Professional Considerations in Digital System Design

ENVIRONMENTAL AND PUBLIC POLICY CONCERNS

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OUTLINE

- Why study environmental concerns?
- Basic environmental questions
- Where do our raw materials come from?
- Production and manufacturing costs
- The consumer lifecycle
- E-waste and electronics recycling
- What can be done
- Case studies

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WHY STUDY ENVIRONMENTAL CONCERNS?

- Accreditation agencies (ABET) deem it an important part of all engineering curricula, including EE and CmpE
- Idea of “best engineering practice” – environmental factors are an important element of this
- Engineers have vast power to oversee the creation and development of designs and the environment, and thus have great responsibility to see to its care

“It is expected that commonplace practice of sustainable development and business practice will evolve over time, either by choice or catastrophe.” F. Splitt, Northwestern University

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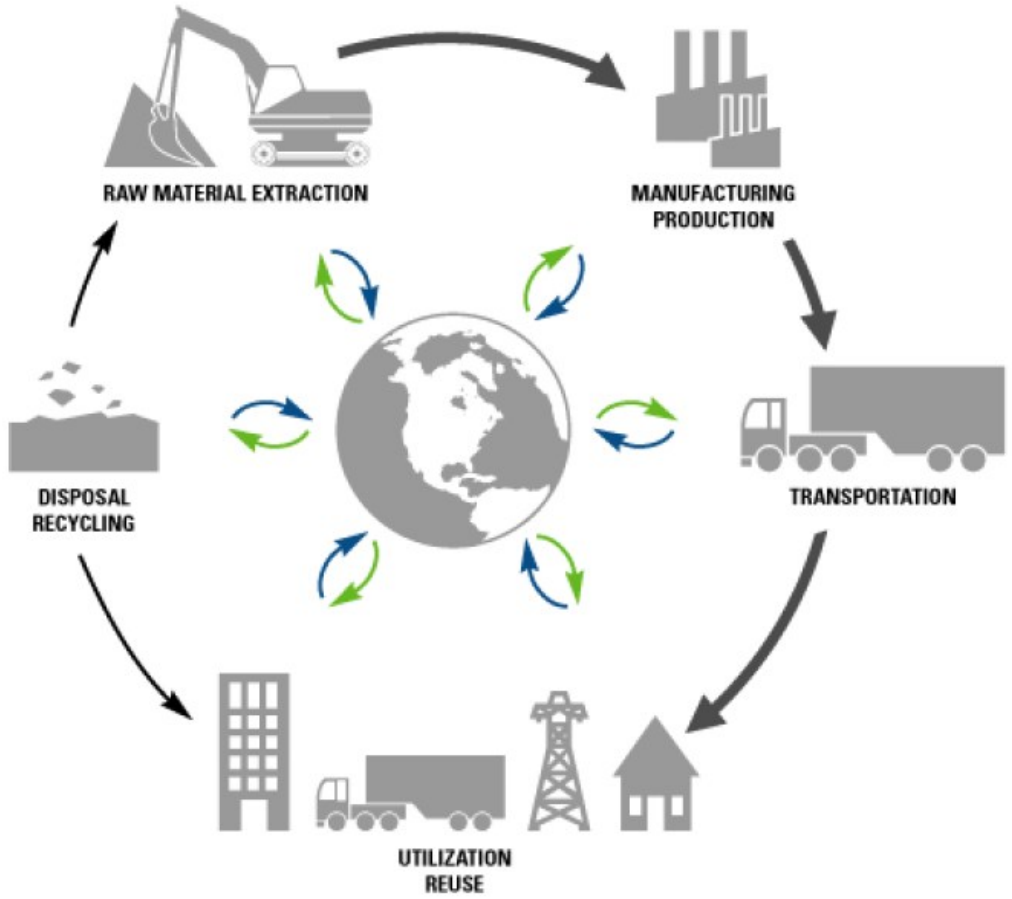
Accredited ABET Engineering Accreditation Commission

BASIC ENVIRONMENTAL QUESTIONS

- What are some of the environmental issues associated with the manufacture, use, and disposal of electronic devices?
- What obligation is there to lengthen useful lifetime of a product to the possible?
- What obligation is there to reduce the energy consumption of a product to possible?



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RAW MATERIALS

Indium

What it's used for: Transparent conductive coating for LCD panels, semiconductor applications, LEDs, anti-corrosion agent in batteries

Where it can be found: Extremely rare, occurs only in the form of indium mineral compounds, none of which are known to occur in significant deposits. Generally extracted from deposits of lead, tin, copper, iron, and zinc

Worldwide Production: ~600 tons

EOL Recycling Rate: <1%

Remaining known supplies: ~14 years

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RAW MATERIALS

Gallium

What it's used for: High-speed semiconductor devices, high-powered lasers. Gallium arsenide (GaAs) and gallium nitride (GaN) are most common variants, accounting for 98% of commercial use

Where it can be found: Extremely rare, occurs only in the form of mineral compounds which are themselves too rare to mine. Extracted as a trace element from bauxite (aluminum ore) and sphalerite (zinc ore).

Worldwide Production: ~300 tons

EOL Recycling Rate: <50%

Remaining known supplies: Significant, but require substantial mining to access

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RAW MATERIALS

Tantalum

What it's used for: High reliability tantalum capacitors, found in phones, computers, tablets, and other consumer electronics.

Where it can be found: Extremely rare, occurs in an estimated 1-2 ppm in the earth's crust. Primary sources include Australia, China, and central Africa. Tantalum mining is linked to warfare and thus Tantalum from these regions is considered a conflict mineral

Worldwide Production: ~1,600 tons

EOL Recycling Rate: ~25%

Remaining known supplies: < 50 years

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RAW MATERIALS

Lithium

What it's used for: Primarily used in batteries due to its low weight and high energy storage capabilities

Where it can be found: Rare, although can be extracted from seawater or mined from the earth's crust in trace amounts (~20 mg per kg of crust). Largest known source is the Salar de Uyuni (left) in Bolivia, containing 50-70% of known global lithium reserves

Worldwide Production: ~20,000 tons

EOL Recycling Rate: ~25%

Remaining known supplies:

< 100 years

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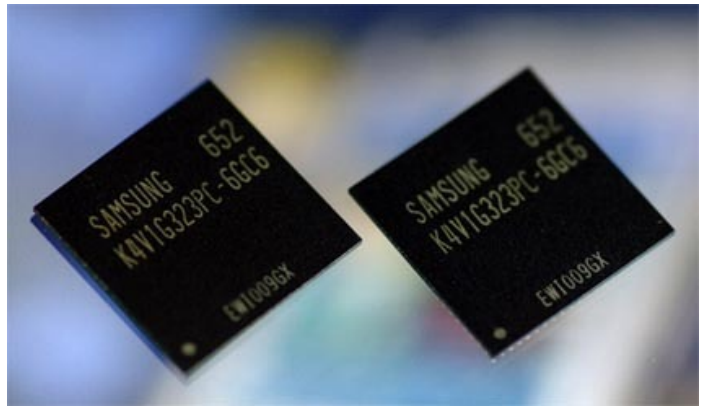
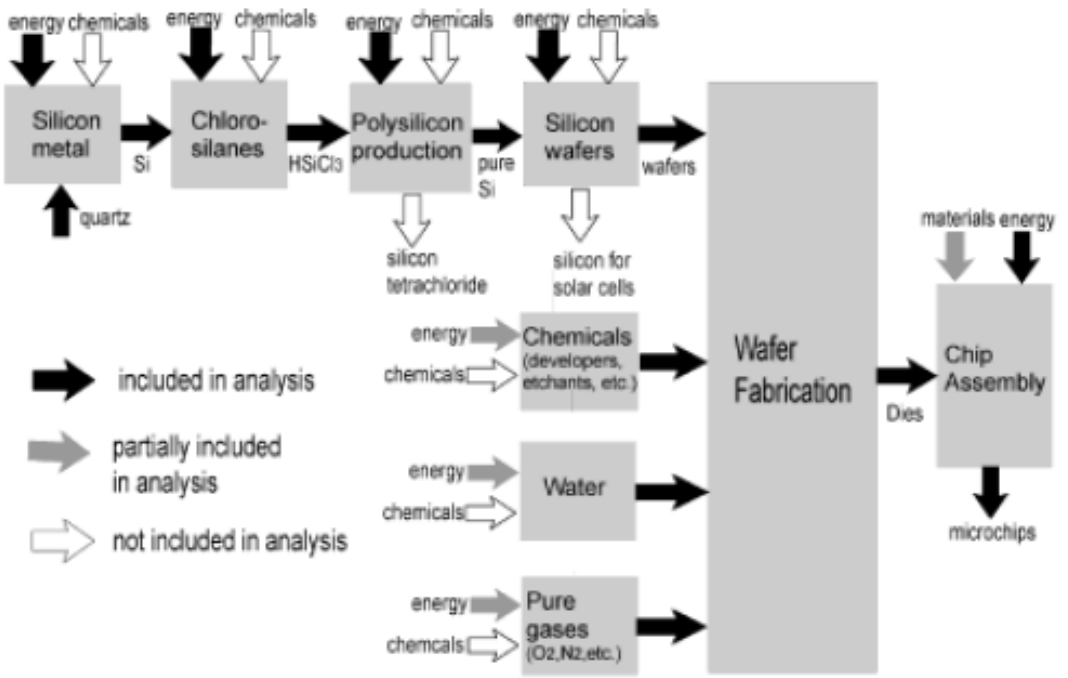
PRODUCTION AND MANUFACTURING

- Modern electronics require highly purified base materials which are rare, scarce, and challenging to extract. Due to the complex designs involved in integrated circuits, the cost and material usage of electronics is much higher than many other products.
- A single 2-gram DRAM chip uses an estimated 1.6 kg of “fossil” fuels and 72 g of chemicals; large amounts of water (32 kg) are required as well. (Source: American Chemical Society)





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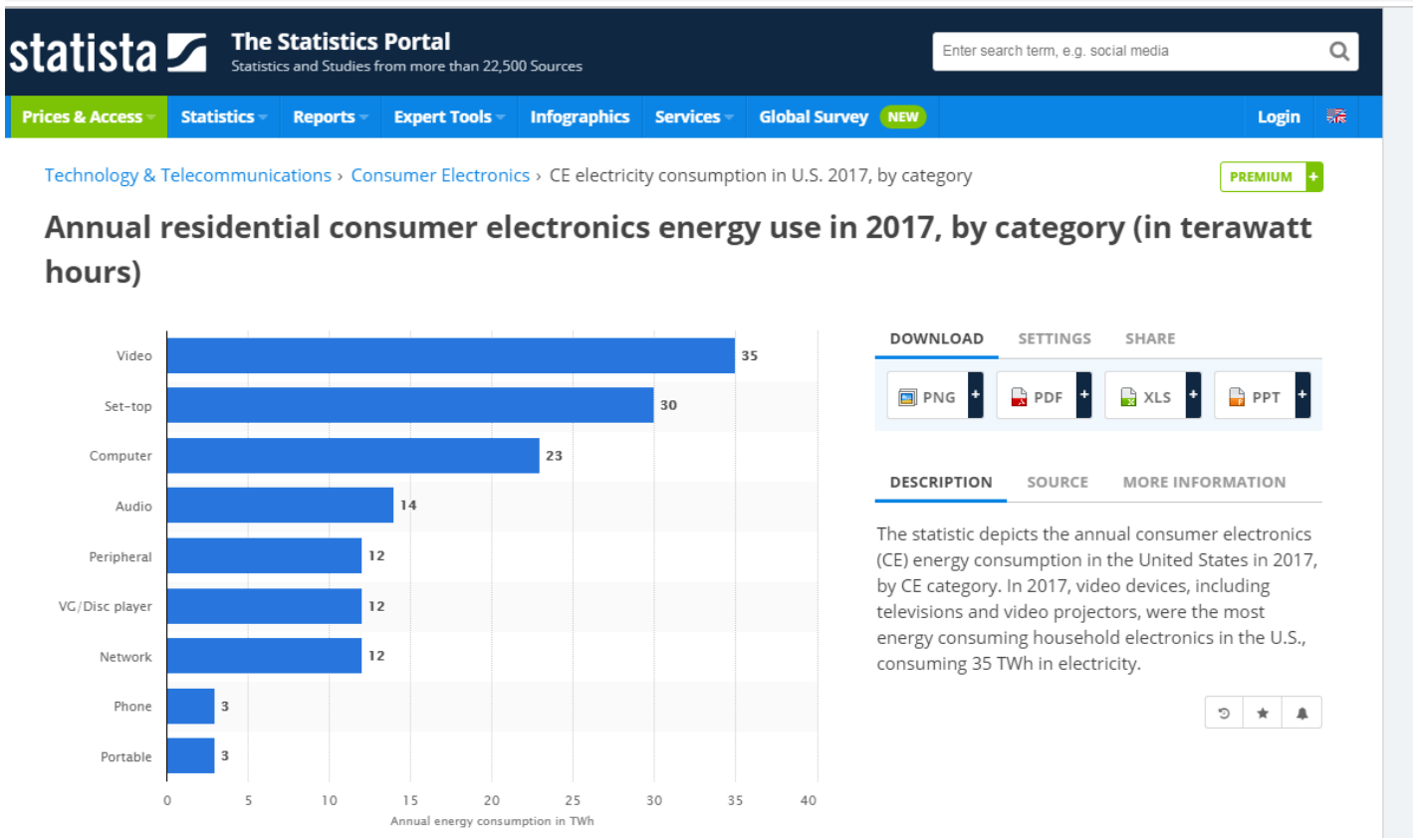
CONSUMER LIFECYCLE

- Once products are manufactured and shipped, they are operated by end users for the intended application over the product's usable lifecycle
- The primary environmental impact at this stage involves energy consumption
- In 2017, U.S. consumer electronics devices used an estimated 144 TWh of energy



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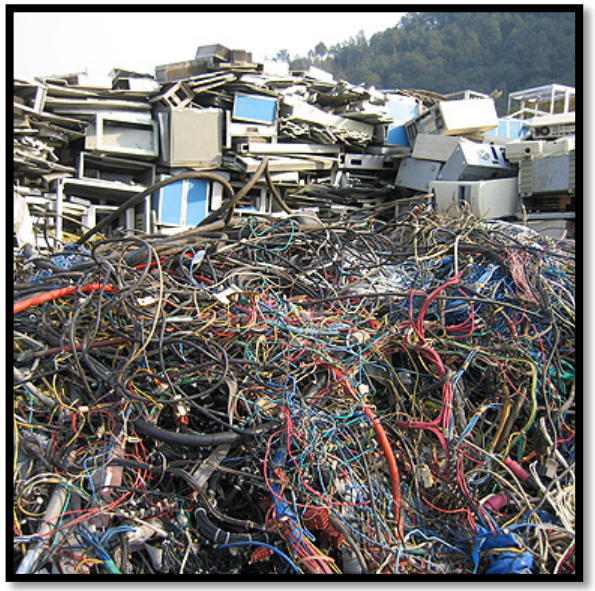
E-WASTE AND RECYCLING

- Increased consumption and demand for electronics in modern society has led to enormous amounts of electronic waste (E-waste)
- In 2014, the United States alone generated an estimated 11.7 million tons of E-waste, much of it sent to landfills (recycling rate is about 30%)
- Some E-waste is exported, largely from developed countries, to developing and poor countries, for recycling
- Recycling of E-waste involves large amounts of labor with numerous environmental and human hazards
- E-waste is often burned, producing byproducts such as lead fumes and metallic toxins, which are extremely dangerous to human health



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WHAT CAN BE DONE

- As engineers, resource depletion and electronic waste can be mitigated in the following steps:
- Eliminate: New devices and designs which eliminate the need for previously existing classes of products (example: smartphones eliminating need for separate MP3 player)
- Reduce: New devices and designs which use fewer resources and energy than their predecessors
- Reuse: New devices and designs which are easily repairable, upgradeable, and multifunctional
- Recycle: Send remaining salvage to recyclers to responsibly recycle old electronic materials

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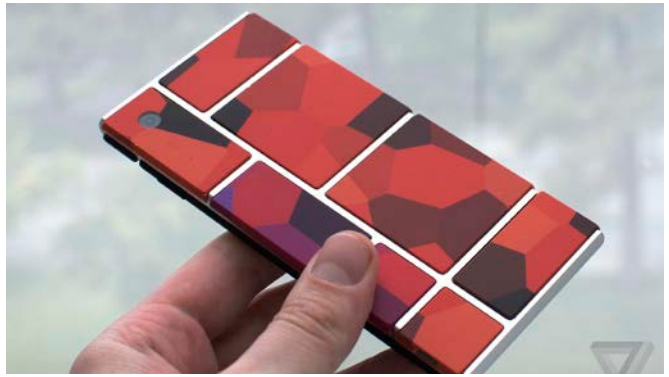
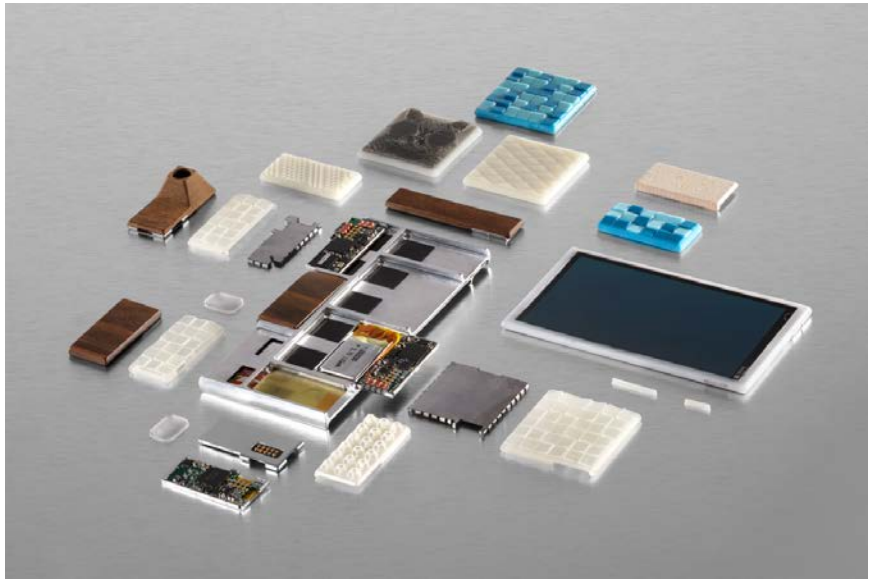
ENVIRONMENTAL & PUBLIC POLICY QUESTIONS

Project Ara

- Google/Motorola initiative - modular smartphone design
- End users can decide which components and functionality their phones need, and purchase modules on this basis
- When an upgrade is desired or a repair needs to be made, the module can be replaced without needing to discard the entire device
- Project Ara concept video: https://www.youtube.com/watch?v=TQjGBEEiejU





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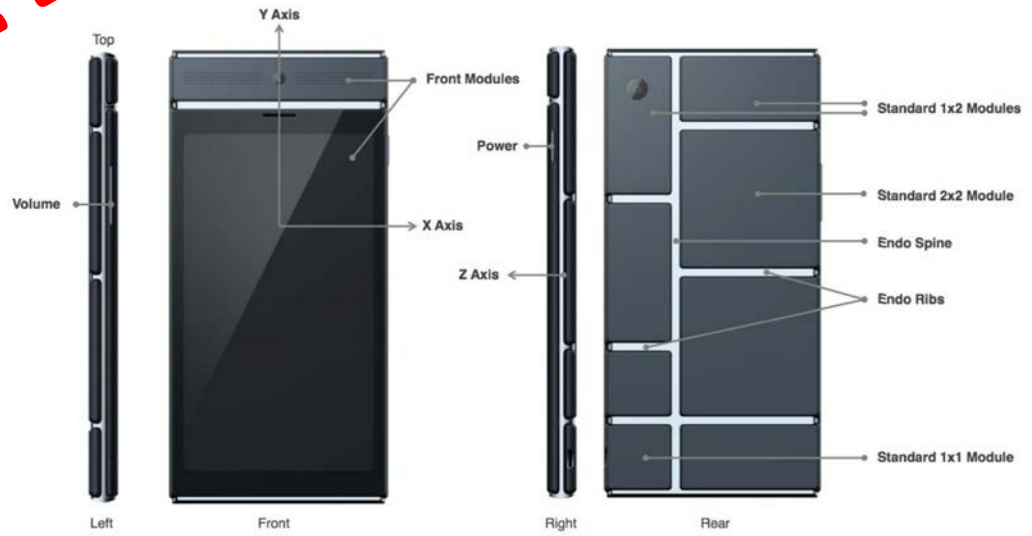
ENVIRONMENTAL & PUBLIC POLICY QUESTIONS

Project Ara

- Relevant questions:
  - What are the positive environmental impacts of this project? Negative impacts?
  - Would you buy a device like this? What premium would you be willing to pay compared to a normal disposable device?

CANCELED in 2016



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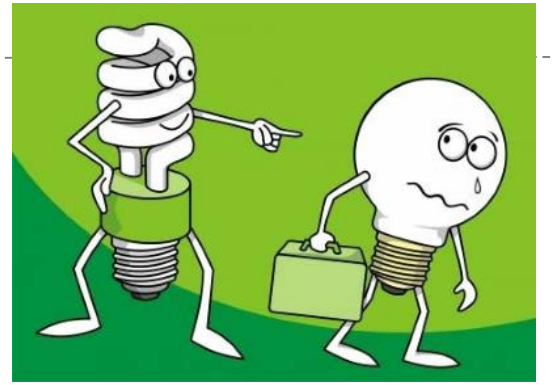
ENVIRONMENTAL & PUBLIC POLICY QUESTIONS

Energy Independence and Security Act of 2007



Household Lighting

- It does not ban the **use or purchase** of incandescent bulbs.
- It does not ban the **sale or manufacture** of **ALL** incandescent bulbs, just those common household incandescent (and other) bulbs that are not energy-efficient.
- **It does not require the use of compact fluorescent bulbs (but…CFL was the only technology available at the time the law went into effect that met the requirements)**
- It requires about 25 percent greater efficiency (that is, 25 percent less energy use) for household light bulbs that have traditionally used between 40 and 100 watts of electricity.
- Many bulbs, including specialty bulbs, three-way bulbs, chandelier bulbs, refrigerator bulbs, plant grow lights and others, are exempt from the law's requirements.
- It was passed by Congress and is implemented by the U.S. Department of Energy (DOE).

Regulatory Updates Since the 2007 Law Went Into Effect

- In January 2017, DOE issued two regulations to expand the scope of the 2007 law to include incandescent reflector bulbs and candle-shaped bulbs used in chandeliers, reflector bulbs used in recessed lighting, three-way incandescent bulbs, and certain other specialty bulbs. These regulations would have taken effect in January 2020.
- In February 2019, DOE issued a proposal to withdraw the January 2017 regulations, on the basis that the legal rationale underlying those revisions misconstrued existing law. Learn more about the current state of these regulations on DOE's Appliance and Equipment Standards Rulemakings and Notices page.

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ENVIRONMENTAL & PUBLIC POLICY QUESTIONS

Home Lighting

- Should the governme
  bulbs that can be ma
- Was the promotion

EE Times

DESIGNLINES | POWER MANAGEMENT DESIGNLINE

Whatever Happened to CFLs?

By Bill Schweber, 06.27.18 19

Not too long ago, the compact fluorescent lamp was supposed to be the efficient and perhaps dominant lighting source of the future, but that future didn't last long; there's a broader lesson here beyond lighting.

It wasn't that long ago that compact fluorescent lamps (CFLs) were hailed as the "next big thing" for the foreseeable future of home and office lighting. And they were fairly successful, at least for a short while. Using them made sense, as they saved significant energy compared to incandescent lamps, with efficiency of about 2-5% (about 13-18 lumens per watt) for the latter, versus 7-10% (55-70 lumens per watt, and often more) for the former. They also fit in many existing fixtures (called luminaires in the lighting trade), and while they were more costly to purchase – anywhere from $1 each to several dollars each, compared to around $0.50 to $1 for an incandescent lamp, their longer life and lower total cost of ownership were very strong points in their favor.

But times change and they change quickly, at least where technology is concerned. On a recent visit to local big-box stores – Home Depot and Lowe's – and small, independent hardware stores, I couldn't find a single CFL. In their placed were extensive displays of LED-based lamps of all sizes and styles, including the small-base candelabra size. It looks like the window of fame for CFLs came quickly and left even more quickly. (For both, of course, the immediate market drivers were their lower operating costs and longer life (impact on labor cost of replacing) along increasingly stringent world-wide regulatory mandates.

So, what happened? Apparently, several factors conspired to knock CFLs out of the contention box. Among them, the top one is most likely that LEDs reached parity in cost at comparable efficiency, while offering other benefits: more pleasing physical appearance, better color performance and options (color temperature and color rendering index, CRI), and better fit with both existing and new luminaires.

There's one other area where LEDs soon surpassed CFLs: ease of dimming. Although there are ways to dim CFLS driven directly from the AC line, the added circuitry in the CFL bulb was tricky to implement and IC vendors invested significant effort to make it happen. Worse, the dimmable CFLs had to be dimmer-compatible with the ubiquitous, low-cost TRIAC-based dimmers already installed by the millions in homes. The low-cost, very effective TRIAC-dimming approach based on zero-crossing PWM had to be "mapped" to a CFL-friendly dimming approach. Consumer would be frustrated by CFLs marked as "non-dimmable" on labels they did not see or read, and then be angry when they didn't work or dim in their installed incandescent socket which used to dim just fine.

cycling: CFLs are sensitive to frequent on/off cycling.
000 hours are reduced in
switched on and off very often.
e lights are needed for brief
descent or LED bulbs.

available for lights using a
e package; not all CFLs can be
sing a regular CFL with a dimmer
n.

outdoors, but should be covered
nts. Low temperatures may reduce
kage label to see if the bulb is suited

ot spot lights. Retail store display
narrow focus beams for stronger spot
for area lighting.

contain small amounts of mercury
This metal may be released if the bulb
sposal. For more information about
below.

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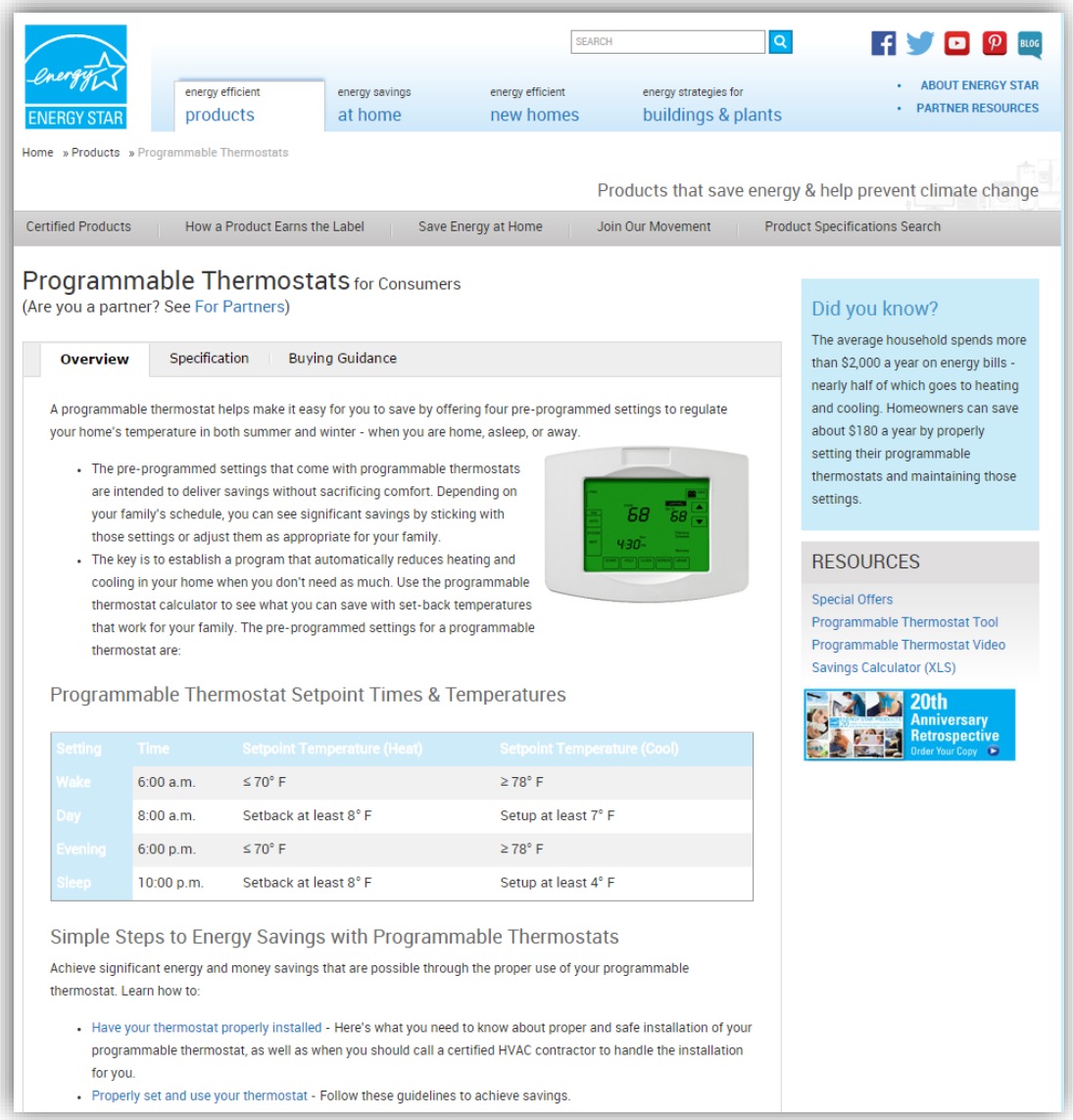
ENVIRONMENTAL & PUBLIC POLICY QUESTIONS

Energy Star Thermostats

Note: The EPA suspended the ENERGY STAR programmable thermostats specification effective December 31, 2009. Currently only “smart” thermostats can qualify for ENERGY STAR qualification.



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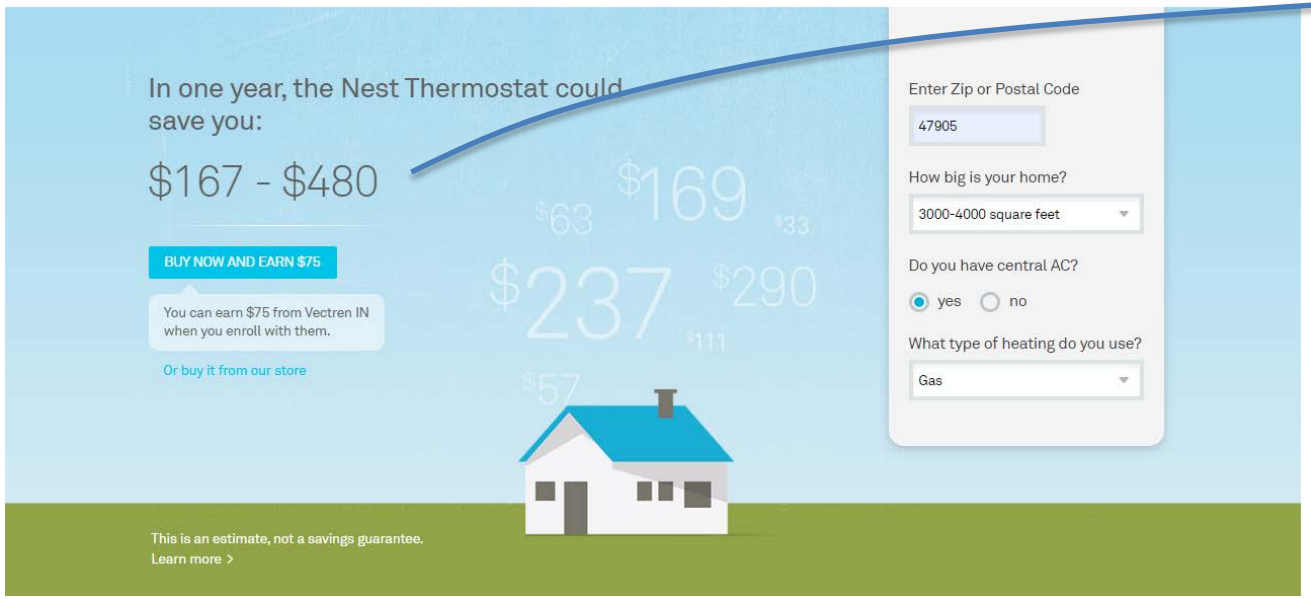
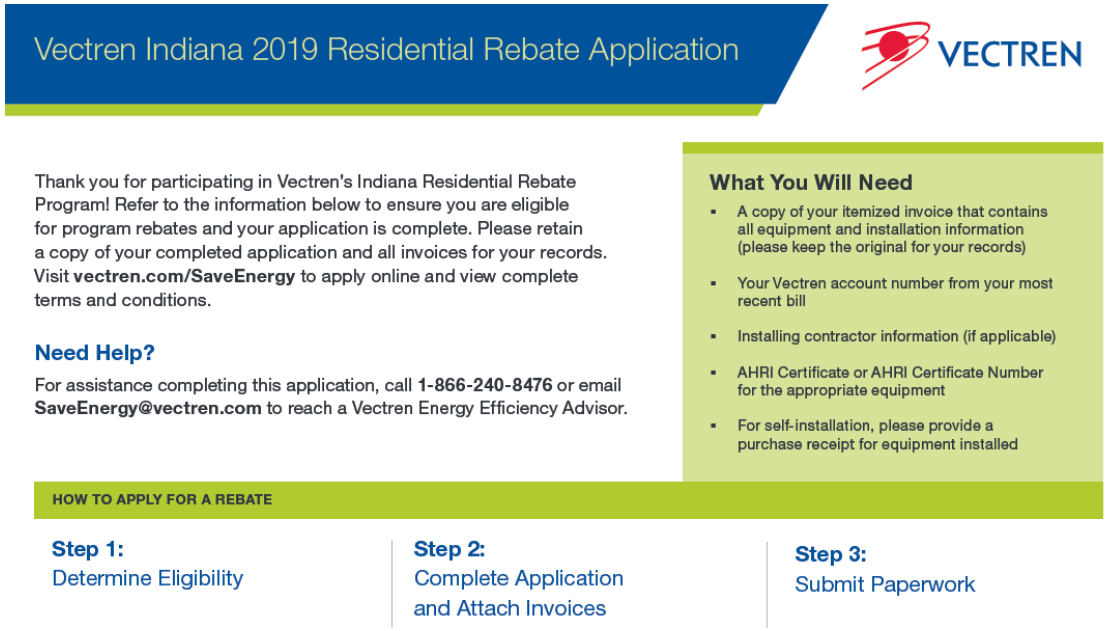
ENVIRONMENTAL & PUBLIC POLICY QUESTIONS

Nest Learning Thermostat Energy Savings Claims





Vectren Indiana 2019 Residential Rebate Application

VECTREN

Thank you for participating in Vectren's Indiana Residential Rebate Program! Refer to the information below to ensure you are eligible for program rebates and your application is complete. Please retain a copy of your completed application and all invoices for your records. Visit **vectren.com/SaveEnergy** to apply online and view complete terms and conditions.

Need Help?

For assistance completing this application, call **1-866-240-8476** or email **SaveEnergy@vectren.com** to reach a Vectren Energy Efficiency Advisor.

What You Will Need

- A copy of your itemized invoice that contains all equipment and installation information (please keep the original for your records)
- Your Vectren account number from your most recent bill
- Installing contractor information (if applicable)
- AHRI Certificate or AHRI Certificate Number for the appropriate equipment
- For self-installation, please provide a purchase receipt for equipment installed

HOW TO APPLY FOR A REBATE

Step 1: Determine Eligibility

Step 2: Complete Application and Attach Invoices

Step 3: Submit Paperwork

☐ **THERMOSTATS**

Equipment specifications (please ✓)	Unit controlled (please ✓)		
☐ Wi-Fi thermostat $50 rebate ☐ Smart thermostat $75 rebate	☐ Central air source heat pump ☐ Gas furnace/boiler with A/C	☐ Electric furnace with A/C ☐ Gas furnace/boiler no A/C	☐ Electric furnace no A/C

Manufacturer	Model number	Serial number	Date installed

Manufacturer	Model number	Serial number	Date installed

- **Homes must have Vectren natural gas or Vectren electric as the primary heat source to be eligible for this rebate. Dual fuel systems are not eligible.**
- Rebate available for existing homes only; new construction is not eligible. If replacing existing (non Wi-Fi) thermostat in newly constructed home, thermostat is eligible.
- Must be Wi-Fi capable without the use of additional equipment and connected to the internet for programming and adjusting remotely.
- Serial number is preferred, but not required.
- Must be ENERGY STAR® certified smart thermostat to be eligible for $75 incentive.
- Household limit is two thermostat rebates.

- Homes using Vectren natural gas or Vectren electric as the primary heat source are eligible for this rebate. Dual fuel systems are not eligible.
- Rebate available for existing homes only; new construction is not eligible.
- *"Smart" thermostat*: Must be Wi-Fi capable and connected to the home. Must be ENERGY STAR certified as "Smart." Limit of two thermostats per home ("Wi-Fi" and/or "Smart").
- *Wi-Fi enabled thermostat*: The product must be Wi-Fi capable and connected to the internet for programming and adjusting remotely. Limit of two Wi-Fi enabled thermostats per home ("Wi-Fi" and/or "Smart").

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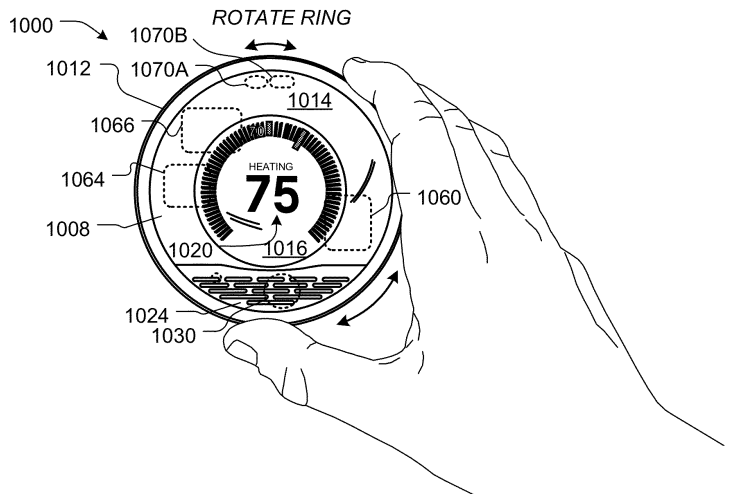
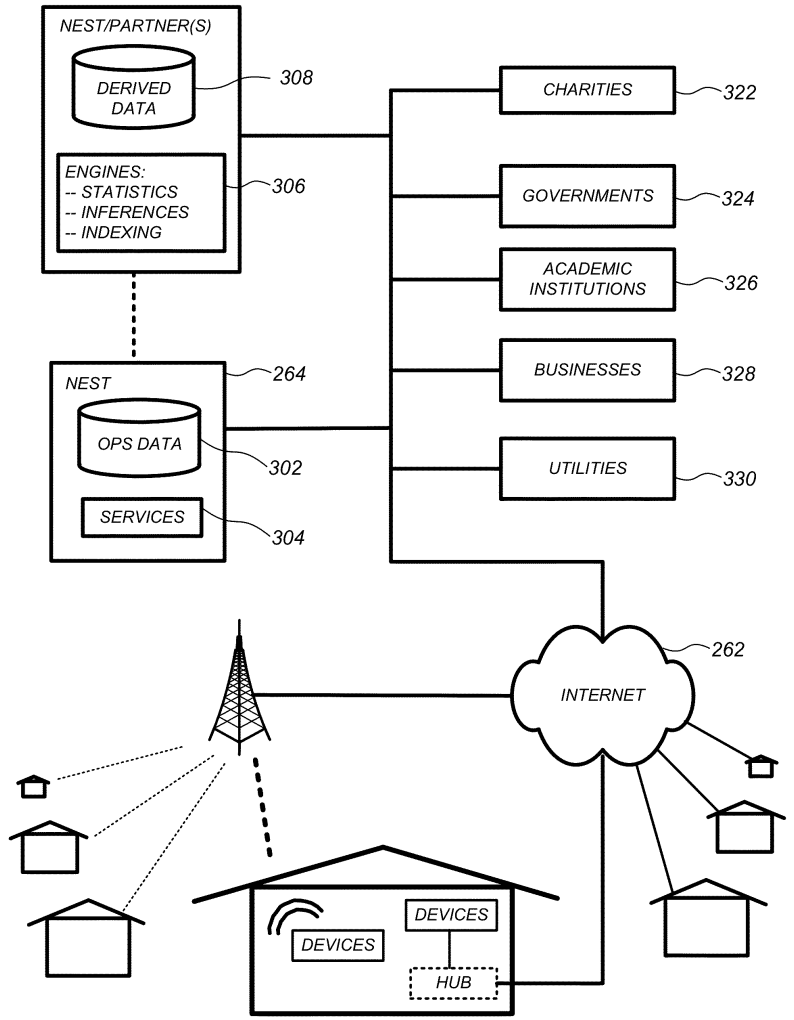
ENVIRONMENTAL & PUBLIC POLICY QUESTIONS

Energy Star Certification

- Should a public utility (gas, electric) have the authority to **monitor** and/or **control** your thermostat settings?
- Should consumers be required to purchase a **specific product** to participate in a government-sponsored (mandated) “energy savings/control” program?
- Should a “consent clause” be included in the purchase agreement for a “Smart” / Wi-Fi enabled thermostat?
- Is there any potential for abuse of data?





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ENVIRONMENTAL & PUBLIC POLICY QUESTIONS

Opinion Poll

Indicate your opinion on the following statement: *"I am OK with a utility company monitoring and controlling my energy use (via a smart, Wi-Fi enabled thermostat) in exchange for a lower monthly bill."*

A. strongly agree
B. agree
C. neutral (no opinion)
D. disagree
E. strongly disagree

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ENVIRONMENTAL & PUBLIC POLICY QUESTIONS

Energy Star Certification

- Are there any **consequences** associated with the promotion of "energy star compliant" products?

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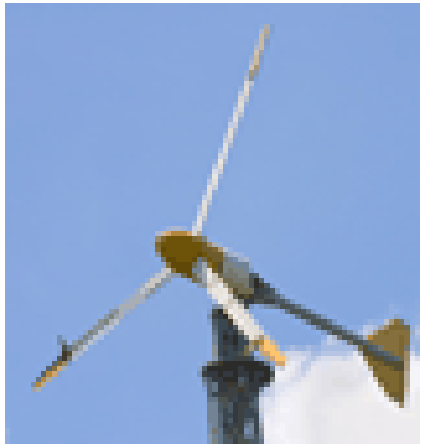
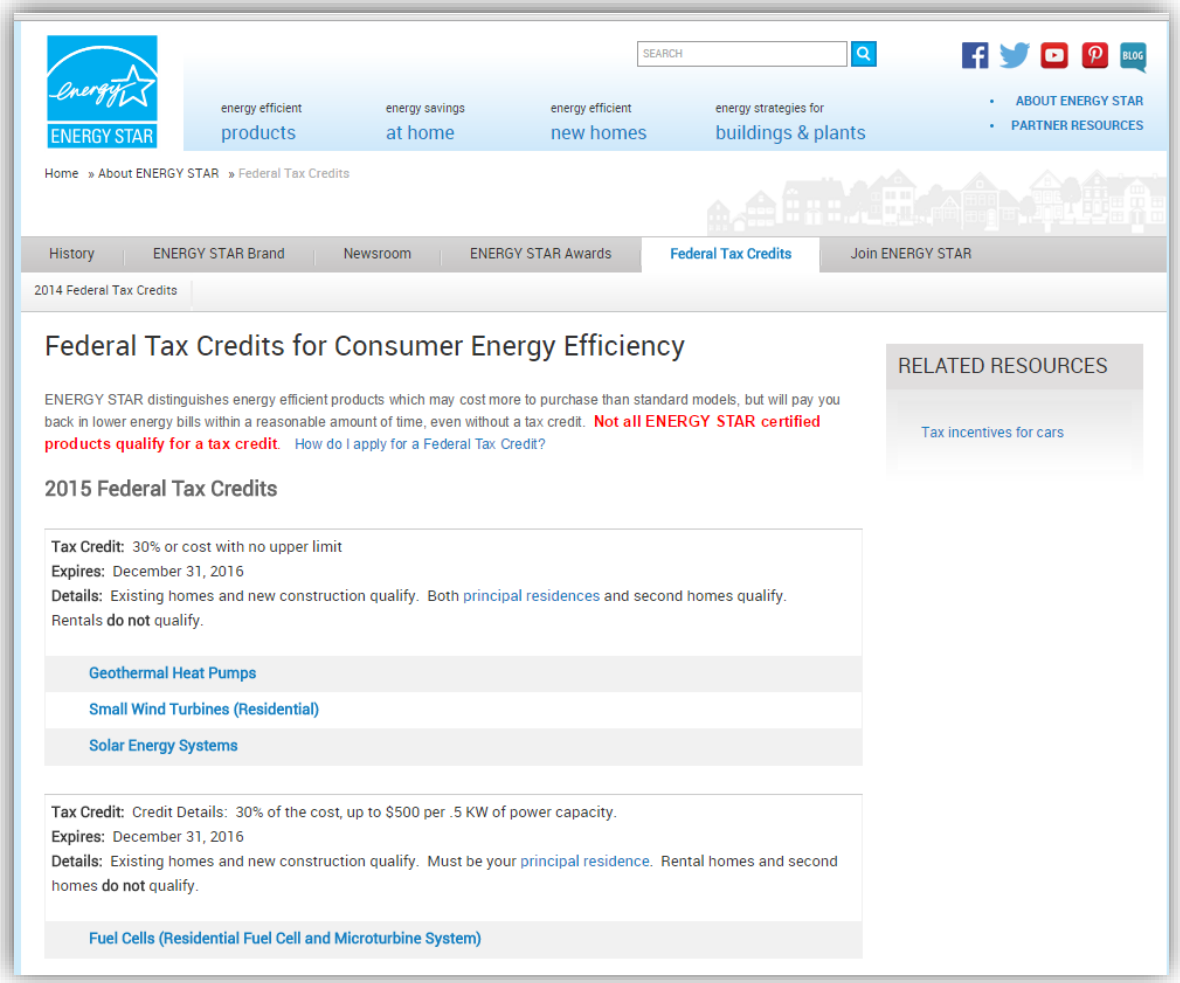
ENVIRONMENTAL & PUBLIC POLICY QUESTIONS

Energy Star Certification

- Should the government offer **tax credits** for the purchase of energy star certified products?



Capacity ≤ 100 KW



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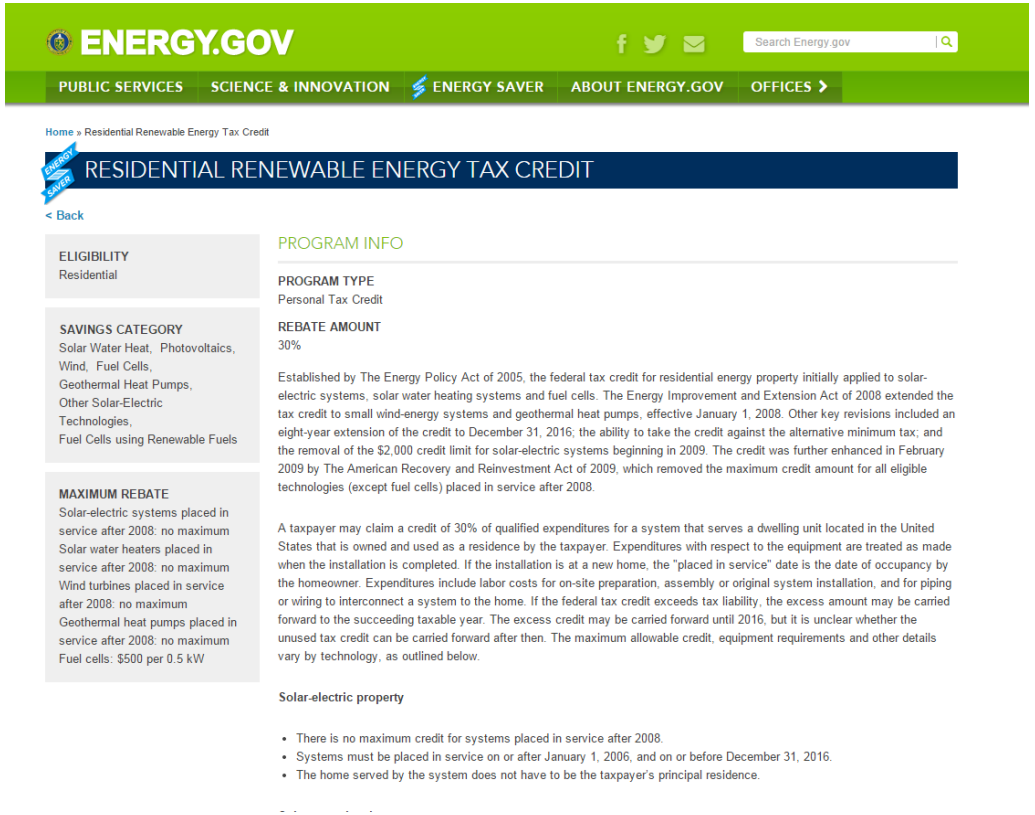
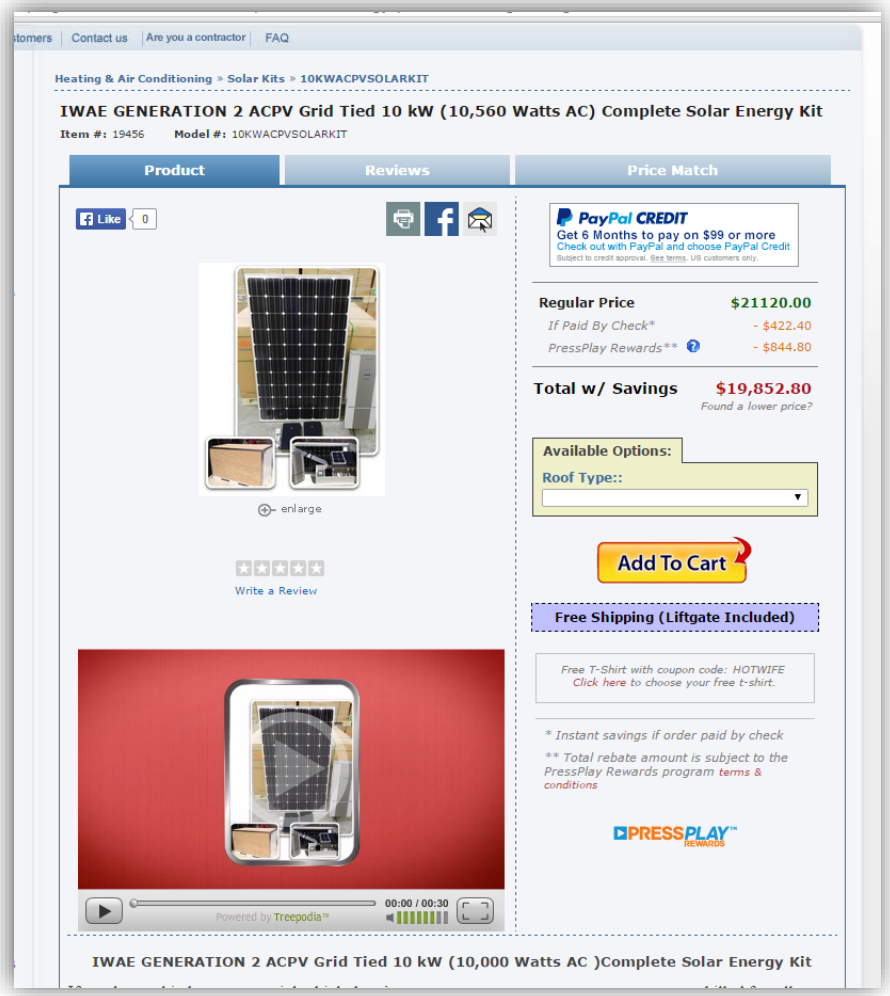
ENVIRONMENTAL & PUBLIC POLICY QUESTIONS

Alternate "Green" Energy Sources

- Should the government **subsidize** alternate energy production?





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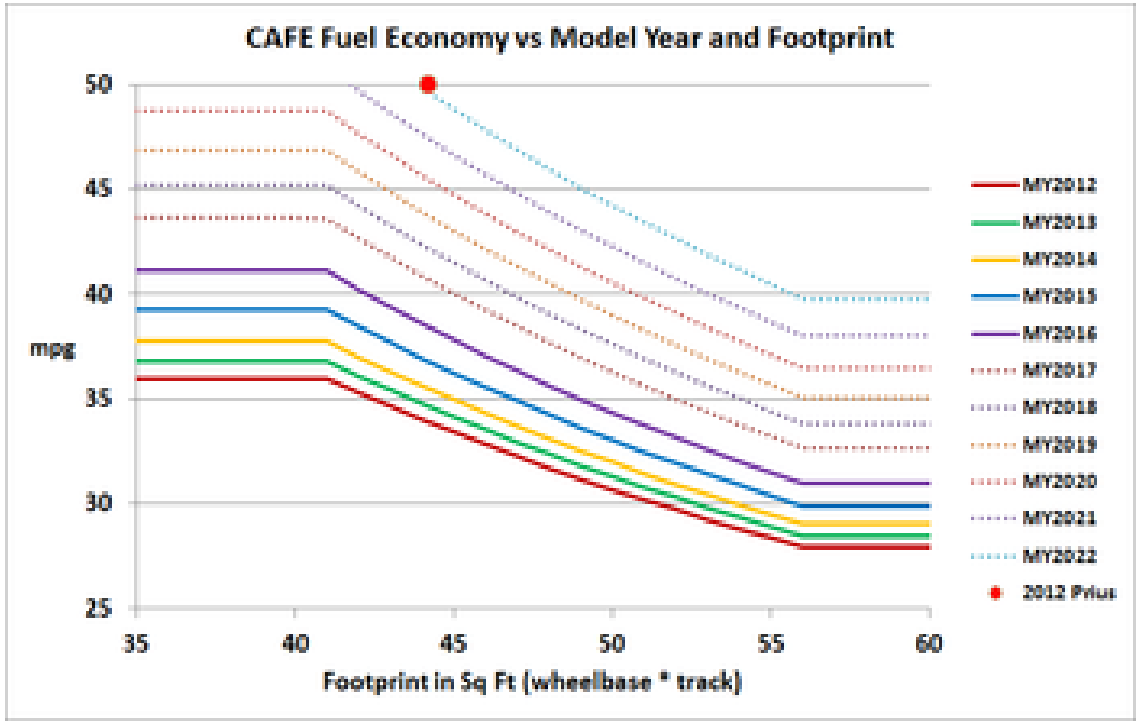
ENVIRONMENTAL & PUBLIC POLICY QUESTIONS

Transportation

- Should the government have the authority to establish **fuel economy** (Corporate Average Fuel Economy or “CAFE”) standards for automobiles?



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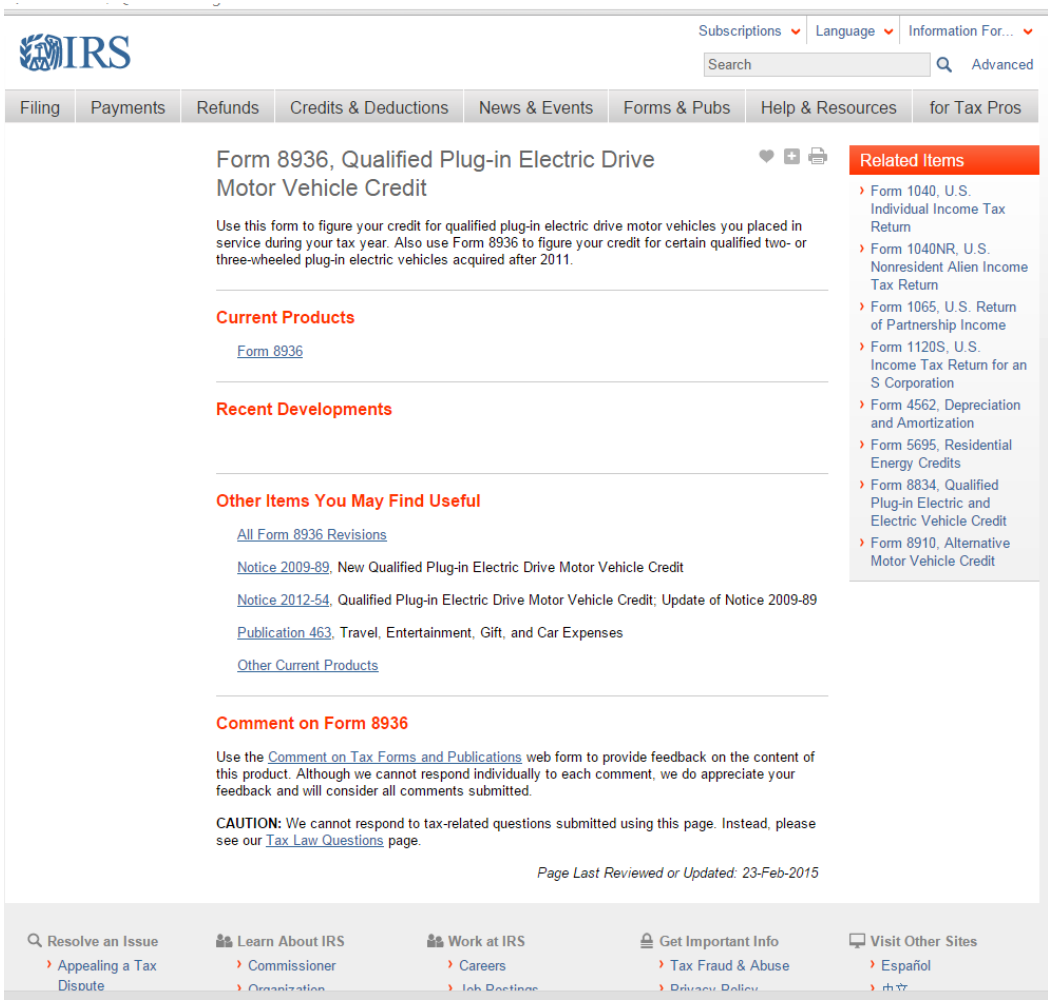
ENVIRONMENTAL & PUBLIC POLICY QUESTIONS

Transportation

- Should the government offer **tax incentives** for all-electric vehicles and plug-in hybrids?



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Form 8936, Qualified Plug-in Electric Drive Motor Vehicle Credit

Use this form to figure your credit for qualified plug-in electric drive motor vehicles you placed in service during your tax year. Also use Form 8936 to figure your credit for certain qualified two- or three-wheeled plug-in electric vehicles acquired after 2011.

Current Products

Form 8936

Recent Developments

Other Items You May Find Useful

All Form 8936 Revisions

Notice 2009-89, New Qualified Plug-in Electric Drive Motor Vehicle Credit

Notice 2012-54, Qualified Plug-in Electric Drive Motor Vehicle Credit; Update of Notice 2009-89

Publication 463, Travel, Entertainment, Gift, and Car Expenses

Other Current Products

Comment on Form 8936

Use the Comment on Tax Forms and Publications web form to provide feedback on the content of this product. Although we cannot respond individually to each comment, we do appreciate your feedback and will consider all comments submitted.

CAUTION: We cannot respond to tax-related questions submitted using this page. Instead, please see our Tax Law Questions page.

Page Last Reviewed or Updated: 23-Feb-2015

Related Items

- Form 1040, U.S. Individual Income Tax Return
- Form 1040NR, U.S. Nonresident Alien Income Tax Return
- Form 1065, U.S. Return of Partnership Income
- Form 1120S, U.S. Income Tax Return for an S Corporation
- Form 4562, Depreciation and Amortization
- Form 5695, Residential Energy Credits
- Form 8834, Qualified Plug-in Electric and Electric Vehicle Credit
- Form 8910, Alternative Motor Vehicle Credit

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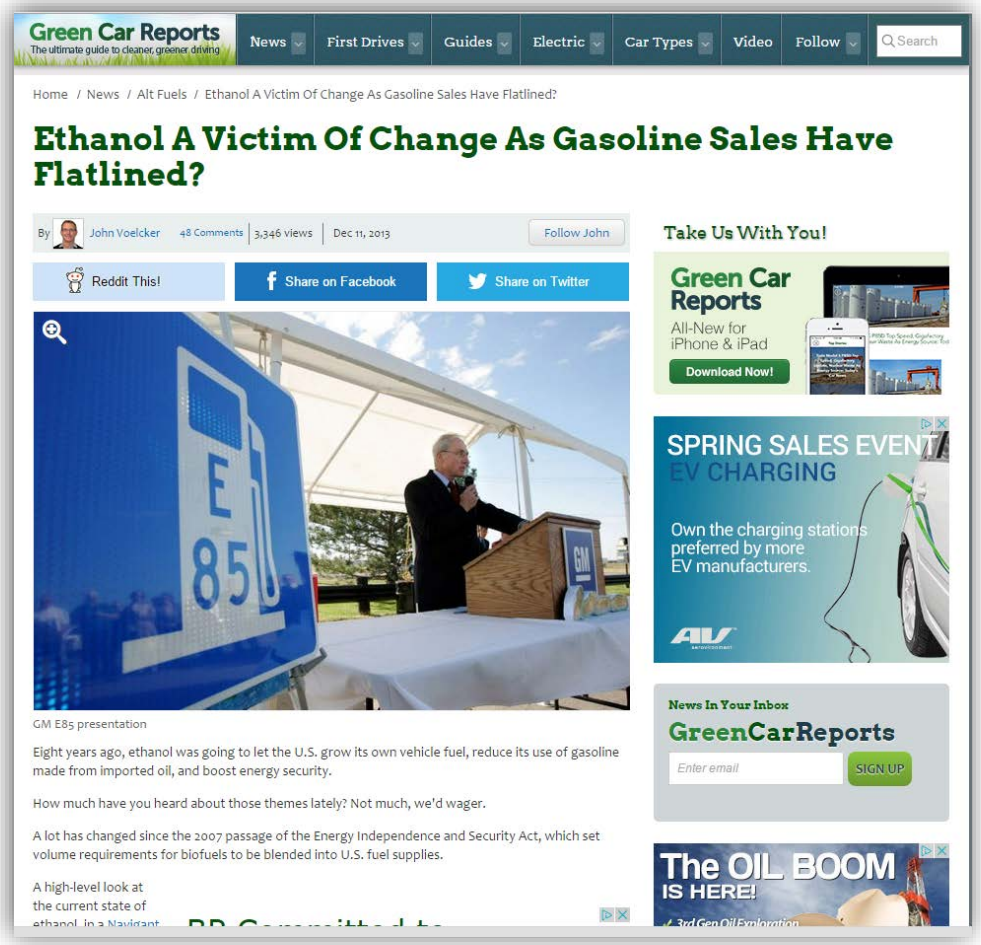
ENVIRONMENTAL & PUBLIC POLICY QUESTIONS

Transportation

- Should the government **require** oil companies to manufacture ethanol (E85) fuel as well as add 10-15% ethanol to gasoline?

It takes 1.5 gallons of ethanol (E-85) to drive as many miles as one gallon of gasoline.

Every gallon of ethanol removes 53 cents from the Federal Highway Trust Fund because of a special tax break for producers.



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SUMMARY

Economics / Freedom / Personal Responsibility

- What aspects of environmental protection and sustainability should be determined or mandated by government?
- Why are *some* regulations ultimately necessary?
- Would we as citizens be better off with a more *limited* government (greater *free-market* based determination of environmental policies), or would we benefit from additional regulations in this area?
- What is our *personal responsibility* toward ensuring environmental protection and sustainability?

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ENVIRONMENTAL IMPACT ANALYSIS REPORT

Homework Assignment (Part 2)

- Outline the environmental impact of your product at various stages of its life-cycle
  - manufacture (natural resources, hazardous chemicals, energy)
  - normal use (expected product lifetime, EMI, energy consumed when both “on” and “off”)
  - disposal/recycling (instructions for hazardous waste handling and disassembly/recycling)
- Discuss how you would address each of the environmental impact concerns outlined in your report

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