A Moore's Law for Mobile Power?

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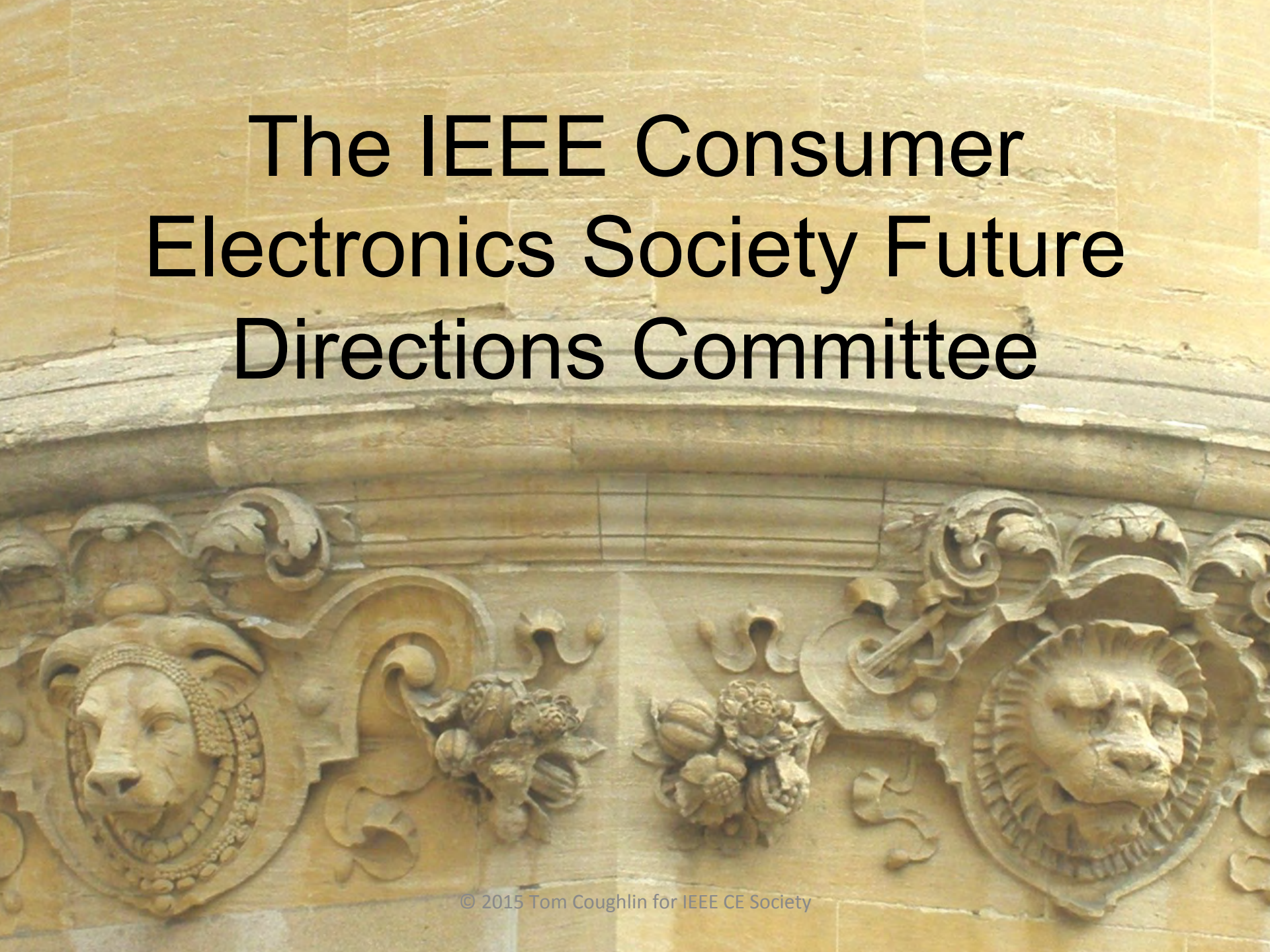
Chair IEEE Consumer Electronics Society Future Directions

Outline

- The IEEE CE Society Future Directions Committee
- Power in Our Hands
- Sources of Power
- Safety and Sustainability Considerations
- Manufacturing Mobile Power Devices
- The Safe Advanced Mobile Power Initiative

The IEEE Consumer Electronics Society Future Directions Committee



Objectives

- Help bring interesting and important topics to CE Society Conferences
- Help to generate articles for the Consumer Electronics Magazine
- Create new initiatives on important topics in consumer electronics
- Create a bigger and lasting presence of the Consumer Electronics Society in the IEEE
- Help create the future

Power in Our Hands

With More Energy in Mobile Devices…

- We can use our devices without recharging for a longer period of time
  - This is convenient in places with reliable power
  - This can be life-saving in areas with less reliable power
- We can do more with our mobile devices during the course of the day

Some General Observations

- Our personal power is tied to the power of the things we carry with us
- We will always try to do more with technology that we carry with us…so there is never enough power
- We will always need some sort of power management in a mobile device both because we never have enough power, but also to control the thermal loads

Why A Phone?

- Mobile phones have been in active use since the 1980's
- Their characteristics are pretty well understood
- They are a good test bed for technology development
- Technology built for a phone can translate to other mobile devices and even devices like cars

Rated and Actual Energy Use and Battery Energy Storage for Conventional Smart Phones

	Product Name	Mfg. Standby	Vendor reported Run Time	Actual Run Time *[1]	Installed Battery
1	**HTC Dream**	406 h	5h 20 minutes	2 ~ 3.5 h	Li-Ion 1150 mAh
2	**Google Nexus One**	290 h	7h	3.5 ~ 5.5 h	Li-Ion 1400 mAh
3	**Apple IPhone 5**	225 h	8h	3 ~ 5 h	Li-Po 1440 mAh (5.45 Wh)
4	**Samsung Galaxy 5**	375 h	6.45 h	2.5 ~ 4.5 h	1200 mAh
5	**Nokia Lumen 1520**	32 days	24 h	9 ~ 10.8h	3400mAh *[2]

Casual Cell Phone User

- The casual user might get 5 hours of use with a 1,400 mAh (1.4 Ah) battery.
- If this was consistent across 7 days the total energy requirement is 7 X 1.4 Ah or 9.8 Ah.
- Assuming this is a 3.7 V device then the actual energy used in a week is 9.8 Ah X 3.7 V = **36.3 Wh or 130,536 Joules**.

Power Cell Phone User

- 12 hours of intense use with lots of radios running (Blue Tooth, WiFi, GPS and NFC), downloading lots of data and watching movies.
- This user may consumer 1,400 mAh (1.4 Ah) in only 3 hours and actually want to consume 4 times more power in the day or 4 X 1.4 Ah = 5.6 Ah.
- If this is a 3.7 V device the energy required for one day would be 5.6 Ah X 3.7V = 20.7 Wh.
- A 7 day energy requirement for such a user would then be 7X20.7Wh = **145Wh or 522,144 Joules**.

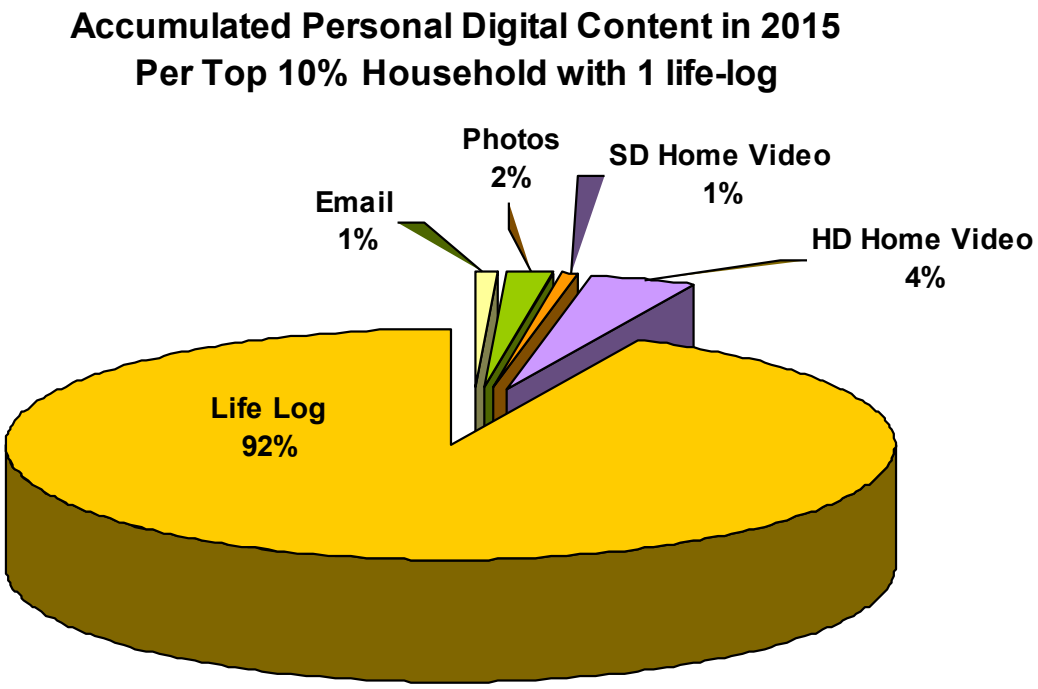
What Else We Could Do?

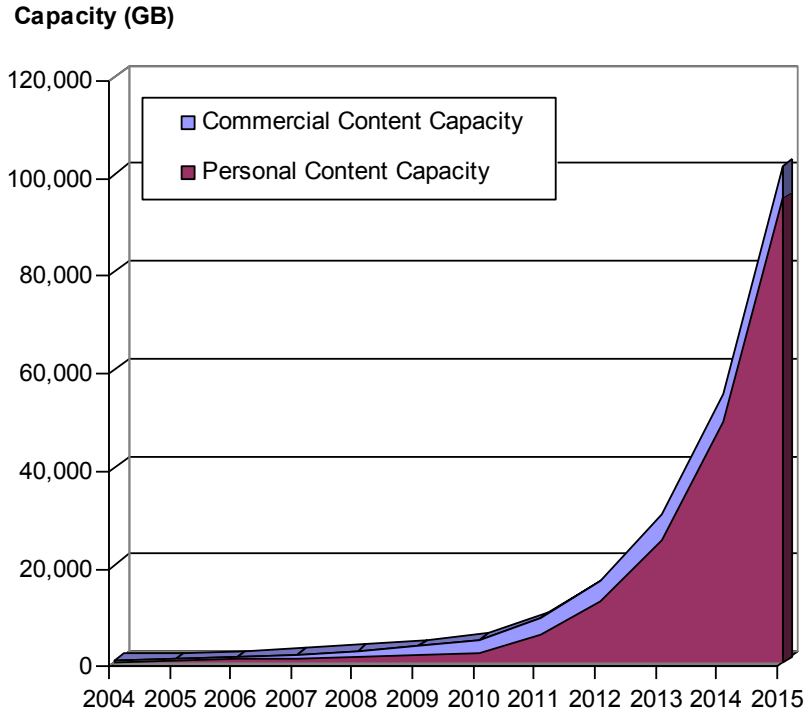
- We could run more radios more often
  - GPS
  - BlueTooth
  - WiFi
- We could have micro-projectors in phones
- We could run cameras all the time with multiple pictures per image…

Future Generation will be Capturing their Lives

- My kids text their friends all the time.
- They also send pictures to each other
- They watch YouTube Videos
- It's only a matter of time before we have the technology for them to record what they do every day
- This will generate petabytes of personal content

Petabyte Households

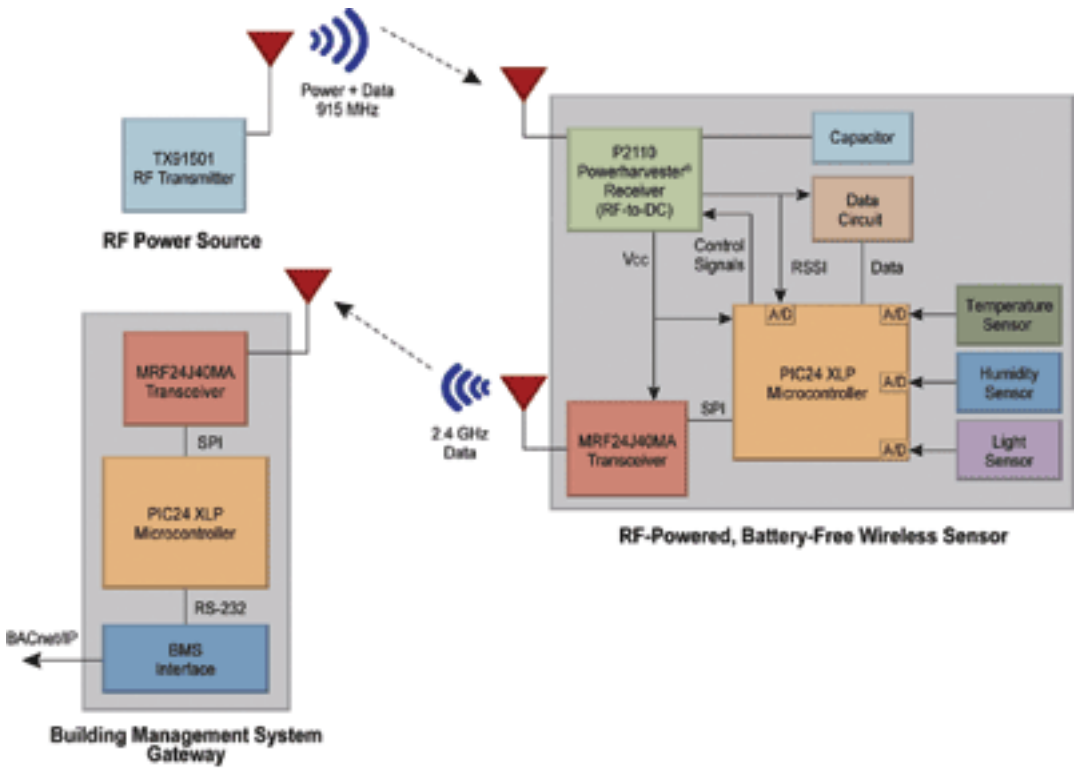




Digital Storage in Consumer Electronics 2008 (Coughlin Associates, release January 2008)

What Else We Could Do (2)

- Provide wireless energy for battery-less wireless devices
- Mobile phones could be the basis of edge networks for the IoTs



A system block diagram for a battery-less sensor system, RF energy harvesting and wireless power, Electronic Productions, August 2011

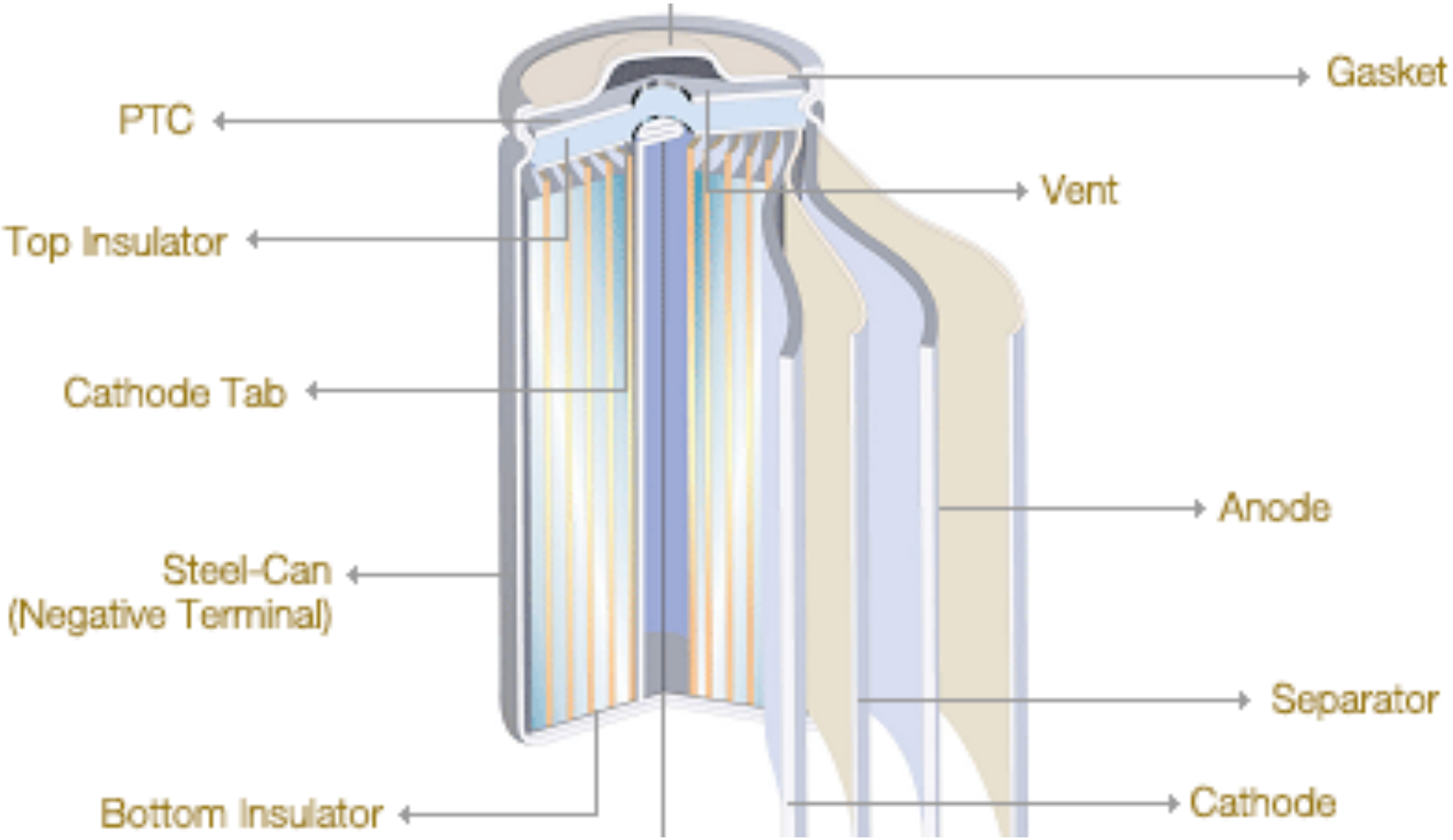
What Else We Could Do (3)

- The phone could power external USB devices
- Phones could be more useful for untethered WiFi hot spots
- With more power, phones could have have more powerful computers and do more complex computations—computational imaging
- We could do things we haven't even dreamed of yet

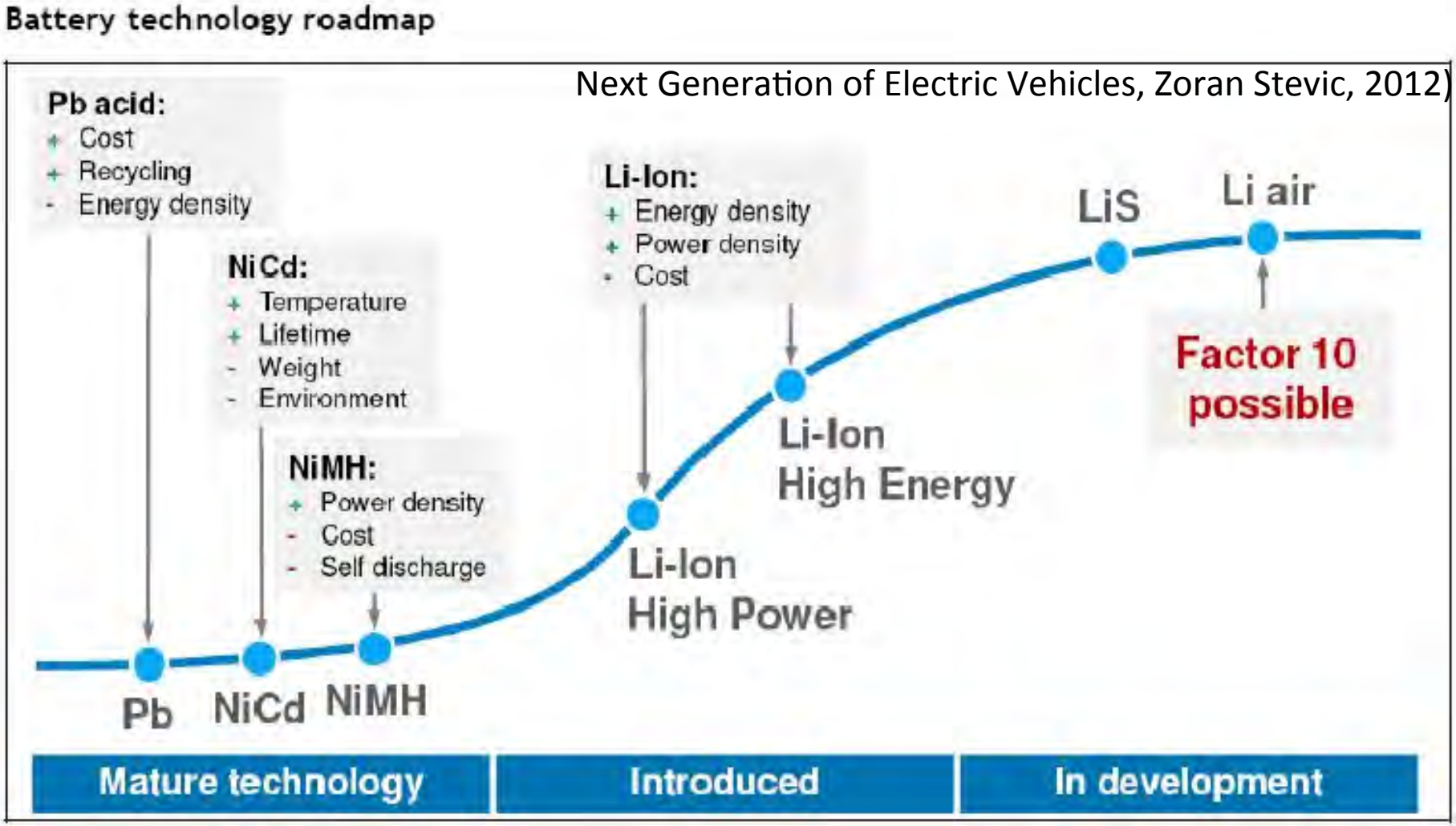
Power Sources

- Energy Storage (e.g. batteries)
- Energy Generation (e.g. fuel cells)
- Energy Harvesting (e.g. motion or heat)
- Wireless Power (like Nicola Tesla)

Basic Battery System (LG Image)



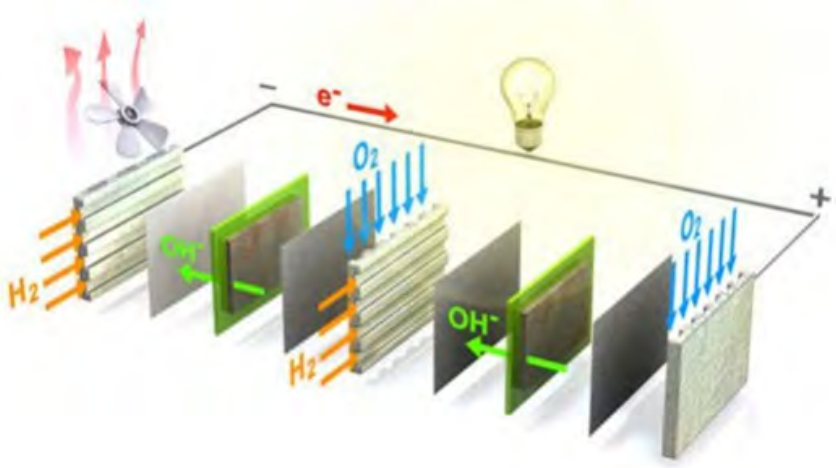
Energy Storage (Batteries)



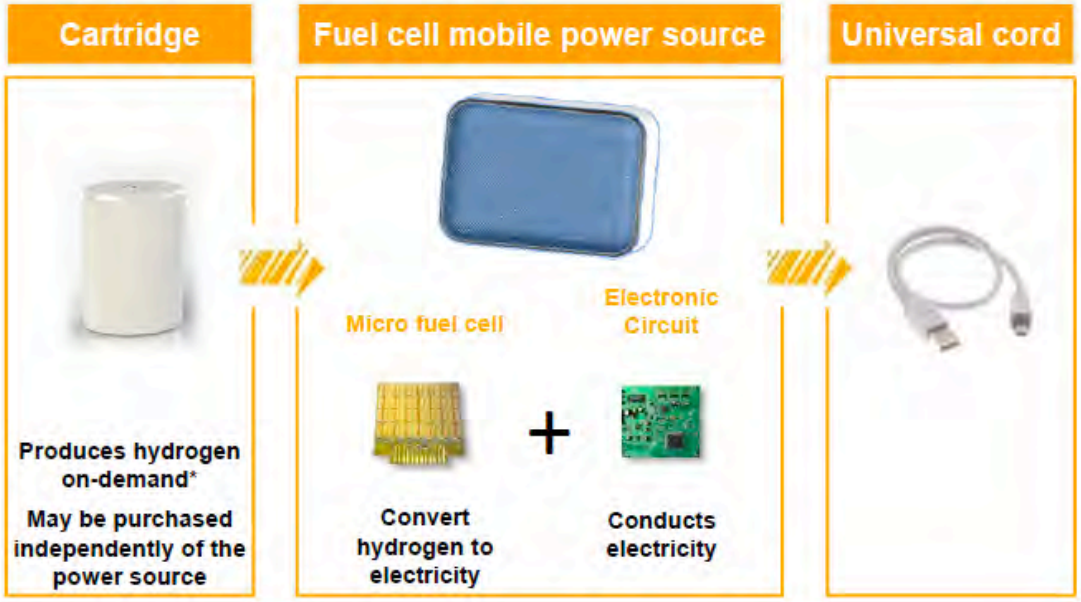
Battery improvements

- Battery energy density seems to double about every 10 years
- This is much slower that Moore's law for semiconductors, network speed growth and storage capacity growth
- At this rate of growth, the energy density required to run a phone for a week could take decades to develop

Energy Generation



- Fuel Cells are an example of a power generation device that could be built into a phone

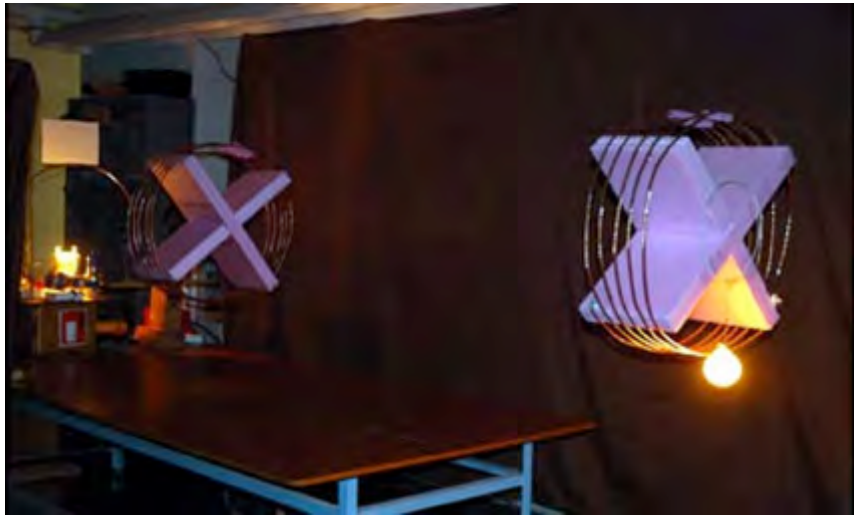


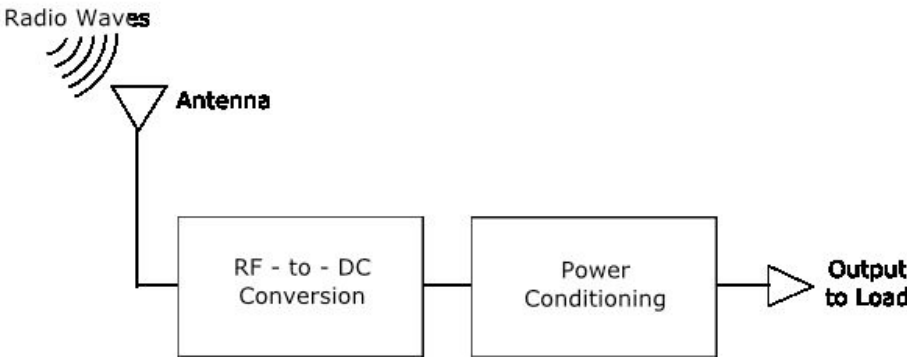
Energy Harvesting

- Micro and nano-machine technologies can be used to create electrical power from ambient energy
  - Motion
  - Heat
  - Electromagnetic
  - Other sources

Power Shorts are lined with an energy-harvesting material that uses voids, or holes inside the material, to create an electrical charge. Courtesy Design News and Vodafone

Wireless Power





- Transmission of power without wires —the dream of Nikola Tesla
- Companies such as WiTricity are working to transmit useable power over significant distances

To Power our Lives…

What we need is something like Moore's Law for Mobile Power

Safety and Sustainability Considerations

Safety Considerations

- Increasing the energy stored in a phone could make it more dangerous—what if that much energy could be expended into the circuitry at once?
- Thus the power source must have a fool proof way to prevent massive power draws
- The energy source must also not cause other hazards to the user—e.g. it shouldn't get too hot in operation
- Safety is the key for a consumer device

Safety Considerations (2)

- The mobile device must not emit radiation that exceed safety and interference specifications
- The mobile device or its parts must not cause cutting, rubbing or other injuries when used under normal conditions in the intended fashion

Sustainability

- The mobile phone power source should last at least 3 years under normal charging use (even for the power user)
- The mobile phone power source should be easy to replace so the phone can be repaired or re-purposed for a secondary market
- The phone should not contain any dangerous substances that could pollute the environment
- Materials used in the phone should be obtained without endangering human rights

Manufacturing Mobile Power Devices

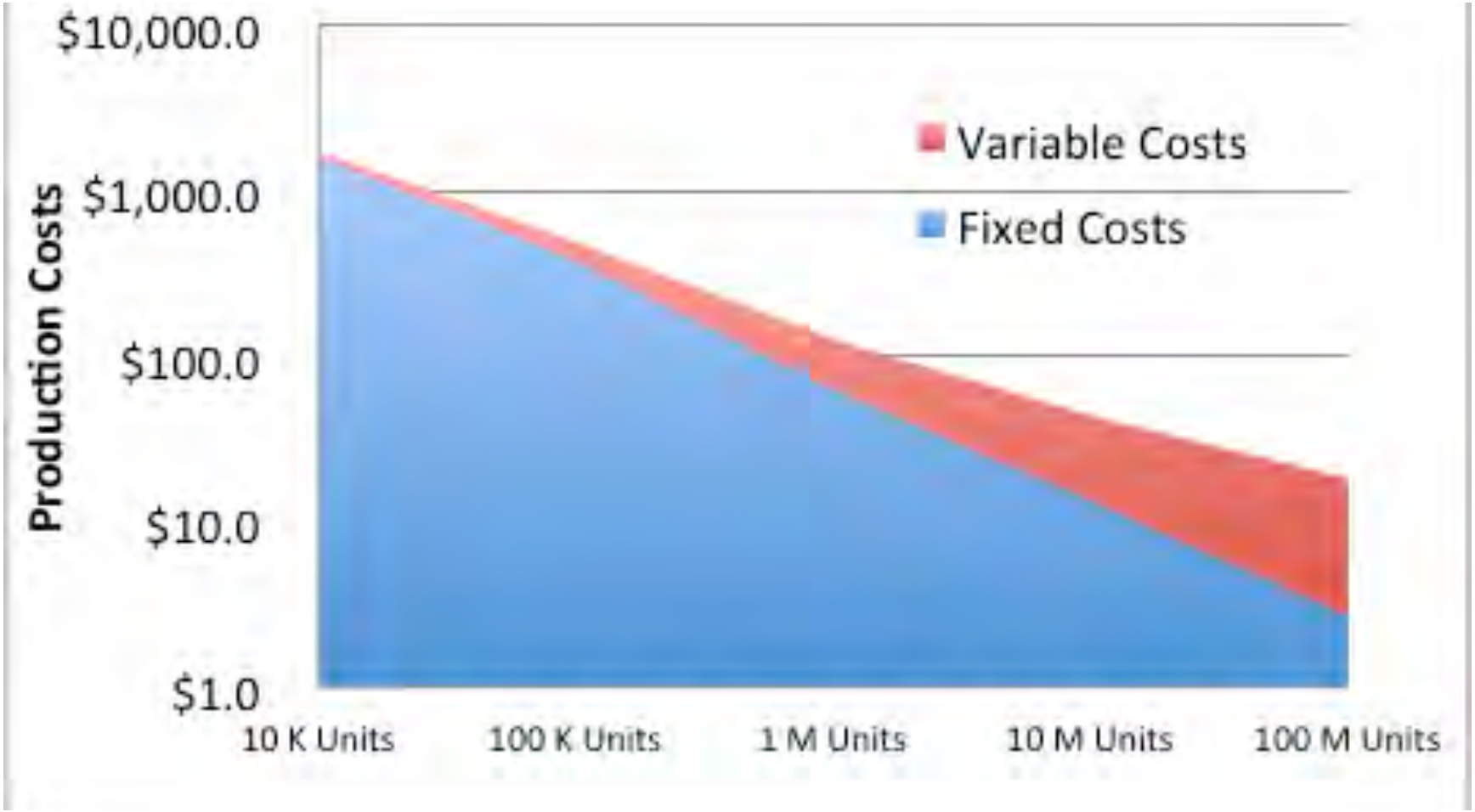
Smart Phone and Tablet Bill of Materials

Function	Smartphone	Tablet	Description
Display/Touch Screen			
Display	$23,00	$69,00	
Touch Screen	$14,00	$63,00	
Main PCB			
Memory			
Nand Flash	$20,00	$20,00	
DRAM	$8,50	$8,50	
Apps Processing			
	$20,00	$20,00	
Power Management			
	$8,00	$20,00	
User Interface			
Sensors	$5,75	$4,50	
Others	$2,00	$2,00	
Connectivity			
WLAN	$2,60	$2,60	
BT	$1,20	$1,20	
Mobile 3G	$2,70		
Touch Control/Drivers PCB			
Drivers	$11,75	$15,00	
Mech. / Electro Mech.			
	$38,00	$43,00	
Battery Pack			
	$5,50	$20,00	
Camera			
	$15,00	$2,50	
Box Content			

Rough Process for Invention and Design and Product Ramp

- We are promoting inventions that can be turned into manufacturable products

Example of Reduction of Unit Cost with Production Volume Due to Decline in Variable and Fixed Costs.



Objective

- The objective of this effort is to create a safe and sustainable mobile energy source for a mobile device, such as a smartphone, that will supply a week's worth of "normal" use without recharging from a fixed power source.
- The creation of longer lasting energy sources for mobile devices will have important technical and social benefits
- Can we create something like "Moore's Law" for mobile power?

One Week's Power Requirements

- Casual Cell Phone user: **36.3 Wh or 130,536 Joules (26 X the typical energy in cell phone battery)**
- Power Cell Phone user: **145Wh or 522,144 Joules (104 X the typical energy in cell phone battery)**
- **We need a battery equivalent of Moore's Law if this is to be accomplished in less than 50 years**

Allowable Solutions

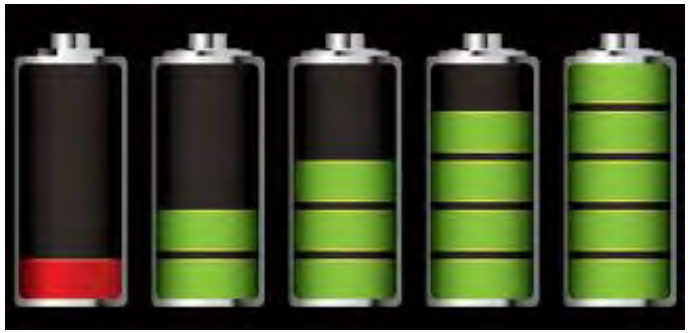
- Longer life, higher energy batteries (power storage devices)
- Other energy storage devices
- Energy generating technologies (such as fuel cells)
- Energy harvesting from the local environment (such as solar energy or user generated energy)
- Wireless power that doesn't require keeping the mobile device in close proximity to the power source
- Any other means for providing energy to the mobile device that doesn't require attachment or proximity to a fixed location energy source

Business Feasibility

- The technology must scale in price with manufacturing volume to a price that is affordable for a mobile consumer device (probably $20 or less at 100 M unit production)
- The product must be useful in all anticipated environments and conditions
- Once developed, this power system would be useful for other applications, including transportation, power management, power generation and other uses

Plans for this Initiative

- We held 2 workshops on this topic in 2014 and completed a white paper that is now available on the CE Society web site.
- In 2015 we will conduct 2 more workshops to further develop plans for this initiative
  - First workshop happened on **Sept. 16-17, 2015 in Milpitas, CA**
  - Next workshop planned Nov 2015 in Ireland
- We will also have a student competition around energy efficient applications



Safe Advanced Mobile Power Workshop and Student Competition

September 16-17, 2015 in Milpitas, California

Sponsored by the IEEE Consumer Electronics Society Future Directions Committee and the IEEE Future Directions Committee

We are currently seeking experts to participate in this 1.5 day workshop to discuss issues around power in mobile devices and the creation of an initiative to provide a week's worth of power for "normal" smart phone use without recharging from a fixed power source and meeting important requirements for mobile phones (and other mobile devices). In particular, we are seeking experts in the following areas:

- Battery technology for mobile devices
- Energy generation for mobile devices (e.g. fuel cells)
- Energy harvesting in mobile devices
- Wireless power for mobile devices (not including inductive charging)
- Mobile device (phone) current and future applications and power requirements
- General requirements for mobile devices (mobile phones)
- Business and manufacturing issues for mobile device and their power systems
- Safety and sustainability requirements/needs for mobile devices

The afternoon of the second day there will be a student energy efficient application competition

Call for Student Designers

- ***Can you design a more efficient mobile application?***
  - We will have two to three mobile application competitions in the Fall of 2015.
  - The first will be in in the San Jose, CA area and will be associated with a follow-on workshop on the Safe Advanced Mobile Power Initiative.
  - The second is going to be in November in Dublin, Ireland associated with our second SAMP workshop.
  - The competitions will be open to higher-level undergraduates and graduate students.
- There will be prizes for the top three winners of each design contest and recognition of the winners from the contests at the 2016 IEEE ICCE Conference in Las Vegas in January 2016.
- You can find more information about the contest and submit an application by June 30 using the form at: http://cesoc.ieee.org/images/files/pdfs/call_for_student_designers.pdf

Other Mobile Power Initiative Activities

- IEEE Battery Flipbook
- IEEE Battery Linkedin Group
- Plans for sessions on mobile power IEEE CE Society conferences
- Plans for articles in magazine related to mobile power
- Work on making mobile power a Major IEEE Future Directions initiative

Conclusions

- The IEEE CE Society Future Directions Committee is looking for volunteers to help create a vision for the future of consumer electronics
- There is a need for additional power in our mobile consumer devices, to meet our needs
- There are several options to provide this power in a safe and sustainable way
- The IEEE Consumer Electronics Society, in association with other groups, has created an initiative to promote the development of energy sources for a weeks worth of smart phone use without recharging from proximity to a fixed power source


Thanks