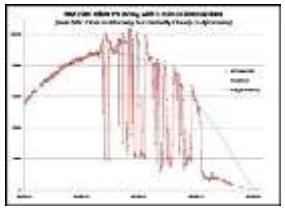




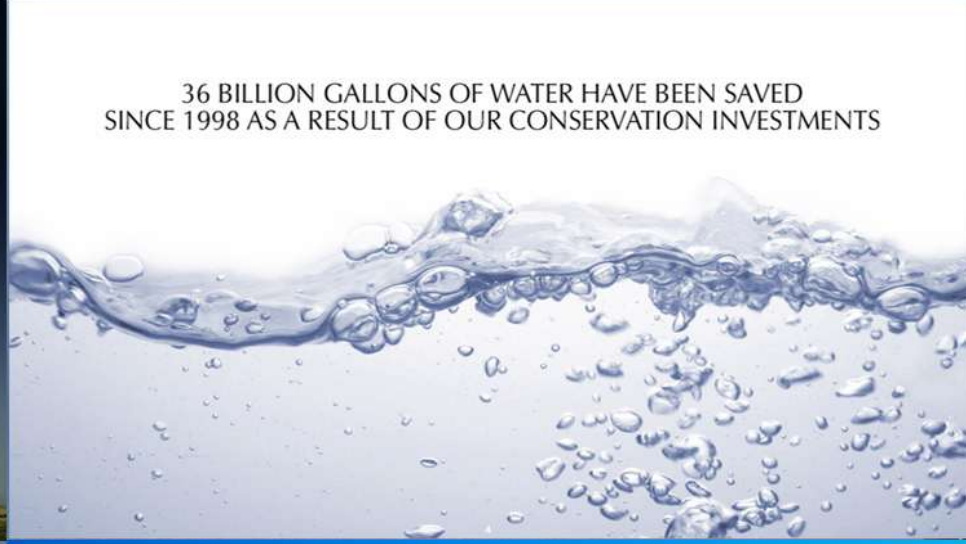


Beyond the Smart-Grid

The resurgence of Direct-Current and Intel research into Demand Side Management and intermittent renew energy

February 9, 2012

Guy AlLee
Research Scientist, Manager
NM Energy Systems Research Center
Intel Labs



Intel Vision & Strategy

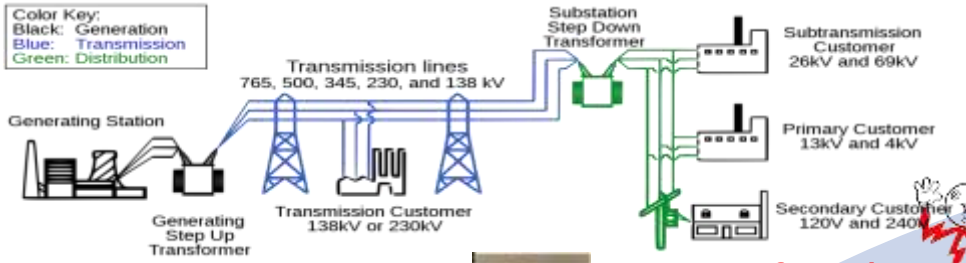
This decade we will create and extend computing technology to connect and enrich the lives of every person on earth.

- *PC, Datacenter, Adjacent Markets, Secure*
- *Care for our people, our planet*

Beyond the Smart Grid – Personal Energy Systems

- The Smart-Grid: automating the electricity supply system
- Personal Energy Systems can make user-centered energy a reality
- Microgrids
  - Local Generation
  - Local Energy Storage
- Plug-n-Play Energy Monitoring & Management
- Eco-Sense Buildings
  - Distributed sensors + personal feedback
- Zero Net Energy Buildings

Electrification: #1 Greatest Engineering Achievements of the 20th Century[1]



1990 Wind competitive with Utility generation

Trans forming!

"Alorming" Reforming

2000s California Energy Crisis, Northeast Blackout, Energy Policy Act of 2005

1970s EPRI, Energy Crisis, PURPA, Three Mile Island

Performing

1930s Hoover Dam, TVA, REA, Public Utility Holding Company Act of 1935, BPA

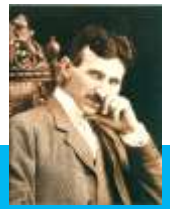
Norming

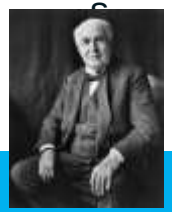
1905 Electric Utility as "Natural Monopoly"

Storming

1888 War of Current

Forming





[1] http://www.greatachievements.org/

Yesterday, Today and Tomorrow

Tomorrow

Gen.

AC

Trans

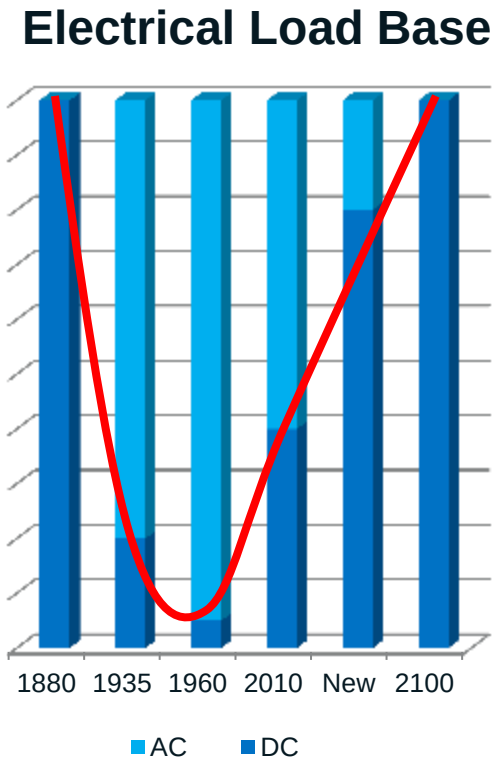
AC

Distr.

AC → DC

Load

DC



DC

DC

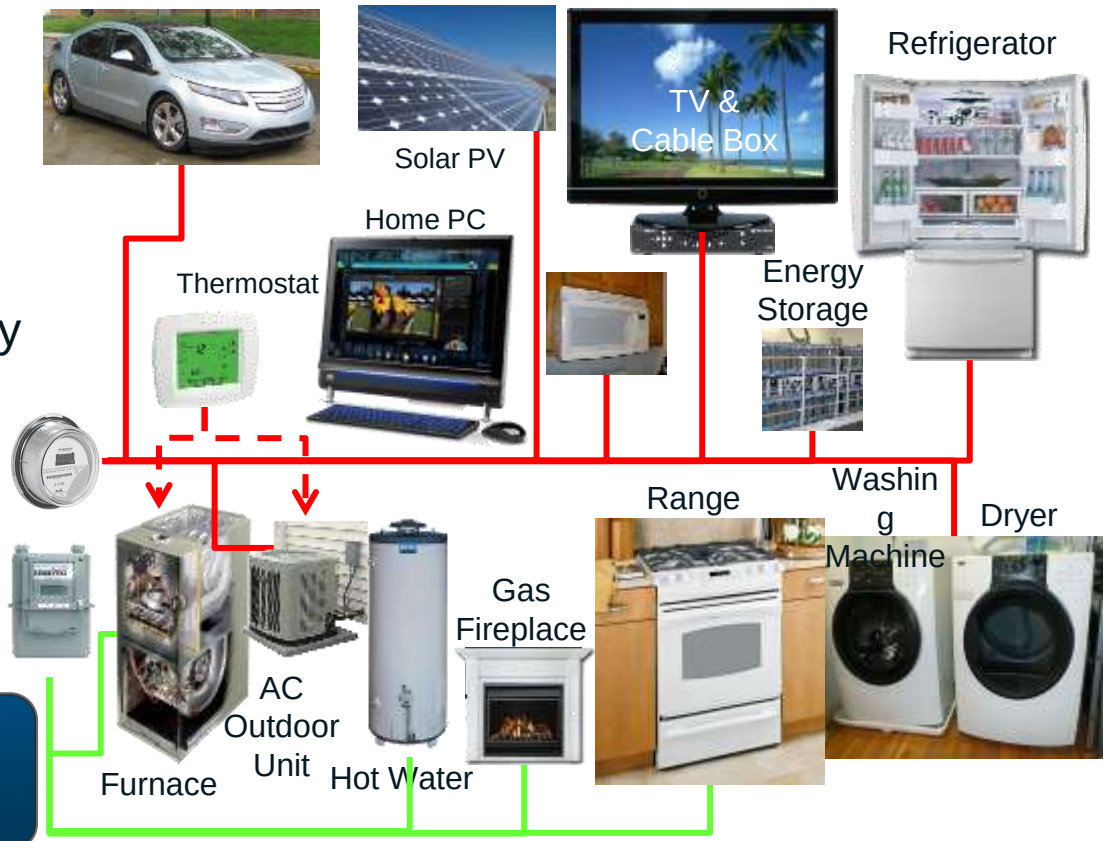
DC

D C

Direct-Current (DC) Microgrids

The world is already DC

- HVDC transmission
- 80% of power handled by power electronics (DC)[1]
- Sustainable /Alternate Energy (PV, Wind, Fuel Cells)
- Energy Storage (Batteries)
- Datacenters (ETSI 300 132-3)
- CFCs, LEDs, EVs, VFD



If we were doing the grid today, it would be DC

[1] Center for Power Electronic Systems [2] EMerge Alliance

Personal Energy Can Empower the Consumer

Rich Consumer Experience
- Simple home management
- Personalized Recommendations
- Significant energy savings
- Accurate budgeting
- Set goals, earn rewards, share results

Clear Utility Benefits
- Integrate with utility smart energy systems
- Enable demand response savings
- Leverage existing smart grid and meter investments
- Drive customer loyalty

Smart, Extensible Platform
- Integrate with 3rd party services like security
- Drive simple user interaction with intelligent analytics
- Extend with application store and new apps

Today, Computing Is Always At Our Fingertips

Part of Our Lives

Everyone Does It

Make it Personal, Open, Scalable, Sustainable

Wireless Energy Sensing Technology

- Energy savings from
  - Energy Monitoring – up to 15%
  - Energy Management – up to 30%
- Current Transducers can cost $400 to $1,000 to have an electrician install.
- WEST – Wireless Energy Sensing Technology
  - Consumer Installed – just plug it in
  - Sensing AC mains voltage variation and using inferencing engine to recognize loads
  - Integrates with standard WiFi
  - Works with Home Energy Monitors or web-based energy analysis
  - Currently in Field Research Trials

Home Energy Management

- 90% of home energy use is just a handful of devices
  - Electric Vehicles will pop to the top
- Energy Mgmt interest: ~2 weeks
- Monitoring must be automated
- Management must be policy-based
- Must be Self-CHOP: -Configuring, -Healing, -Optimizing, -Protecting
  - Privacy/Security must be built in
- Researching: Private & secure scheduling of appliances (HVAC, PEV, etc.) for optimal cost & comfort

Appliance	Consumer Perception
AC	7.93
Clothes Dryer	6.63
Water Heater	6.34
Refrigerator	6.23
Clothes Washer	5.47
Oven	5.01
Dishwasher	4.88
Television	4.54
Range	4.39
PC	3.94

10

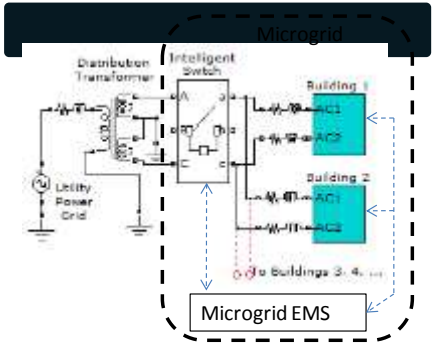
Source: *The New Energy Consumer* ZPryme Research and Consulting, May 2011

Eco Sense Buildings

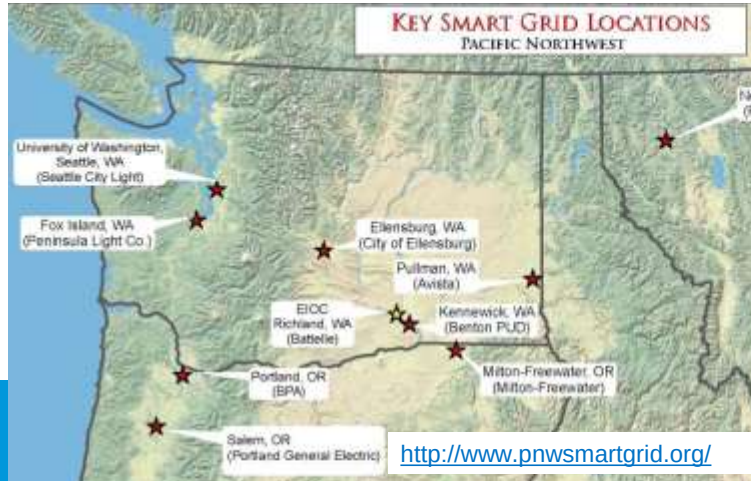
- 72% of Electricity used by Buildings
- 52% is plug loads (mostly IT); BMS (Building Mgmt Systems) mostly HVAC
- Extend IT technology in buildings for energy efficiency, comfort & safety
  - sensors to monitor and manage PC/IT power
  - Augment BMS with IT sensing: occupancy, ambient, task & comfort
  - Eco-feedback on PC – monitor and manage your own energy use

Microgrid control with Univ. of Colorado & PGE

- 2010-11 : Developed component and system models in a simulation platform to support investigations of architectural, control and optimization techniques in microgrids. (ECCE ‘10)



- 2011-12 : Using platform to develop an Energy Mgmt System for a microgrid planned in Portland General Electric (PGE) service territory as part of the Pacific Northwest Smart Grid Demonstration Project

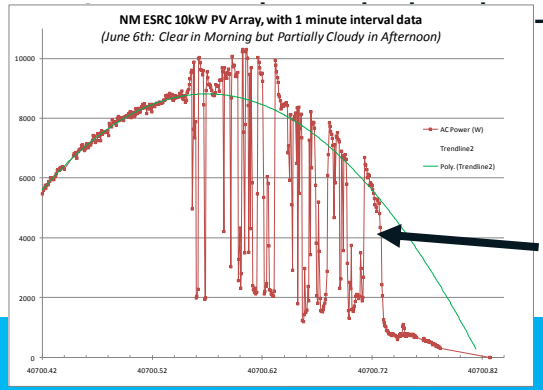


11

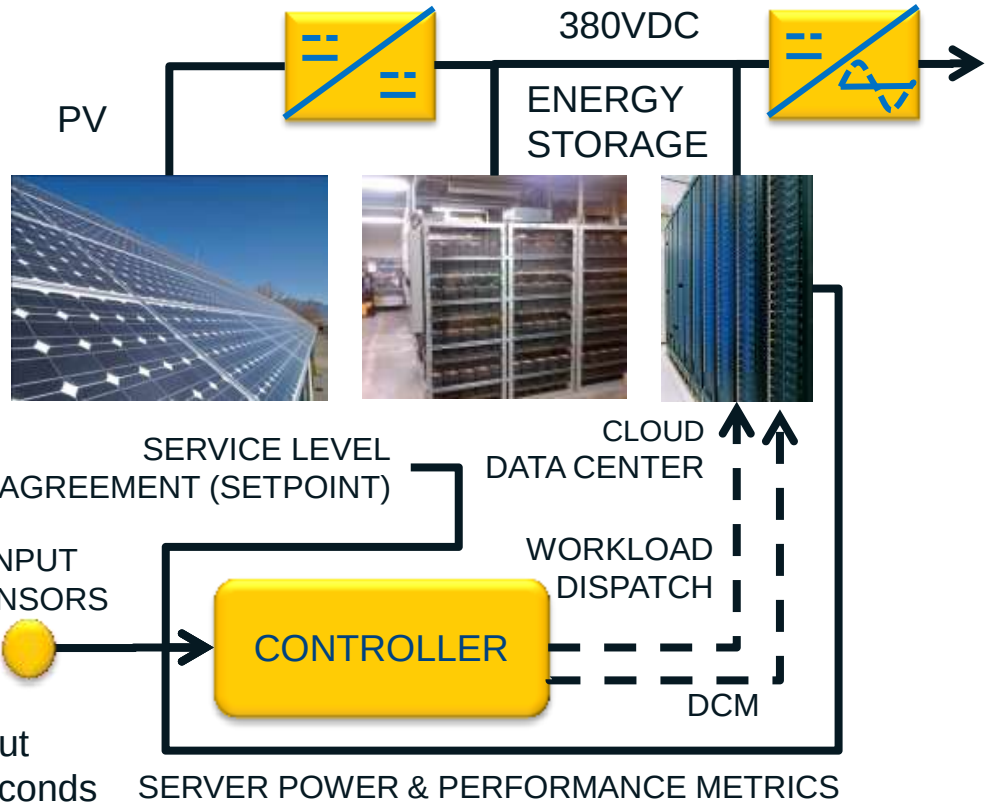
More Renewables on the grid with Micro-Dispatchable Loads

- The Smart-Grid can only add 20-30% alternate energy
- Use Cloud Data Centers, as a load
  - Balance Power vs. Workload
  - Stabilize & firm the output
- Augment Cloud Data Centers with Demand-Response revenue

-signal, …



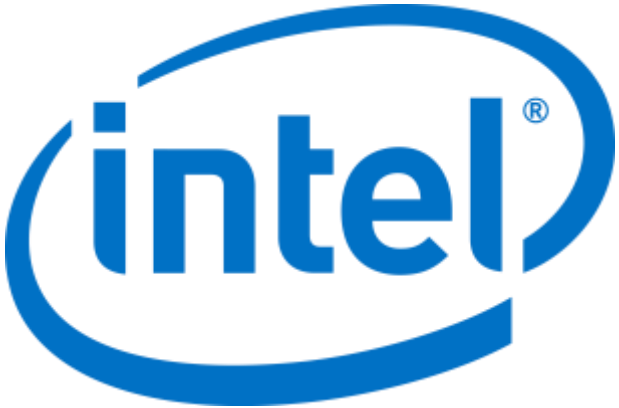
Clouds can take PV output To 20% in seconds



Summary

- The World is Becoming DC
- Personal Energy
  - Empowers the Consumer
  - Ubiquitous Ambient Sensing
  - Policy Driven
  - Self-CHOP
    Configure, Heal, Optimize, Protect
  - Open, Scalable, Sustainable
  - Revolutionizes Demand-Side Mgm
  - Creates the revenue stream to pay for the Smart-Grid

Personal Energy for a Sustainable Future


intel

Additional Sources of Information

Plug and Play Electricity http://blogs.intel.com/research/2010/04/plug_and_play_energy_efficienc.php

DC, An idea whose time has come and gone?
http://blogs.intel.com/research/2010/05/dc_-_an_idea_whose_time_has_co.php

“A Microgrid That Wouldn’t Quit,” IEEE Spectrum, Oct 2011
http://spectrum.ieee.org/energy/the-smarter-grid/a-microgrid-that-wouldnt-quit/0

EMerge Alliance http://emergealliance.org

Environmental view of 380VDC from Yale School of Forestry & Environmental Studies:
http://environment.research.yale.edu/documents/downloads/0-9/05-DC-Microgrids.pdf

Enernet: Internet Lessons for Solving Energy, Bob Metcalfe
http://www.slideshare.net/gigaom/bob-metcalfe-internet-history-applied-to-solving-energy

Electricity 2.0: Unlocking the Power of the Open Energy Network http://ndn.org/electricity20

SMART 2020: Enabling the low carbon economy in the information age, The Climate Group on behalf of the Global e-Sustainability Initiative (GeSI), ©2008 www.smart2020.org

World Energy Outlook 2009, International Energy Agency http://www.worldenergyoutlook.org/

Intel Corporate Responsibility: Doing Our Part for the Environment
http://www.intel.com/content/www/us/en/corporate-responsibility/eco-responsible-operations.html

Energy Savings
Opportunities for Building Owners

Building Applications *(in priority timing of EMerge Alliance*)*	% of Building Energy	Potential Energy Savings - DC	Keys to Maximizing Efficiency in Going DC
Interiors (Lighting)**	28%**	**Up to 15%**	LED, Renewables
Data/Telecom	17%	**Up to 30%**	Higher voltage conversions, Renewables
Service/Utility (HVAC)	36%	**Up to 10%**	Renewables
Outdoor	6%	**Up to 10%**	LED, Renewables
Other (misc equip loads)	13%	**Up to 5%**	Different voltage conversions

Vision: DC Microgrids Throughout Buildings

**Higher energy use in office buildings, up to 40%

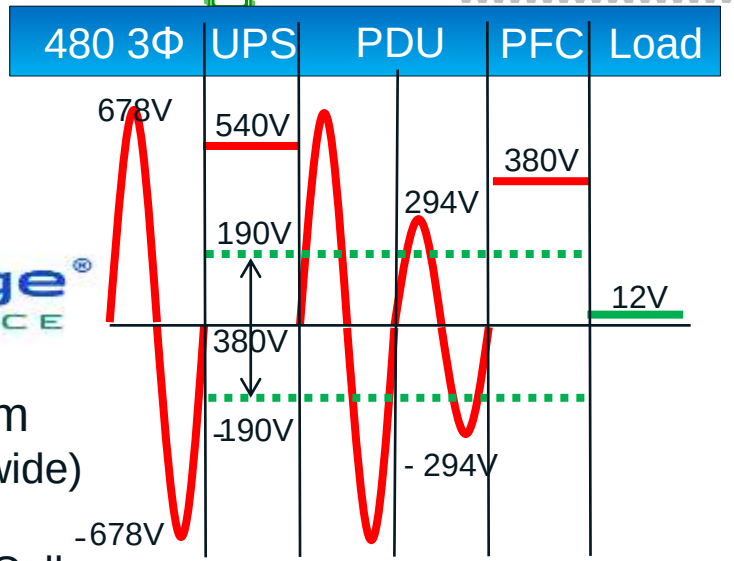
380Vdc – The New Standard

380Vdc has consistently demonstrated superior efficiency

- LBNL 2006, Intelec 2007, Intel, Emerson, HP Study 2009
- Fewest Conversions, Highest Voltage, Flexibility, Reliability

380Vdc has considerable advantages

- *28% more efficient than 208VAC[1]*
- *7% more efficient than 415VAC[2]*
- *15% less up-front capital cost in volume[2]*
- *33% less floor space[2]*
- *36% lower lifetime cost[3]*
- *200%-1000% more reliable[2]*
- *No Harmonics, As Safe or Safer[4]*



380Vdc has considerable support and momentum

- EPRI, EMerge Alliance (80+ organizations, worldwide)
- ETSI 300132-3-1 v2.1.13 (1) (2011), NEC 2014
- Applicable to lights, motors, EVs, PV, Wind, Fuel Cells

[1] Intel, Intelec Paper, 2007 [2] Intel, HP/EYP, Emerson, Whitepaper, 2009 [3]Validus/GE Study, 2010[4] IEC 23E WG2 as safe as 250Vac, safer than 415Vac

IEC 23E WG 2 – as safe as 250Vac, safer than 415Vac

Voltage to earth	Breaking times (s) AC	Breaking times (s) DC		
	Direct contact (IEC 60479) IΔn ac max= 30 mA	Direct contact (IEC 60479) IΔn dc max= 100 mA	Fault protection (IEC 60364-4-41)	
			TN	TT
400V	**560 Ω 714 mA Not possible**	**560 Ω 714 mA Not possible**	0,4	0,2
300V	**595 Ω 500 mA Limit.Not recommended**	**595 Ω 500 mA Limit. Not recommended**	0,4	0,2
250V	**620Ω 400mA 150ms safety margin for ac is aprox. 1/4 (40 ms)**	**620Ω 400mA 80ms Does not allow same safety margin as for ac**	0,4	0,2
200V (3 wires with Middle point grounded)		**640 Ω 300mA 150ms Allows comparable safety margin as for ac (1/4)**	5	0,4