Volvo sales in China**, doubling them to 61,146 by last year.
- It aims to sell 800,000 vehicles in 2020 (200,000 in China, 120,000 in US, and the rest in Sweden and Europe).
- Geely **invests \$11 billion** for **3 new factories in China**, U.S. marketing campaign, and **SUV designed for US**.

1927 Founded

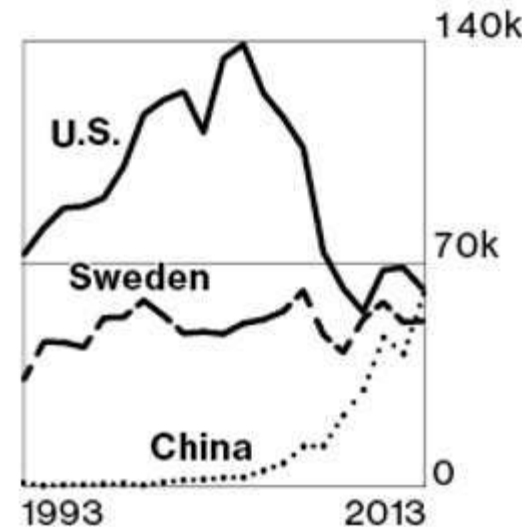
1999 Purchased (car division) by FORD for 6.45 billion USD.

2010 Purchased by Geely Automobile of China for \$1.8b.

Headquarters: Gothenberg, Sweden

No. Employees: 110,000

Volvo sales



Reversing the Brain Drain: Exploring Diaspora



Chinese Universities Send Big Signals to Foreigners

By LIZ GOOCH
Published: March 11, 2012

In the 1990s, Jeffrey S. Lehman, then the dean of the University of Michigan Law School, began visiting Beijing to help open a program for members of his faculty to teach at Peking University's law school during the summer.

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Given [China's](#) rising influence, he thought it would be beneficial for his colleagues to learn about legal education in China at one of the country's most prestigious institutions.

expect to work for a Chinese university himself.

But Mr. Lehman, who is also a former president of Cornell University, did not

-  RECOMMEND
-  TWITTER
-  LINKEDIN
-  SIGN IN TO E-MAIL
-  PRINT
-  REPRINTS
-  SHARE



ENGINEERING EDUCATION

FRUITS OF EDUCATION: Output-Based Approach



What distinguishes similar trees from one another are their fruits.



What sort of education program will yield the Engineer with desirable characteristics?

What kind of Engineering Education? = What kind of Engineer?

Paradigm Shift in Education

Teaching



OUT

Learning



IN

Classroom:

A place of directing to sources of knowledge and discussion; not a place of 'loading' knowledge.

Bologna process, MÜDEK, ABET 2000 Criteria:

- Learning how to learn,
- Lifetime learning,
- Output based education: skills gained, competencies acquired.

ABET 2000 (Student Outcomes): The Gold Standard in Engineering Education

- (a) an ability to apply knowledge of mathematics, science, and engineering
- (b) an ability to design and conduct experiments, as well as to analyze and interpret data
- (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- (d) an ability to function on multidisciplinary teams
- (e) an ability to identify, formulate, and solve engineering problems
- (f) an understanding of professional and ethical responsibility
- (g) an ability to communicate effectively
- (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- (i) a recognition of the need for, and an ability to engage in life-long learning
- (j) a knowledge of contemporary issues
- (k) an ability to use the techniques, skills, and modern engineering tools

Historical Perspective on Engineering (1922): 14 Essential Qualities of an Executive Engineer

1. **Judgment** – Reasoning ability, accuracy in conclusions, ...
2. **Initiative** – Alertness, imagination, originality, independence in thinking.
3. **Integrity** – Truthfulness, honesty, sincerity.
4. **Organizing Ability** – Systematizing, planning and delegating, ...
5. **Health** – Bodily vigor, good sight, hearing, etc., included.
6. **Perseverance** – Industry, ambition, concentration.
7. **Aggressiveness** – Energy, courage, domination of will.
8. **Open-Mindedness** – Reasonableness, openness to new ideas.
9. **Co-Operativeness** – Unselfishness, kindness, cheerfulness, tact, loyalty.
10. **Competitiveness** – Interest in playing the business game.
11. **Control of Emotions** – Freedom from outbursts of anger or touchiness.
12. **Refinement** – Courtesy, manners, general culture.
13. **Appearance** – Well-groomed appearance, pleasing facial expressions, ...
14. **Sense of Humor**

8 Key Competencies (for lifelong learning)

(European Parliament, 2006)

(Combination of knowledge, skills and attitudes, necessary for personal fulfillment/development, social inclusion, active citizenship and employment)

1. Communication in the mother tongue
2. Communication in foreign languages,
3. Mathematical competence and basic competences in science and technology.
4. Digital competence
5. Learning to learn
6. Social and civic competences
7. Sense of initiative and entrepreneurship (turn ideas into action).
8. Cultural awareness and expression

These key competences are all interdependent, and the emphasis is on critical thinking, creativity, initiative, problem solving, risk assessment, decision taking and constructive management of feelings.

2025 Graduates: 'Skill' rather than 'knowledge'



EDUCATION

What Colleges Will Teach in 2025

America must resolve the conflict between knowledge and know-how

The prevailing contemporary vision, even in the liberal arts, emphasizes action:

- active thought,
- active expression,
- active preparation for lifelong learning.

Engaging with a text or question, marshaling data and arguments and **expressing oneself** takes precedence over the acquisition of general knowledge.

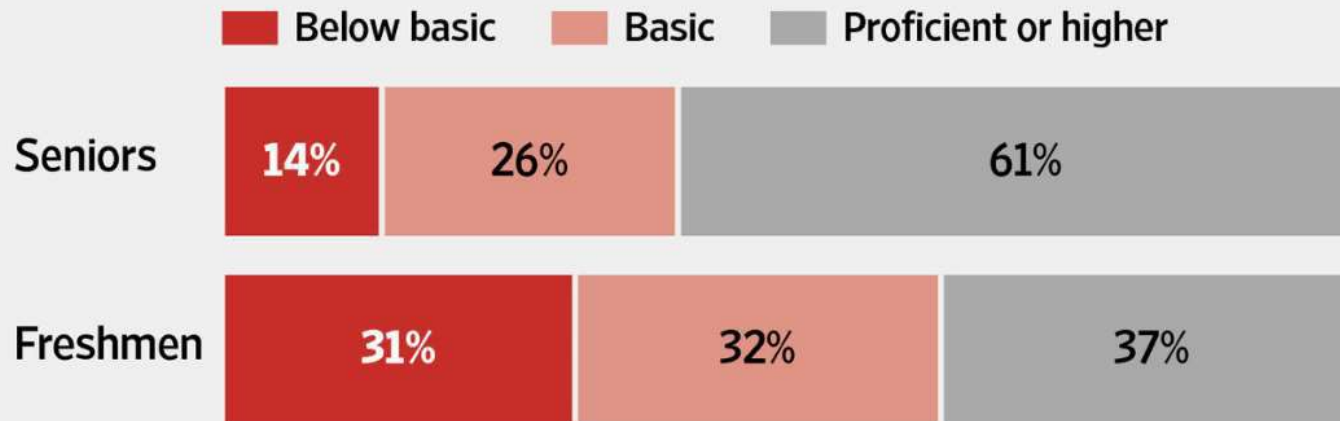
Survey: İşverenlerin yarısı **yetkin yeni üniversite mezunu** bulmakta zorlandıklarını ifade etmektedir.

Skill Assessment of College Graduates: Critical Thinking and Written Communication

Below Grade

19 Ocak 2015

Percentage of students scoring at each level in CLA+, an assessment designed to measure critical thinking and written communication



Note: Results based on 31,652 students at 169 participating institutions. Figures may total more than 100 due to rounding.

Source: Council for Aid to Education

The Wall Street Journal

- Test Finds College Graduates Lack Skills for White-Collar Jobs.
- 40% of Students Seen Ill-Prepared to Enter Work Force;
- Critical Thinking Key

- The CLA+ (Collegiate Learning Assessment Plus) exam measures the intellectual gains made between freshman and senior year. The test doesn't cover subject-area knowledge; rather it assesses things like **critical thinking, analytical reasoning, document literacy, writing and communication** — essentially mimicking the baseline demands for professionals. These are the skills that are important no matter what you are doing.

Less Than Half of UK Engineering Graduates Work in Industry

BBC

Mobile

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NEWS EDUCATION & FAMILY

September 8, 2011

Home UK Africa Asia-Pac Europe Latin America Mid-East South Asia US & Canada Business Health

8 September 2011 Last updated at 13:01 GMT

947

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Engineering graduates 'taking unskilled jobs'

By Katherine Sellgren
BBC News education reporter

Nearly a quarter of UK engineering graduates are working in non-graduate jobs or unskilled work such as waiting and shop work, a report suggests.

The study says it is "not easy or automatic" for qualified engineers to find related employment in the UK.

Employers and industry leaders have repeatedly raised concerns about a lack of good quality science and engineering graduates.



46% of 2009 engineering graduates were in jobs related to their degree six months after university

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<https://www.edx.org/>

30 Nov 2013

MOOCs (EdX and Coursera) in 2012: 2.5 Million Students

- Students who complete online courses receive an **honor certificate** based largely on trust that the student has completed the work on his own.
- Despite the overwhelming interest in MOOCs, the **potential for cheating** casts doubts on the credibility of the certificates issued.
- In response to such criticisms, edX has teamed up with PearsonVue, a computer-based testing group, to enable students to sit **real-world tests**.
- “Students will be able to go these **proctored sites** with their IDs, and take edX exams, and get a **proctored certificate**.”
- EdX online learning system is integrated with Pearson’s, so the student sits down and **take the exam online** on edX’s own software system.
- **Employers** are **increasingly interested** in tapping into databases of edX students who have shown the interest and attitude needed to complete **online courses on their own**.
- Anant Agarwal of MIT: **These certificates will become a universal, international currency**. Now students can parlay their certificates for advancement in their own companies and for jobs.”

CLOSING:
The Spirit of Entrepreneurship

Entrepreneurship is More Important Than Knowledge



Bill Gates (Microsoft: \$87 billion/yr, 2014)
2nd richest person in the world. Drop-out from Harvard pre-law. Wrote programs since grade school.



Steve Jobs (Apple: \$183 billion/yr, 2014)
Drop-out from Reeds College. In 1980s built the first graphic-based PC (Macintosh). Apple is the most valuable publicly traded firm in the world (\$700 billion).



Mark Zuckerberg (Facebook: \$13 billion/yr)
Drop-out from Harvard (Psychology and Computer Science). The youngest billionaire in the world.

Michael Dell (Dell: \$57 billion/yr, 2014)
Drop-out from University of Texas, pre-med. Started the Dell company when he was a student.

Lawrence Ellison (Oracle: \$38 billion/yr, 2014)
5th richest person in the world. Drop-out from Univ of Illinois.

But



These college drop-outs and their firms:

- Never hire college-dropouts;
- Hire the brightest graduates from the best universities;
- Many entrepreneur people hired by these companies quit their high-paying jobs and start their own company after a while.

An important note: These people did not succeed because they dropped out of college; they left college because they achieved success while they were still students.

LAST WORD

On Creativity and Innovation

“Everything that is really great and inspiring is created by the individual who can labor in freedom.”

- Albert Einstein, 1938

