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El Webinar de hoy es coproducido por la Sociedad de Química de México y
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1

¿Tiene alguna pregunta?

"¿Por qué he sido "silenciado"?

No se preocupe. Todo el mundo ha sido silenciado, excepto los presentadores y la moderadora. Gracias, y disfruten de la presentación.

Escriba y someta sus preguntas durante la presentación.

2

¿Está en un grupo grande hoy?

Díganos de dónde son ustedes y cuántas personas están en su grupo!

3

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Hoy tenemos representantes de 34 países

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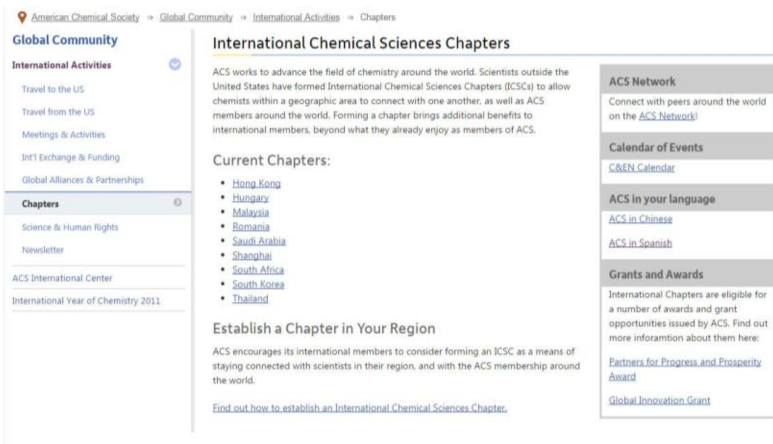
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ACS works to advance the field of chemistry around the world. Scientists outside the United States have formed International Chemical Sciences Chapters (ICSCs) to allow chemists within a geographic area to connect with one another, as well as ACS members around the world. Forming a chapter brings additional benefits to international members, beyond what they already enjoy as members of ACS.

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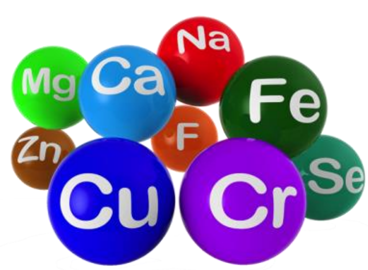
¿Has descubierto el elemento que falta ?



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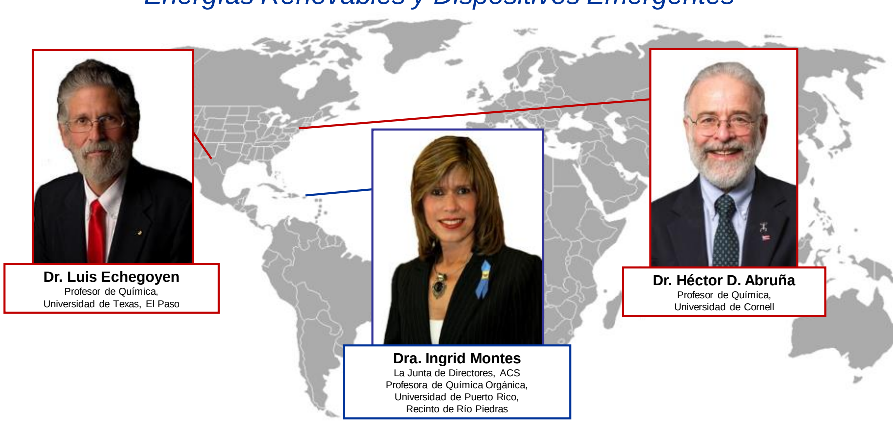
*"**Panorama Energético en la Era de la Sostenibilidad**:*
Energías Renovables y Dispositivos Emergentes"



Las imágenes de la presentación están disponibles para descargar ahora

http://bit.ly/WebinarEnergia

El Webinar de hoy es coproducido por la Sociedad Química de México y the American Chemical Society

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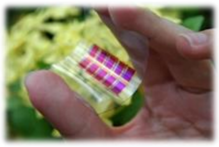
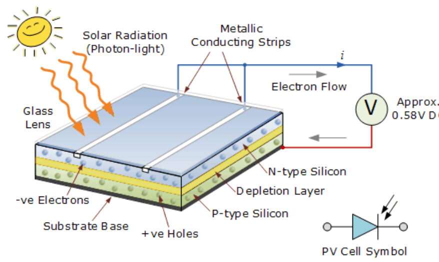
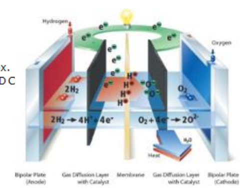
“Panorama Energético en la Era de la Sostenibilidad:
Energías Renovables y Dispositivos Emergentes”








Luis Echegoyen[1] y Héctor D. Abruña[2]

[1]University of Texas at El Paso y [2]Cornell University

ACS y SQM Webinar el 18 de Marzo de 2015

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Tópicos y Plan General

1. Problemas: Necesidades de Energía para el Futuro
2. Sostenibilidad
3. Energía Solar: Viabilidad
4. Células Fotovoltaicas: Tipos e Investigación Actual
5. Células de Combustible
6. Baterías y Condensadores

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Humanity's Top Ten Problems for the next 50 years

1. **ENERGY**
2. WATER
3. FOOD
4. ENVIRONMENT
5. POVERTY
6. TERRORISM & WAR
7. DISEASE
8. EDUCATION
9. DEMOCRACY
10. POPULATION

2004 **6.5 Billion People**
2050 **~10 Billion People**

Source: R. Smalley, DOE Nano-summit: Nano-scale science and our energy future

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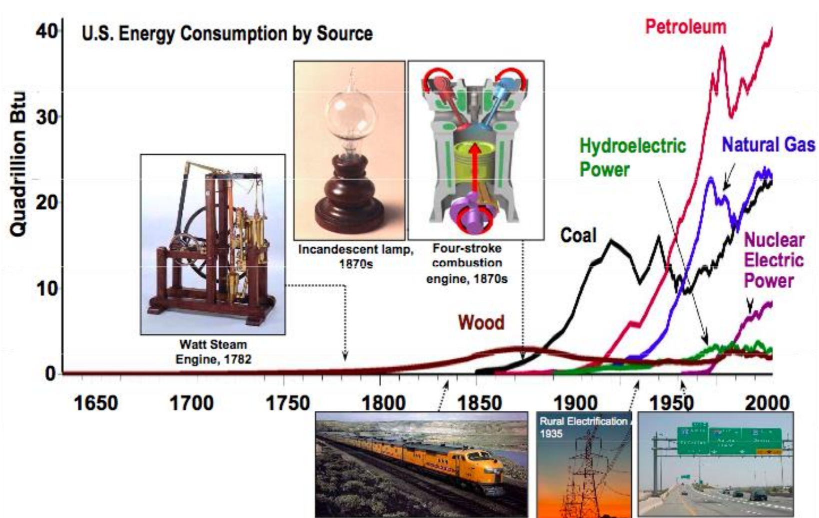
400 Years of Energy Use in the U.S.

19th C discoveries and 20th C technologies are very much part of today's infrastructure



Courtesy: H. Kung @ DOE

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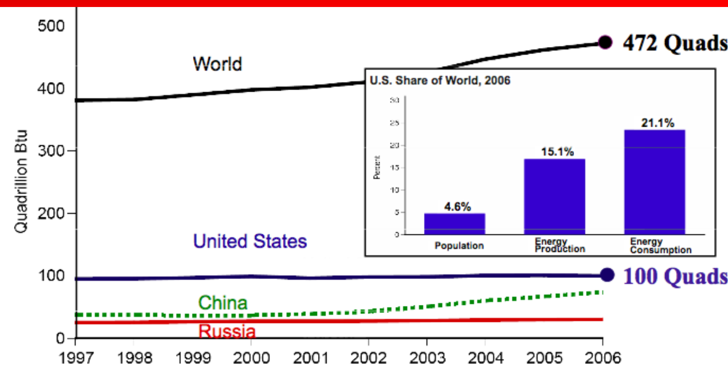
U.S. and World Consumption Today

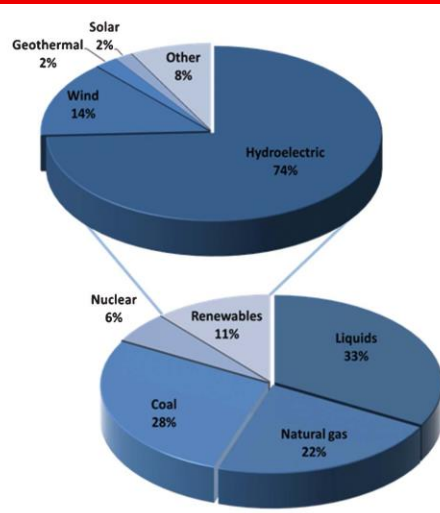
With <5% of the world's population, the U.S. consumes 21% of all the primary energy



By 2050 world energy needs will double!
Oil will be mostly depleted in next 50 to 60 years.
Need new energy sources and more efficient energy conversion & storage.
Must start to plan now! (Actually, we are already late.)

Courtesy: H. Kung @ DOE

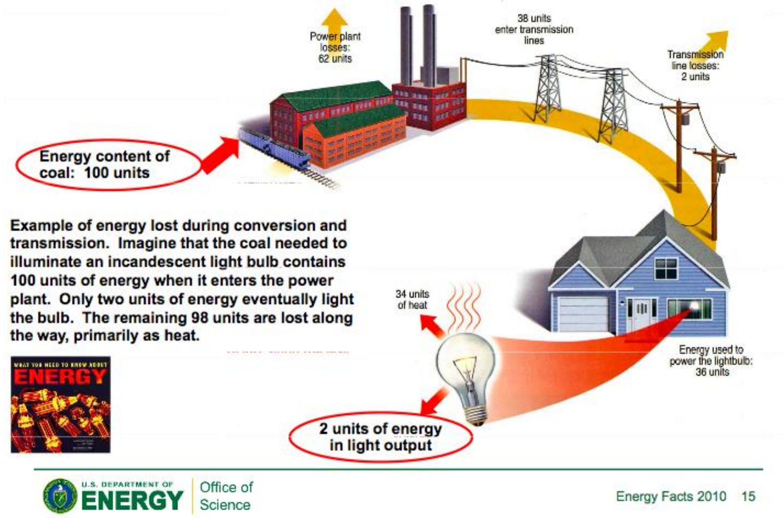
Energy Sources



Global energy consumption breakdown by energy source in 2013

Overall Efficiency of an Incandescent Bulb ≈ 2%

Lighting accounts for 22% of all electricity usage in the U.S.



Courtesy: H. Kung @ DOE

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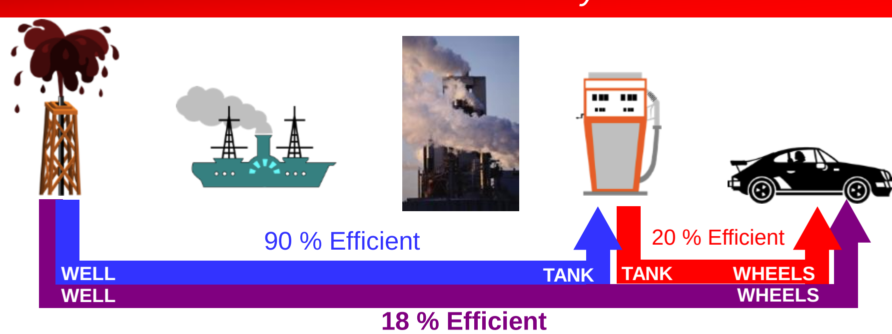
Oil Production and Efficiency:

"Well-to-wheels" Analysis



- Analysis based on CO_2 evolution very similar
- Automobile efficiency can be greatly improved
- Advanced combustion techniques will close some of the gap: improved transmissions, hybridization, materials, etc. also important
- Reaching efficiency of 30 % is very challenging, even with hybrids, unless significant breakthroughs occur

Source: ***Exxon Research***

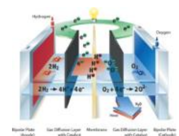
What options do we have?

- Increase use of renewables:
  - ❖ Solar
  - ❖ Wind
  - ❖ Tidal



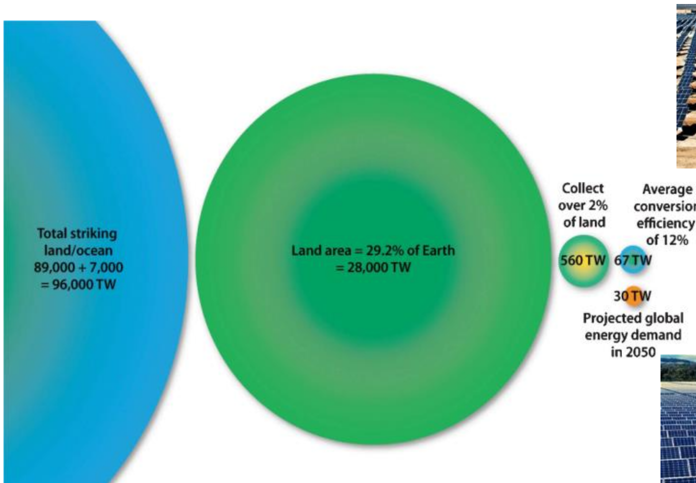
- Biomass/biofuels

- Reconsider nuclear fission?
- Nuclear fusion



- Employ more efficient energy conversion and storage devices
  - ❖ Fuel Cells
  - ❖ Batteries

Solar Energy

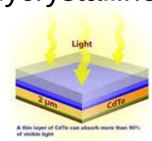


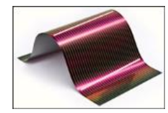
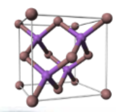

Rough approximation of technically feasible photovoltaic solar energy worldwide supply based on usage of 2% of land area and a power conversion efficiency of 12%

Solar Energy Cells – Photovoltaics (PV)

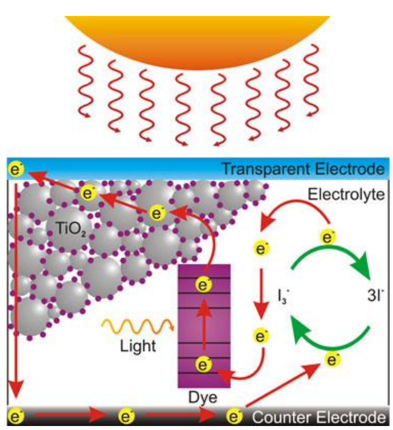
1. Silicon: Monocrystalline, Polycrystalline, Amorphous
2. Cadmium Telluride (CdTe)
3. Copper indium gallium diselenide (CIGS)
4. Gallium Arsenide (very high efficiencies but production issues)
5. Dye Sensitized Solar Cells (DSSCs)
6. Organic Photovoltaics (OPV)
7. Perovskite Solar Cells



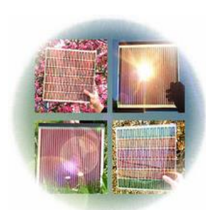
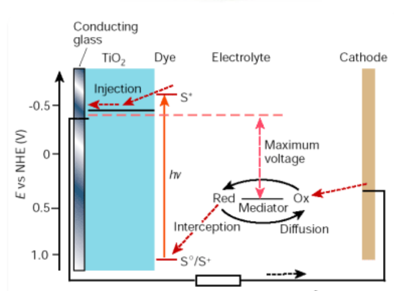



Dye Sensitized Solar Cells (DSSCs)



Maximum PCEs ~12%

▶ Ref: Grätzel, M. Nature 1991, 414, 338.

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Organic Solar Cells (OSCs)

Flexible, Potential to be Mass Produced, Light (25-50 g/m2), Better Global Energy Balance, Color Flexibility

Image retrieved from: http://**www.oled-display.net/files/u1/heliatek-solarcell.jpg** October 11, 2010

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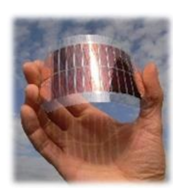
Bulk Heterojunction Organic Solar Cells (OSCs)

- The cell thickness is typically only 100 nm
- Flexible and lightweight
- Easy to manufacture, scalable
- Inexpensive
- **PCEs ~11%**

- ***Photoconversion Efficiency* (PCE):**

$$PCE = V_{\text{Open Circuit}} \times J_{\text{Short Circuit}} \times FF/P_{in}$$

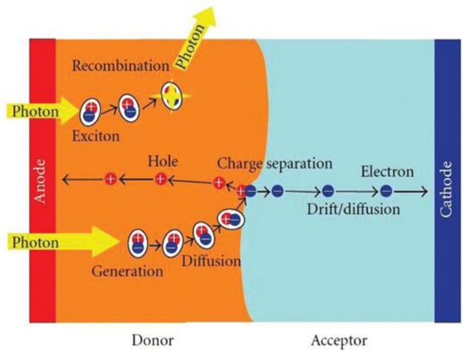


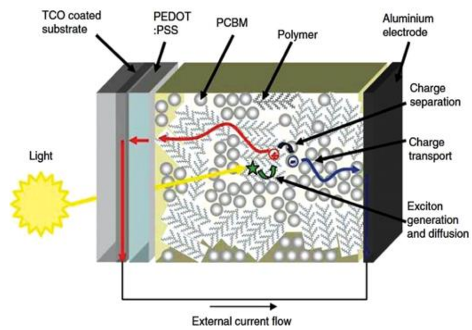
where P_{in} is the input power

24

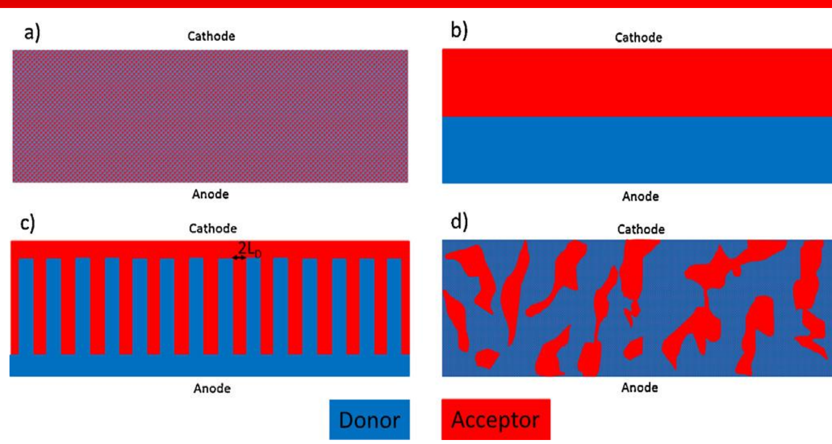
Bulk Heterojunction Organic Solar Cells (OSCs)

Charge transfer in bilayer and bulk OPV (organic photovoltaic) heterojunctions





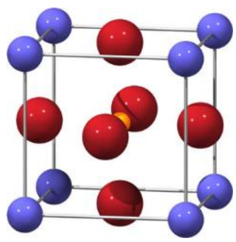
Bulk Heterojunction Organic Solar Cells (OSCs)



Schematic cross-section of nanomorphologies of bulk heterojunction solar cells. (a) Fine mixture of donor and acceptor molecules, (b) bilayer arrangement, (c) **ideal morphology of a bulk heterojunction solar cell** and (d) typical morphology of solution processed device

Perovskite Solar Cells

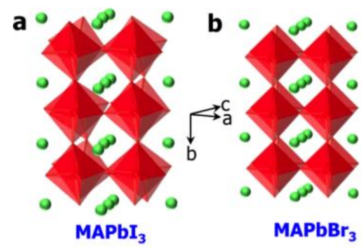
Perovskites (ABX_3): Structure modifications



ABX_3

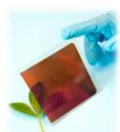
The only one used for PV:

$CH_3NH_3PbI_3$
$CH_3NH_3PbI_{3-x}Cl_x$



Metals: Fe^{2+}, Mg^{2+}, La^{3+}…
Organic molecules: methylamine, formamidinium

Oxides
Halides



Usually tetravalent metals: Sn, Ti, Ge
But also trivalent: Al, Cr, Ga

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Perovskite Solar Cells

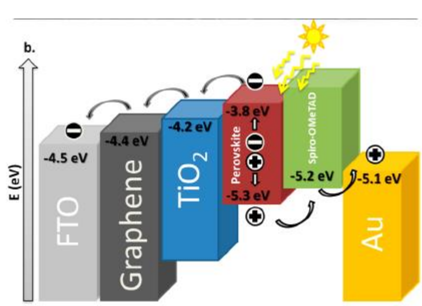
Methylammonium lead halide in photovoltaic devices

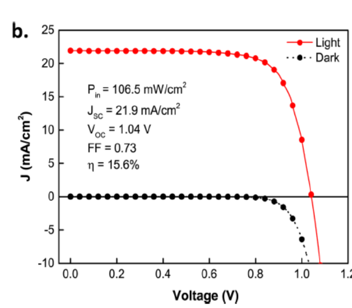
Low-Temperature Processed Electron Collection Layers of Graphene/TiO_2 Nanocomposites in Thin Film Perovskite Solar Cells

Jacob Tse-Wei Wang,[†] James M. Ball,[†] Eva M. Barea,[‡] Antonio Abate,[†] Jack A. Alexander-Webber,[†] Jian Huang,[†] Michael Saliba,[†] Iván Mora-Sero,[‡] Juan Bisquert,[‡] Henry J. Snaith,*[,†] and Robin J. Nicholas*[,†]

Current PCE Record = 20.1%!!

Nano Letters





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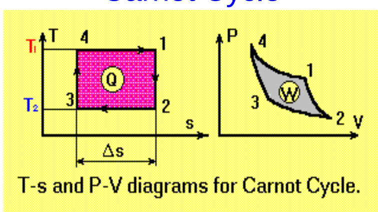
What is a Fuel Cell?

A Fuel Cell is a device which converts the chemical energy in a redox reaction directly to electrical energy.

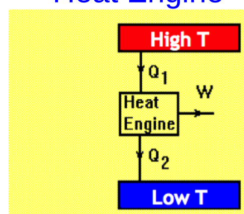
Why Fuel Cells?

In principle, a fuel cell can convert chemical energy to electrical (and thus mechanical) energy more efficiently than internal combustion (heat) engines or even turbines due to Carnot Cycle limitations of heat engines.

Carnot Cycle



Heat Engine



$Q_1 > W$, $Q_2 > 0$ **Thermal efficiency** $= T_h - T_c / T_h$

Internal combustion (cars and trucks): 20 – 25 % efficient
Electrical power generation: 35 – 40 % efficient (52% of US plants are coal fired)
Fuel Cells: 50 - 60 % even 90% or more, depending on type

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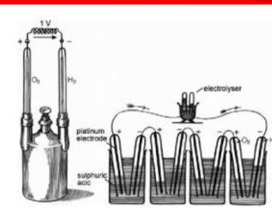
How Does A Fuel Cell Work?

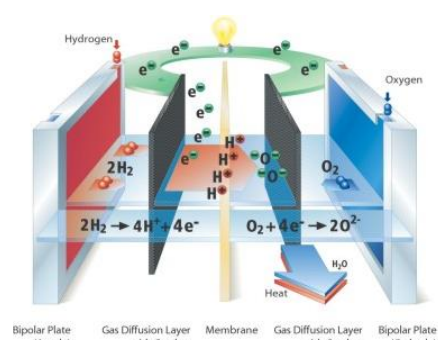
Sir William Grove 1839

A fuel cell physically separates the oxidation and reduction steps:

Oxidation: $2\ H_2 \rightarrow 4\ H^+ + 4\ e^-$
Reduction: $O_2 + 4\ H^+ + 4\ e^- \rightarrow 2\ H_2O$
Net: $2\ H_2 + O_2 \rightarrow 2H_2O$



Thus, two conducting electrodes are required for the collection/distribution of electrons – and an ionically conducting medium is needed to transport the ions from one electrode to the other



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Potential Markets

- Automotive

- Stationary Energy (buildings and houses)

- Consumer Electronics

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Challenges for Near Ambient Temperature Fuel Cells

- **Anodes:** So far emphasis on H_2. Need catalysts for renewable fuels such as ethanol. Mitigate "poisoning" by S, Cl and CO.
- **Cathode:** (oxygen reduction) Pt has slow kinetics leading to high overpotentials and 1/3 loss in efficiency.
- **Membranes are not durable**. Degradation during operation leads to loss in performance.
- **System costs are presently too high** by a factor of 5 to 10 depending on application; especially automotive.

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Energy Storage is a Key Need for the nation's Future

Achieving an electric fleet and storing energy from intermittent sources will not be possible without innovations in electrical energy storage.

- These applications place great demands on energy storage
- Higher energy and power densities
- Appropriate recharge rates
- Long life cycle
- Reliability
- Safety

US in 1900

1500 electric cars *vs.* **1000** ICE cars

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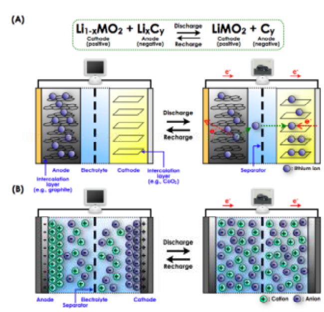
Two Major Types of Electrochemical-Based Energy Storage Devices

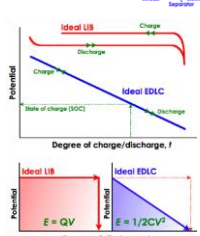
Batteries:

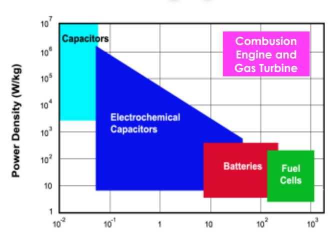
- Store energy in chemical reactants capable of generating charge
- High energy densities
- Many different varieties

Electrochemical Capacitors:

- Store energy as charge
- High power densities
- Sub-second response time







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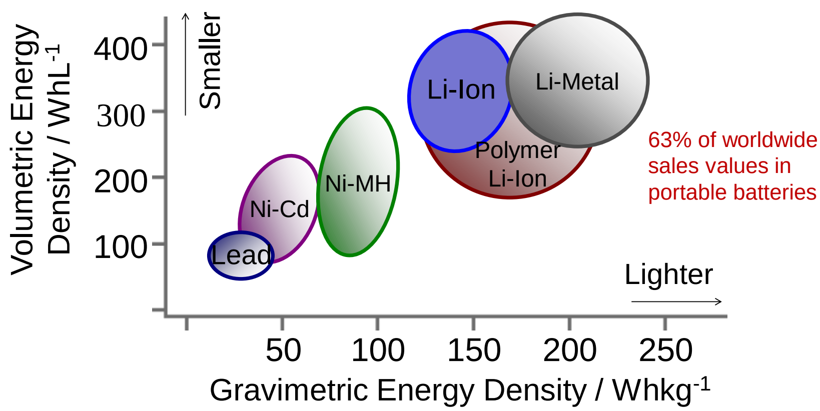
Energy Density for Secondary Batteries



J.-M. Tarascon & M. Armand, *Nature*, 414 359 (2001)

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Applications and Key Words for LIBs & Ultracapacitors

Mobile Electronic Devices

- Cell phone
- Laptop Computer
- PDA
- Portable Music Player

Power-Tools

HEV's and PEV's

KEY WORDS

High Power for intensity of use

- More positive redox potential
- Fast charge transfer kinetics

High Energy (High Capacity) for length of use

- More charge per weight/volume

Safety and Cost

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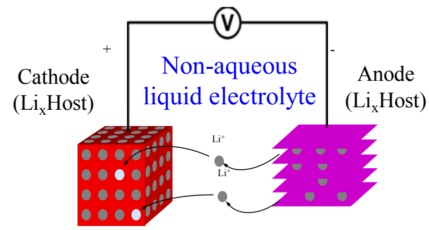
Limitations of Current Battery Technologies

- Increasing energy and power density without compromising safety or lifetime

ADVANCES WILL REQUIRE:

- Breakthroughs in materials and chemical processes
- Understanding of solid-electrolyte interface
- Control of charge transfer and transport



Rechargeable Li-ion battery schematic

“Charcoal Starter”

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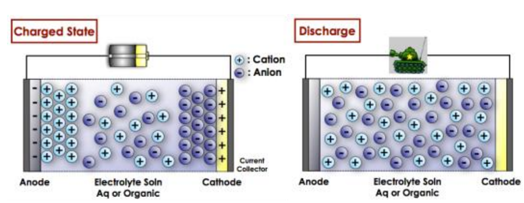
Limitations of Current Electrochemical Capacitors

- Increased energy densities
- Increased lifetimes; shelf-life (self-discharge) and cycles



ADVANCES WILL REQUIRE:

1. Understanding of charge storage mechanisms
2. Tailored multifunctional materials
3. New electrolytes

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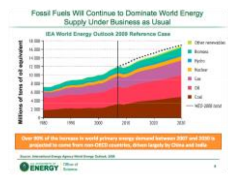
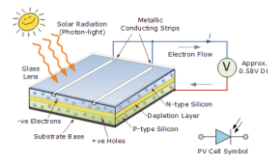
Conclusions and Outlook

Our current dependence on non-renewable (largely fossil) energy sources is unsustainable.

While for the foreseeable future we will still largely depend on non-renewable energy sources, we must, pave the way to rapidly transition to renewable, sustainable sources, especially solar.





We must transition to and integrate the use of high efficiency devices (compact fluorescence bulbs) and energy conversion (fuel cells) and storage (battery) devices.

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Additional Information

1. Sustainable Energy Without the Hot Air; David JC MacKay
2. Energy For Future Presidents; Richard A. Muller
3. Out of Gas; David Goodstein
4. Chemical Reviews, Vol. 104, #10, 2004; volume dedicated to fuel cells and batteries
5. Basic Research Needs For Electrical Energy Storage; DOE (2007)
6. Basic Research Needs for the Hydrogen Economy; DOE (2003)
7. Basic Research Needs for Solar Energy Utilization; DOE (2005)
8. Héctor D. Abruña; "Energy in the Age of Sustainability", *J. Chem. Educ.* (2013), 90(11), 1411-1413.

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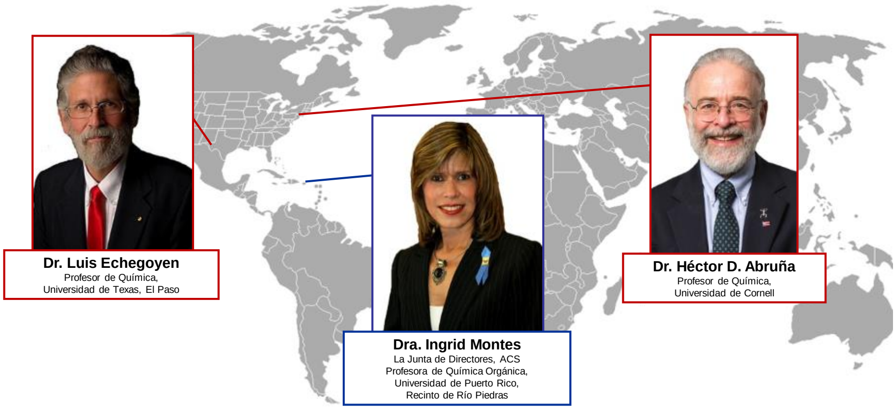
*"**Panorama Energético en la Era de la Sostenibilidad**:*
Energías Renovables y Dispositivos Emergentes"



Las imágenes de la presentación están disponibles para descargar ahora

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Sugieran temas y expertos que les interesarían para el próximo webinar.

El próximo webinar del ACS y la SQM será en Junio 2015.

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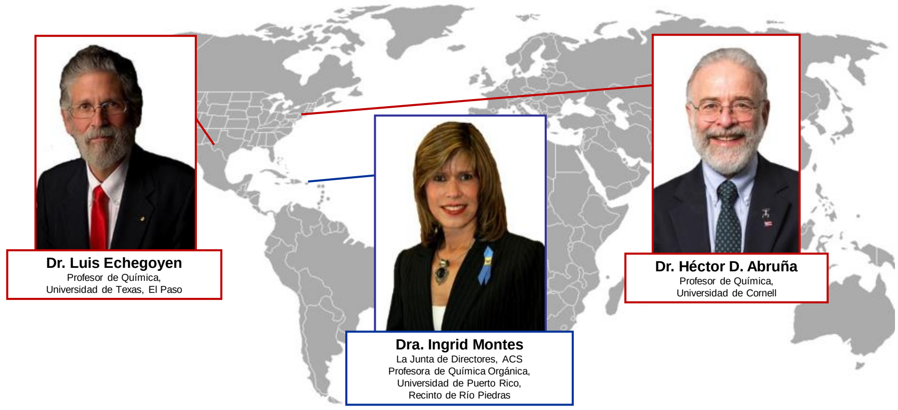

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El Webinar de hoy es coproducido por la Sociedad Química de México y the American Chemical Society

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La Diversidad de la Audiencia

Hoy tenemos representantes de 34 países

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Sociedad Química de México

La Sociedad Química de México, A. C., es una Organización Nacional fundada el 16 de marzo de 1956 y constituida el 27 de agosto del mismo año, por un grupo de ilustres químicos encabezados por los Químicos Rafael Illescas Frisbie y José Ignacio Bolivar Goyanes, los Ingenieros Químicos Manuel Madrazo Garamendi, Guillermo Cortina Anciola, y la QFB, María del Consuelo Hidalgo Mondragón.

http://www.sqm.org.mx

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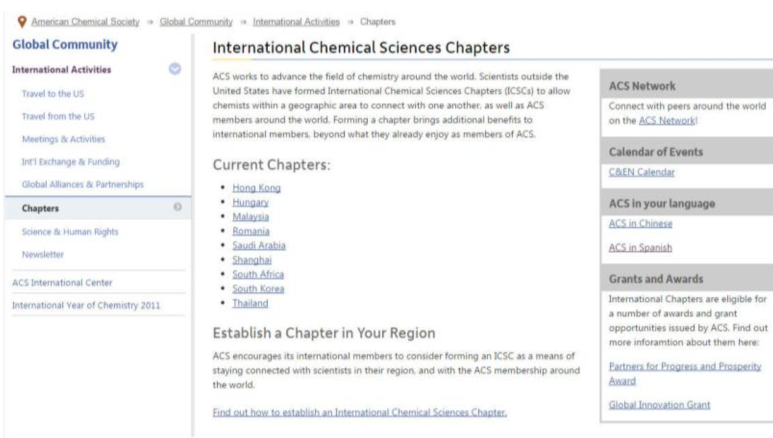
La Oficina de Actividades Internacionales



American Chemical Society → Global Community → International Activities → Chapters

Global Community

- International Activities
  - Travel to the US
  - Travel from the US
  - Meetings & Activities
  - Int'l Exchange & Funding
  - Global Alliances & Partnerships
  - Chapters
  - Science & Human Rights
  - Newsletter
- ACS International Center
- International Year of Chemistry 2011

International Chemical Sciences Chapters

ACS works to advance the field of chemistry around the world. Scientists outside the United States have formed International Chemical Sciences Chapters (ICSCs) to allow chemists within a geographic area to connect with one another, as well as ACS members around the world. Forming a chapter brings additional benefits to international members, beyond what they already enjoy as members of ACS.

Current Chapters:

- Hong Kong
- Hungary
- Malaysia
- Romania
- Saudi Arabia
- Shanghai
- South Africa
- South Korea
- Thailand

Establish a Chapter in Your Region

ACS encourages its international members to consider forming an ICSC as a means of staying connected with scientists in their region, and with the ACS membership around the world.

Find out how to establish an International Chemical Sciences Chapter.

ACS Network

Connect with peers around the world on the ACS Network!

Calendar of Events

C&EN Calendar

ACS in your language

ACS in Chinese

ACS in Spanish

Grants and Awards

International Chapters are eligible for a number of awards and grant opportunities issued by ACS. Find out more inforamtion about them here:

Partners for Progress and Prosperity Award

Global Innovation Grant

International Activities

www.acs.org/ic

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