CEATI • 1010 Sherbrooke Street West, Suite 2500, Montreal, Quebec, Canada H3A 2R7
www.ceati.com • info@ceati.com • Phone +1 (514) 866-5377 • Fax +1 (514) 904-5038

CESIG and SOIG Joint Workshop: "Utilizing Energy Management Systems (EMS) to Integrate Demand Response (DR), Distributed Generation (DG) and Storage"

May 7th, 2014

David Katz

Sustainable Resources Management

Former: Ontario Hydro System Planner

Financial Evaluations Officer

Member: Ontario Smart Grid Forum Corporate Partners Committee

Domain Expert on SGIP H2G/B2G/DRGS

Continental Automated Building Association

CEATI • 1010 Sherbrooke Street West, Suite 2500, Montreal, Quebec, Canada H3A 2R7
www.ceati.com • info@ceati.com • Phone +1 (514) 866-5377 • Fax +1 (514) 904-5038

Executive Summary

- *Ontario Sandbox effort and how it is under review in light of Smart Grid Award to Ryerson U.*
- *US NIST Smart Grid Interoperability Panel transition to global SGIP 2.0 Membership*

Agenda

I have contacted the authors of the following papers and presentations and they welcome the opportunity to have me share them with CEATI on the topic of the Integrating Renewables into the Home (Net Zero Homes)

- *2010-* **Modular power manager and gateway: an approach to home-to-grid energy management and demand response** Timothy Schoechle, Ph. D. 2010-11-16
- Integrating Renewables into Homes and Buildings(Elaboration on *Modeling Distributed Premises-Based Renewable Integration Using HOMER) @ 2011 GRID INTEROP*
- **Heart Akerson** CEO Heart Transverter -.**EPRI PQ and Smart Distribution 2010 Conference**
- **Heart Akerson at OSI Soft Conference at 2013**
- **CABA Home Area Networks in a Smart Grid @ Smart Energy Canada (if time permits)**
- **Transverter ETL/CSA Approval IEEE 1547 received.**

Discussion

- **SGIP Distributed Generation Microgrid Priority Action Plan**
- **Home 2 Grid DEWG White Paper on micro grid and micro gen including behind the meter**

Enabling Interoperable Solutions

- The modernized electrical power grid is expanding
- SGIP eases Smart Grid growing pains by
  - Comprehending customers' requirements
  - Engaging all stakeholders to identify and solve critical problems
  - Encouraging practical implementations
  - Overseeing the path to interoperability through Smart Grid standards for hardware, software and systems

Why Achieve Interoperability

- Reducing the distance to integrate
  - Reduces installation and integration costs
  - Creates well-defined points in a system for new applications
  - Enables substitution of automated components
  - Provides an upgrade path that preserves system operation
  - Increases opportunity for multiple vendors to compete
  - Allows for easier integration of new capabilities & features

Smart Grid Interoperability Panel

orchestrates the work behind power grid modernization

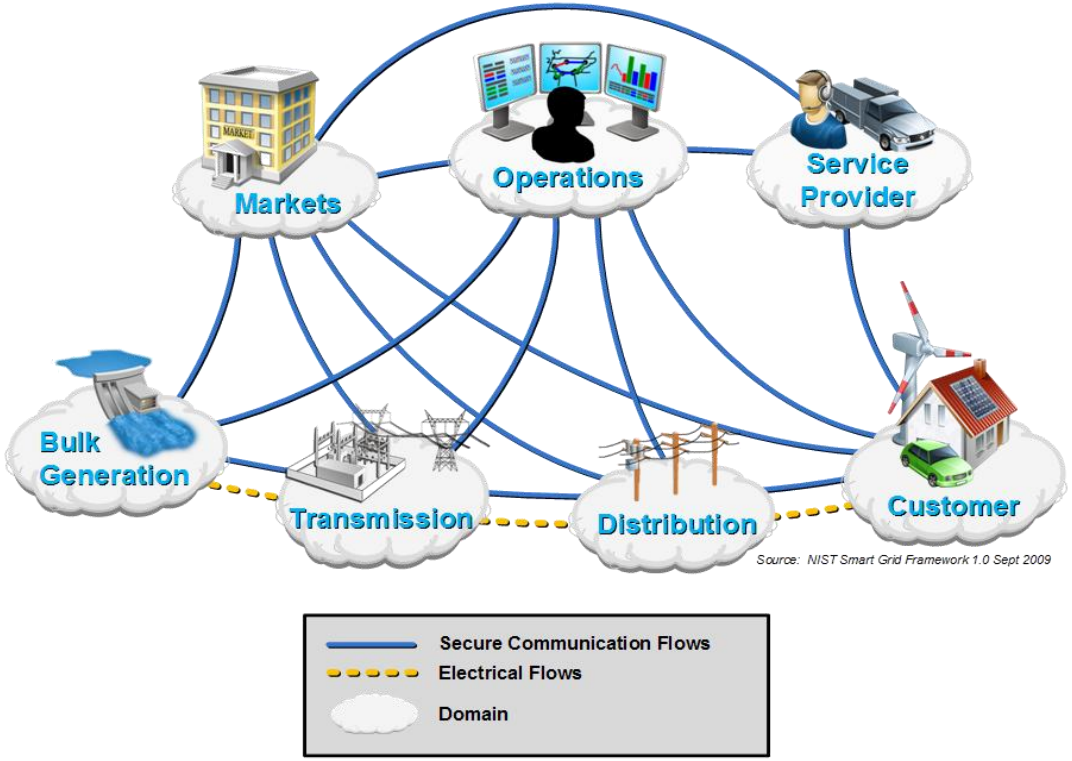
SGIP Reduces Risks and Costs

- Optimizes resources and time
- Avoids proprietary vendor lock-in
- Helps build technology roadmaps
- Simplifies decision making

SGIP is a collaborative, transparent, and trusted forum to share standards information and practical, hands-on knowledge about deployments from industry experts.

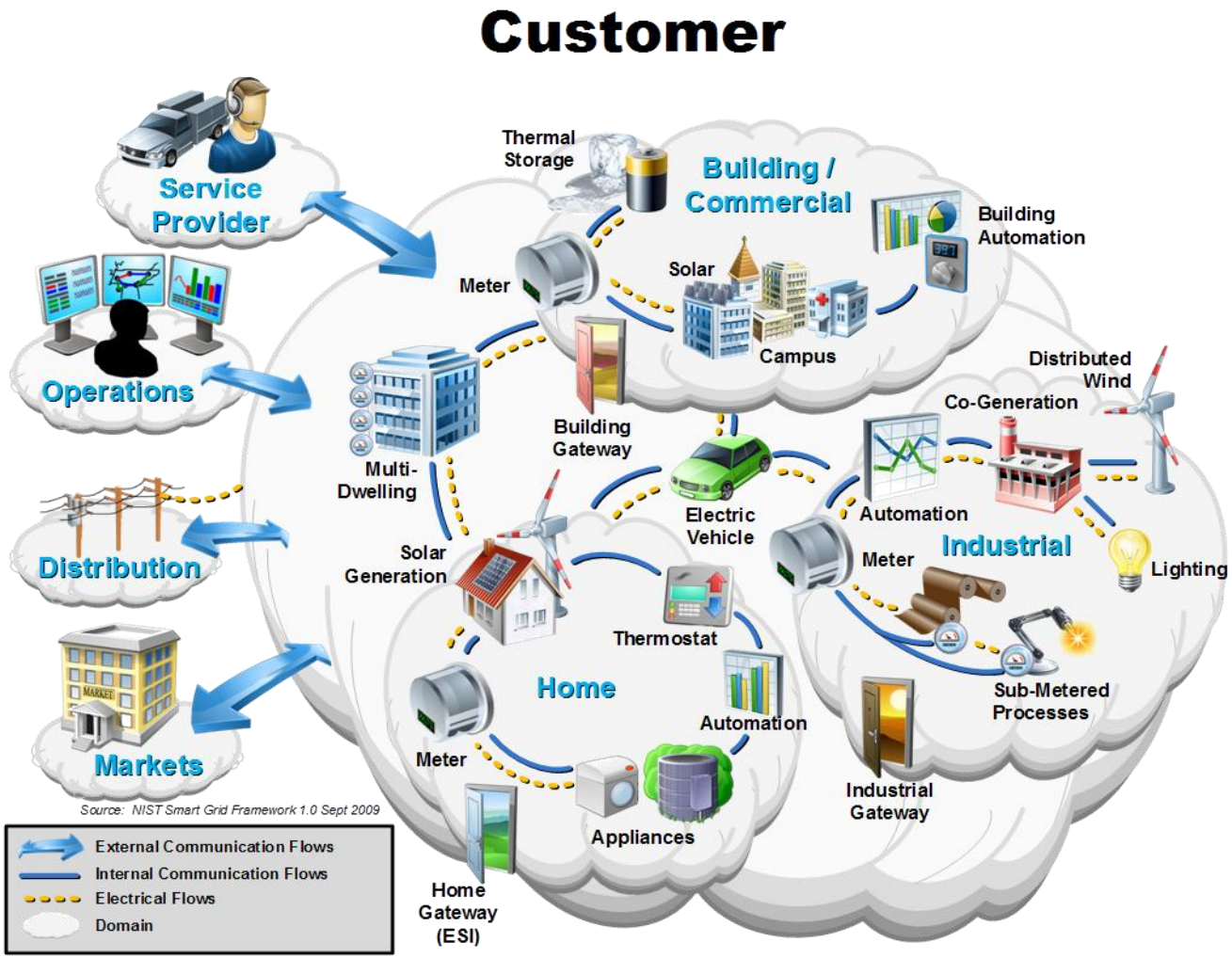
Smart Grid Conceptual Model

The SGIP Smart Grid Conceptual Model, showing the seven “domains” of the Smart Grid



(http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/SGConceptualModel)

Smart Grid Conceptual Model



SGIP Member Groups Activities

SGIP Members

- Electric Utilities
  - Investor Owned Utilities, Rural Electric Cooperatives, Municipal
  - Renewable Power, Transmission System Operators, Retail, Financial Market
- Governments & Regulators
  - Federal & State agencies
- Manufacturers
  - Appliance, Industrial, Vehicle, Power Equipment, Communications, Information Technology, Integrators
- Associations and Standards Development Orgs (SDOs)

SGIP Member Groups

Membership

Domain Expert Working Groups (DEWGs)

- Building to Grid
- Industry to Grid
- Home to Grid
- Vehicle to Grid
- Transmission & Distribution
- Business & Policy
- Distributed Renewables, Generation & Storage

Priority Action Plans (PAPs)

- Wireless Comm - 02
- Energy Storage Interconnect - 07
- Distribution Grid Mgmt - 08
- Standard DR & DER Signals - 09
- Map IEEE 1815 to IEC 61850 - 12
- Power Line Comm - 15
- Wind Plant Comm - 16
- Facility Smart Grid Info Std - 17
- Wholesale Demand Response - 19
- Green Button ESPI Evolution - 20
- Weather Info - 21
- EV Fueling Submetering - 22

Standing Member Committees

- Architecture
- Cybersecurity
- Implementation Methods
- Testing & Certification

Work Products

- Conceptual Models & Roadmaps
- Requirements
- Use Cases
- Whitepapers
- Standards Evaluations
- Catalog of Standards

Grid-Interop™

Modeling distributed premises-based renewables integration using HOMER

Nathan Johnson (HOMER Energy)
Peter Lilienthal (HOMER Energy)
Timothy Schoechle (Smarthome Laboratories, Ltd.)

#GridInterop

Grid-Interop 2011

Grid-Interop

Integrated modeling and control of smart microgrid power systems

Grid-Interop

Smart microgrids

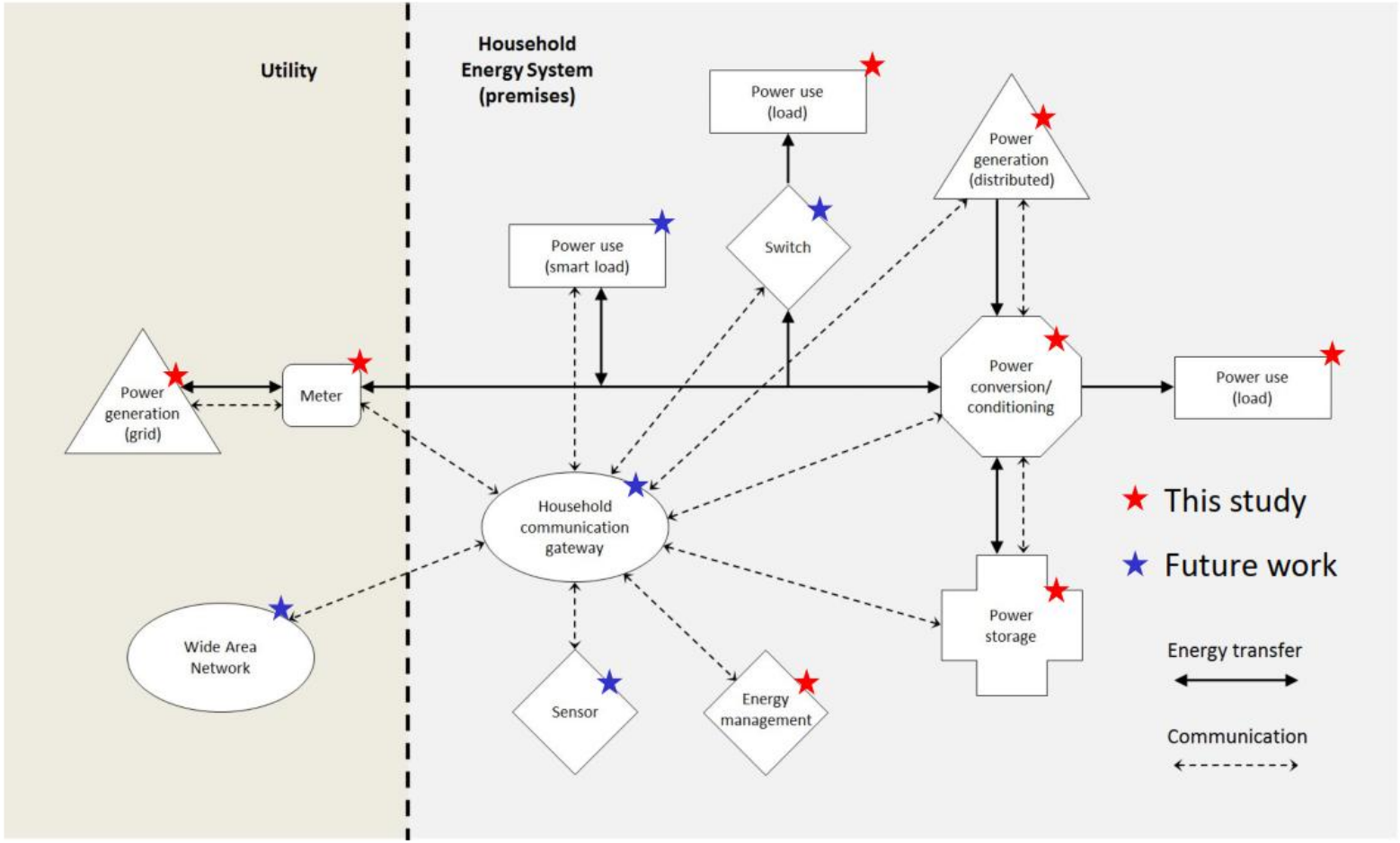
Energy management

- Arbitrage
- Demand response
- Frequency control

Distributed generation and storage

- Solar PV
- Combined heat and power
- Wind
- Electric vehicles
- Batteries, fly wheels, hydrogen tank, reservoir

Premises-based energy system architecture



The Heart Transverter

The HT2000 power module is a Universal Power Converter that bi-directionally transfers power between any combinations of its four connections.

The Transverter can simultaneously be any combination of inverter, grid-tie inverter, UPS, solar charge controller, DC-DC converter, and programmable power supply.

HEART transverter

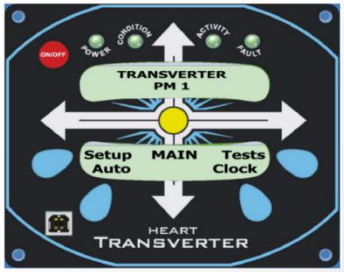
Smart Grid Product Line

Transverter	Load Controller	Micro Utility
• Bidirectional Inverter • Uninterruptible Power • DC – DC Converter • Solar Charge Control	• Demand Response • Load Management • Data Logging • Power Analysis	• Energy Computer ™ • Energy Storage • Energy Operator System

HT 2000-Transverter

T13-X Load Controller

HTREM Remote Panel



HOMER modeling

Simulation — Hourly for one-year: generation, storage, use

Optimization — Lowest net present cost for each system configuration

Sensitivity — Test power system robustness

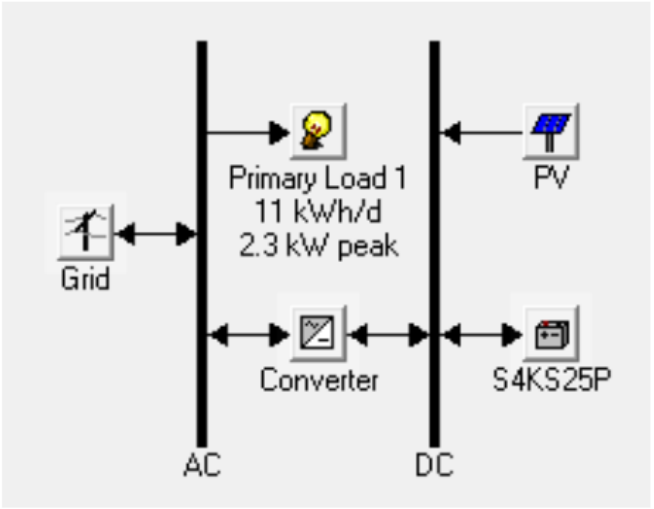
Residential solar PV in Boulder, Colorado

Use: single family, July peak

Generation: grid, PV

Storage: battery bank

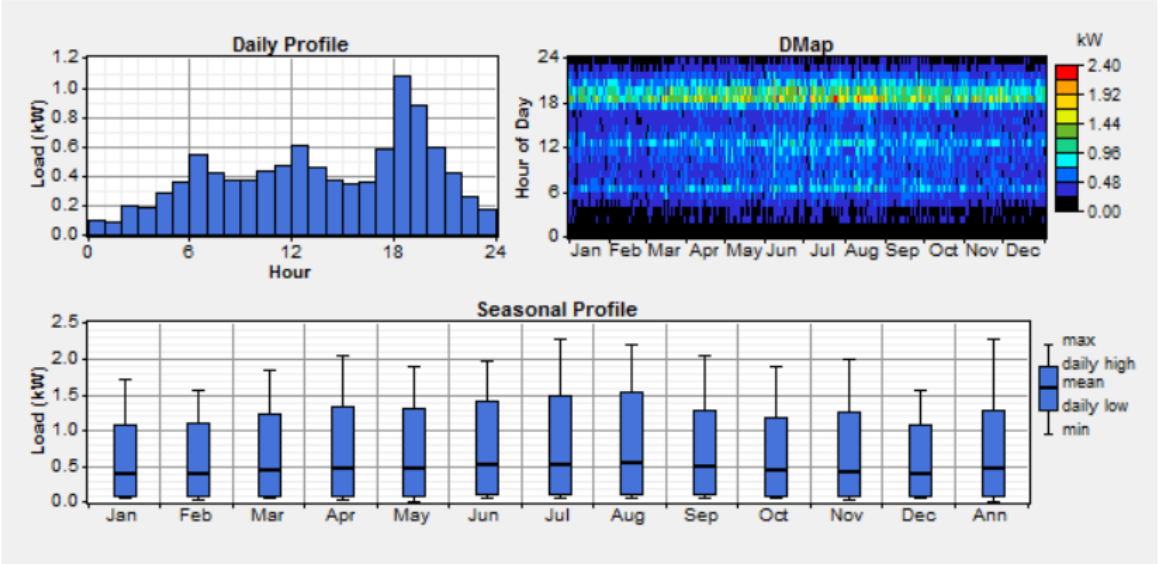
Conversion: Transverter™



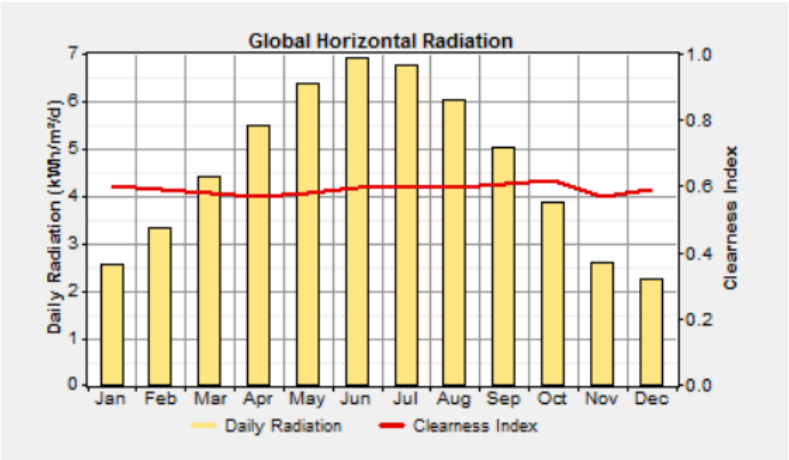
Power system configuration options

Grid-Interop

Load



Radiative flux



Technology parameters

Solar PV

2.6 kW max capacity, $4000/kW, 25-year lifetime

Transverter™

2 kW, 91% rectifier efficiency, $1500, 15-year lifetime

Battery

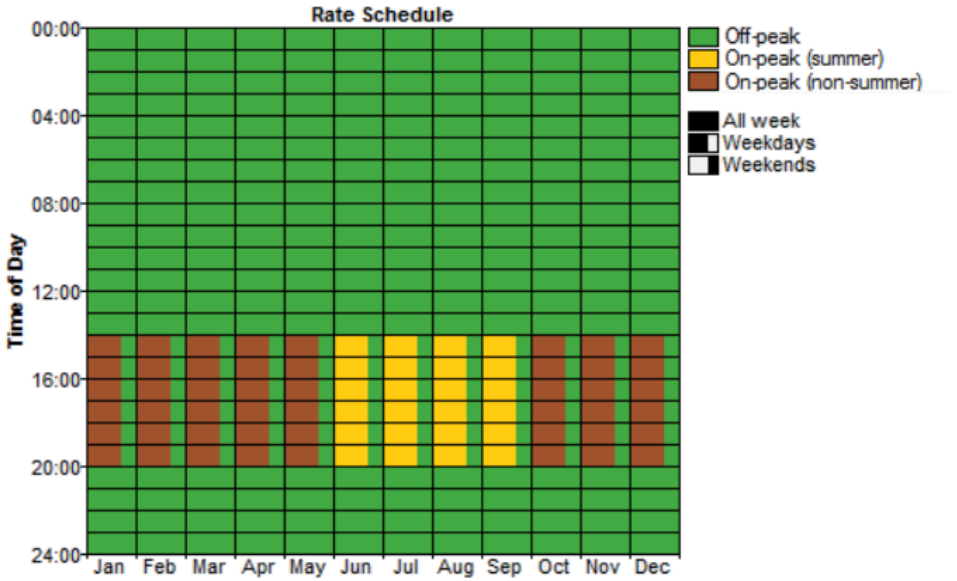
Surrette 4KS25P, flooded lead-acid, 7.6 kWh, $1200, $60/yr O&M, max throughput ~10,600 kWh

Grid-Interop

Time-of-use pricing

Time-of-use (pilot program)	Price ($ / kWh)
Off-peak	0.100
On-peak (summer)	0.249
On-peak (non-summer)	0.121

Tiered (typical rate)	Price ($ / kWh)
Non-summer	0.105
Summer (< 500 kWh)	0.107
Summer (>= 500 kWh)	0.157



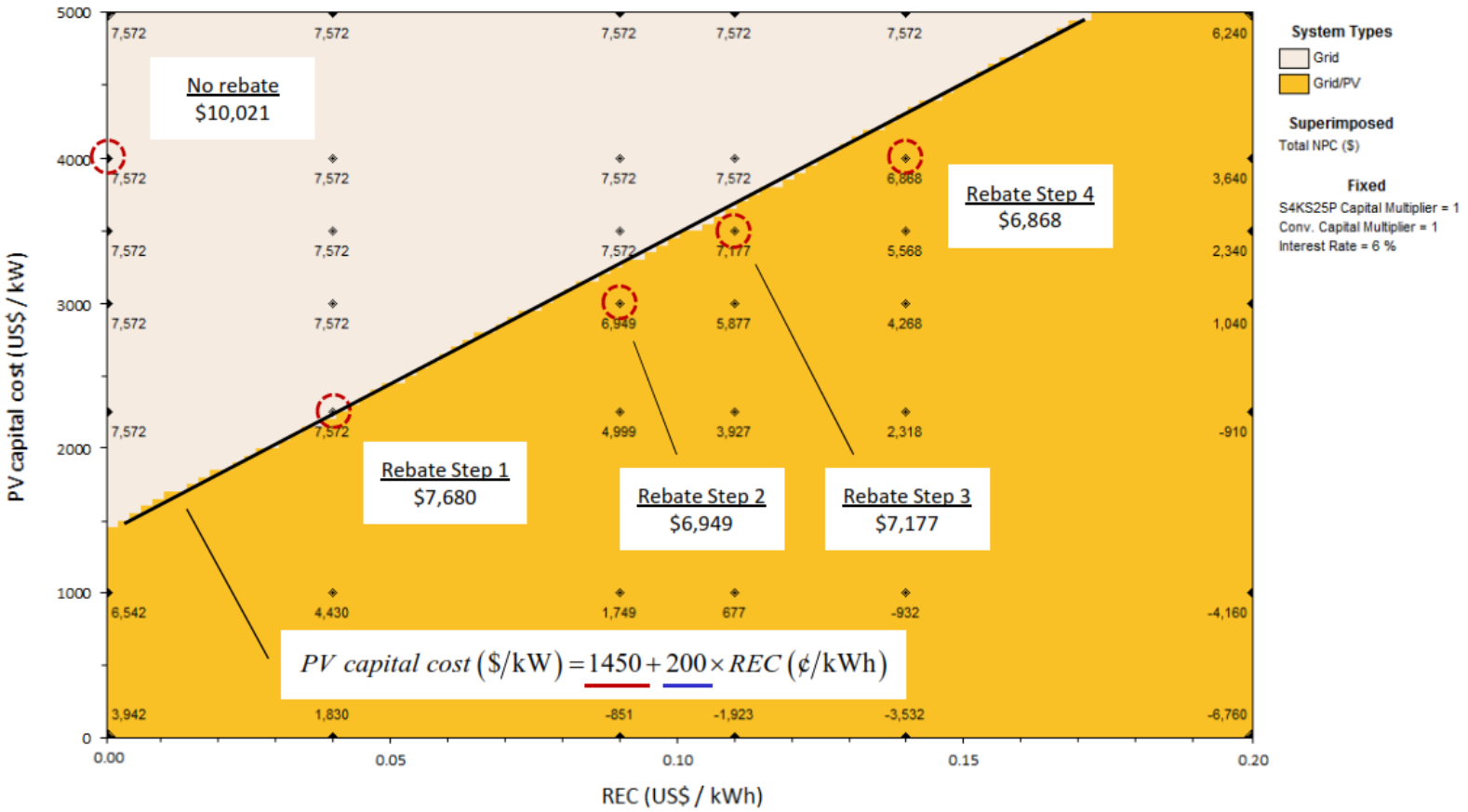
Grid-Interop

Sensitivity analysis

- PV capital cost (Xcel rebate)
- PV throughput credit (Xcel rebate)
- Transverter™ cost
- Battery cost
- Grid electricity price
- Real interest rate
- Energy management controls

Step	Capacity rebate ($ / W)	REC ($ / kWh)
1	1.75	0.04
2	1.00	0.09
3	0.50	0.11
4	0.00	0.14

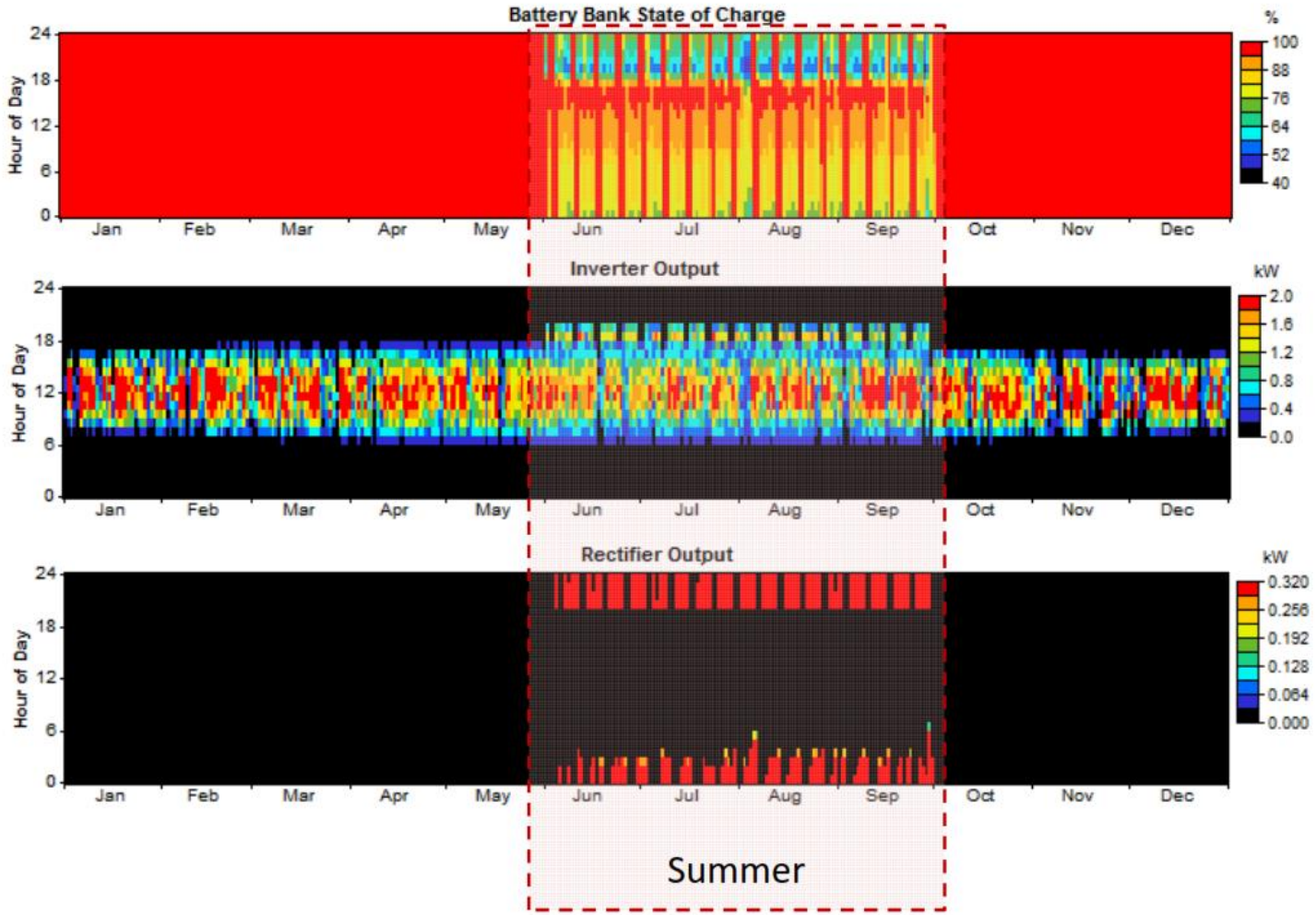
Optimal System Type graph (OST)



Net Present Cost for Grid only: $7,572

Grid-Interop

Battery and converter use



Grid-Interop

Sensitivity analysis

Battery cost needs to reduce by 90% to be cost-effective

A 10% increase in grid electricity price increases the cost of a grid-only system by $626, and a grid/PV system by $76

A $1,000 decrease in Transverter™ cost is equivalent to a reduction in PV capital cost of $500 to $800 / kW

Reducing the real interest rate improves the cost-effectiveness of a grid/PV system

Future work

Demand response

- Individual load modeling
- Prioritization of loads
- Controls for individual household loads
- Programmable dispatch decisions

Link microgrid modeling with real-time control

Intermittent grid failures

Questions?

Nathan Johnson
nathan@homerenergy.com

Peter Lilienthal
peter@homerenergy.com

Timothy Schoechle
timothy@schoechle.org

Download software at www.homerenergy.com

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Hydro Québec

HEART TRANSVERTER

Heart Transverter

Implementing the Smartest Grid for the Least Amount of Time and Money

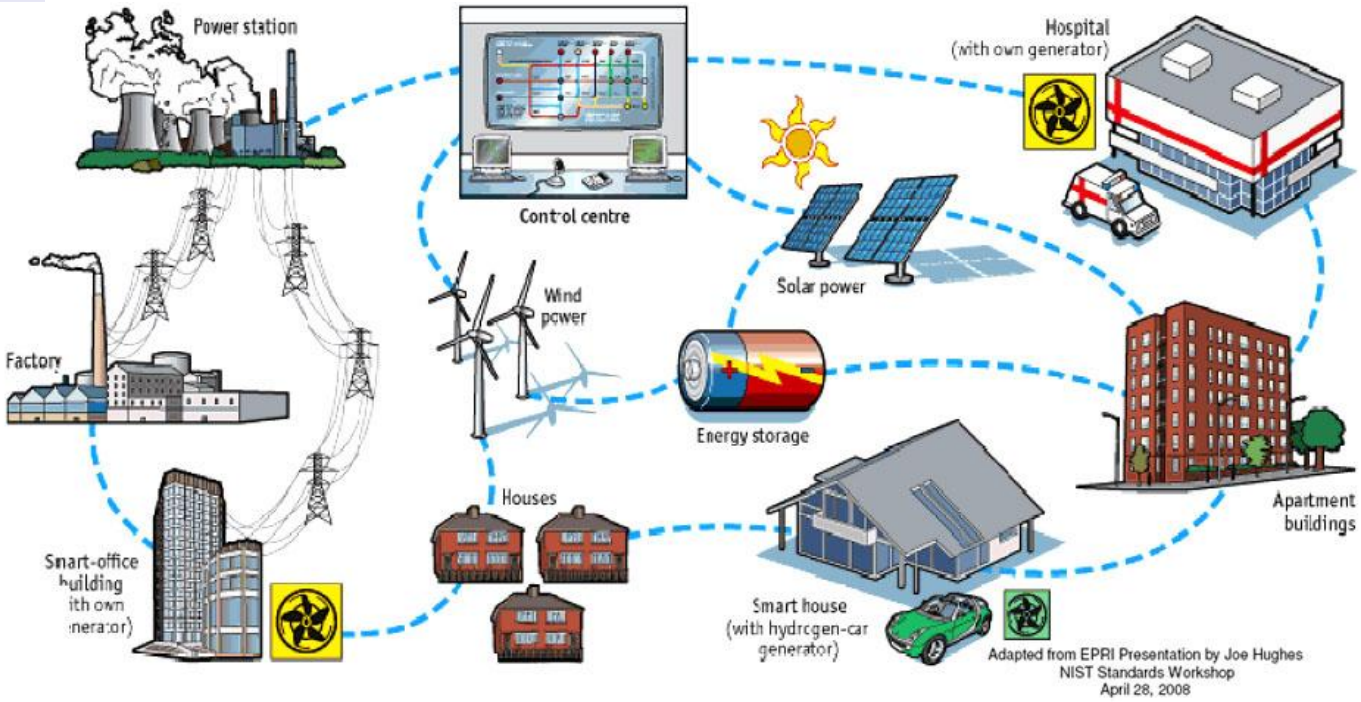
Heart Akerson
CEO Heart Transverter S.A.

EPRI PQ and Smart Distribution 2010 Conference and Exhibition

Transporting You into the 21st Century Distribution System

June 14–17, 2010

The Popular Smart Grid Idea: Data Intensive Monster



EPRI estimates this will cost $165 Billion and take 20 years to install.

Real time decisions involve detailed data being sent all the way to the central control center and then back to each device.

This idea depends on an extremely complicated high speed communications network that is a combination of HAN, FAN/AMI, WAN & LAN (the blue dotted lines). The software to manage this amount of data processing will be cumbersome and introduce major new security risks.

The Grid could be inundated with calls about why someone's washing machine doesn't work.

There is no autonomous energy security for the office or home.

The Problem: Dynamics of the Typical Home or Office

1.7 kW average load ⟷ 100 amp service 24 kW peak load

Electricity is mostly billed by the kwh but the dynamics heavily influence the true cost.

Peaker plants deal with the dynamics but use hydrocarbons, are expensive and pollute.

The hidden cost of Renewable Energy is more dynamics which means more peaker plants.

Imagine a world where the houses used a flat 1.7 kW with no dynamics. Imagine a world where RE was integrated into every home driving the grid load to a flat 1.2 kW, still with no dynamics.

This is the REAL SMART GRID.

100 houses need 170 kW average with possible peak of 2.4 MW

Typical load varies between 100 kW and 270 kW

This brings up ideas of complex rate structures for peak and off-peak.

There is a driving need for energy security.

The Real Smart Grid (One House at a Time)

Local Data - Local Decisions

Global Summaries - Global Guidelines

100 amp service → 50 amp service

PHEV

Heater

Frig.

Hot Water

HVAC

Well Pump

6 Relays with Current Sensing (30 amp)

T13X AMI & Load Management

4 Line Voltage & Current Sensing (100 amp)

AC GRID

AC Generator

4 kW Power Modules

AC in

AC out Data

920 watts solar expands to 4 kW

6 kWh Battery Bank Lead Gel or Li-ion

4 kW critical loads, lights, electronics, frig., UPS

Remote Panel

LAN to GRID, Neighbors, Smart Appliances

Typical House or Office System (One House at a Time)

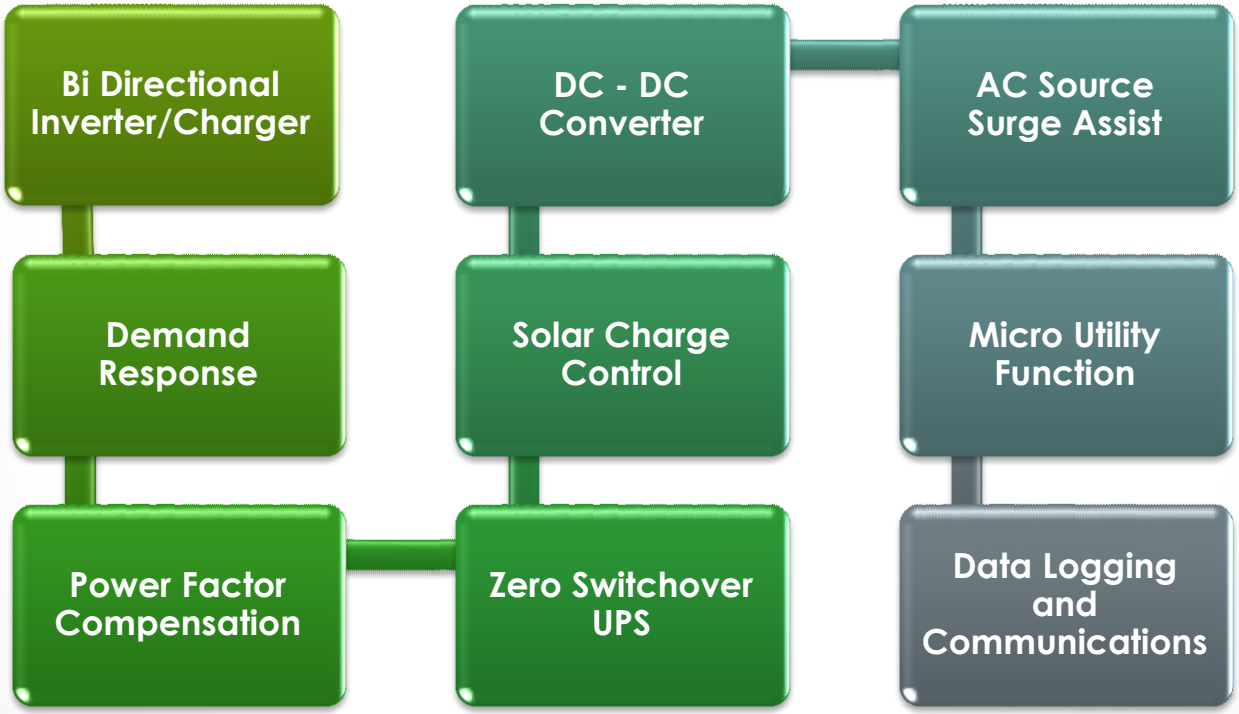
Boulder 4 kW UPS, 920 w Solar, 138 kWh solar per month	QUANTITY	COST	EXTENDED
SOLARWORLD SW230-mono MODULE 230W 24V MC4-Blue	4	$ 928	$ 3,712
TRANSVERTER POWER MODULE 2000W	2	$ 2,000	$ 4,000
TRANSVERTER REMOTE PANEL	1	$ 200	$ 200
TRANSVERTER T13X (Smart Grid in a Box)	1	$ 600	$ 600
MK S31-SLD-G 12 V 108AH BATTERIES GEL	6	$ 262	$ 1,572
Hardware, wires and other B.O.S.			$ 782
		TOTAL	$ 10,866

IMPACT OF 100 HOUSE PROJECT

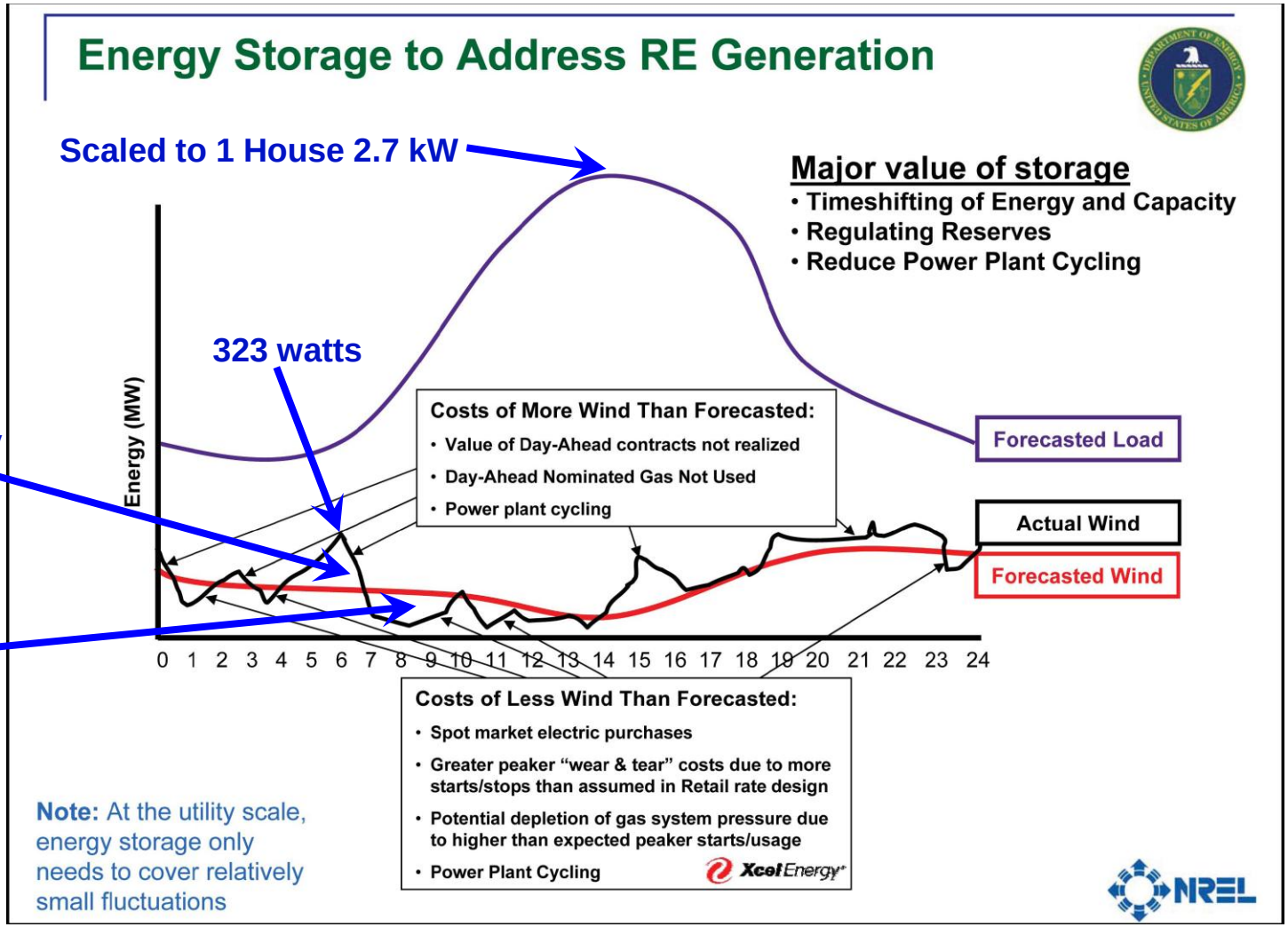
- END USER COST $1,087K, RAW MATERIALS $746K, LOCAL INSTALLERS $341K
- REDUCED ENERGY CONSUMPTION BY 20% SAVING OVER 23 MWH / MONTH
- PRODUCING 13.8 MWH SOLAR / MONTH AND REDUCING GRID BY 37 MWH/MONTH
- SOLAR CAN BE EXPANDED UP TO 60 MWH / MONTH AT CUSTOMERS OPTION
- AUTOMATIC SURGE ASSIST TO GRID OF 400 KW
- AUTOMATIC POWER FACTOR CORRECTION TO GRID OF 400 KW
- DEEP DATALOGGING, REAL TIME INFORMATION & DOCUMENTATION
- 100 AMP SERVICE → 50 AMP SERVICE BY AUTOMATIC LOAD SEQUENCING ABSOLUTELY CUTS THE COST OF THE ELECTRICAL INFRASTRUCTURE IN HALF
- COMMUNITY ENERGY STORAGE CAPABILITY IN PLACE (JUST SET THE RULES)
- INDIVIDUAL HOME ENERGY SECURITY, 6 KWH OF BATTERY BACKUP + SOLAR
- FEEDS THE R&D EFFORTS OF EVERYTHING IN ENERGY & SMART GRID SECTORS

HEART transverter

Differentiating Features



Making Renewable Energy Real (One House at a Time)



Charging .485 kWh
8% battery capacity
@ C/19

Discharging .474 kWh
8% battery
capacity @ C/28

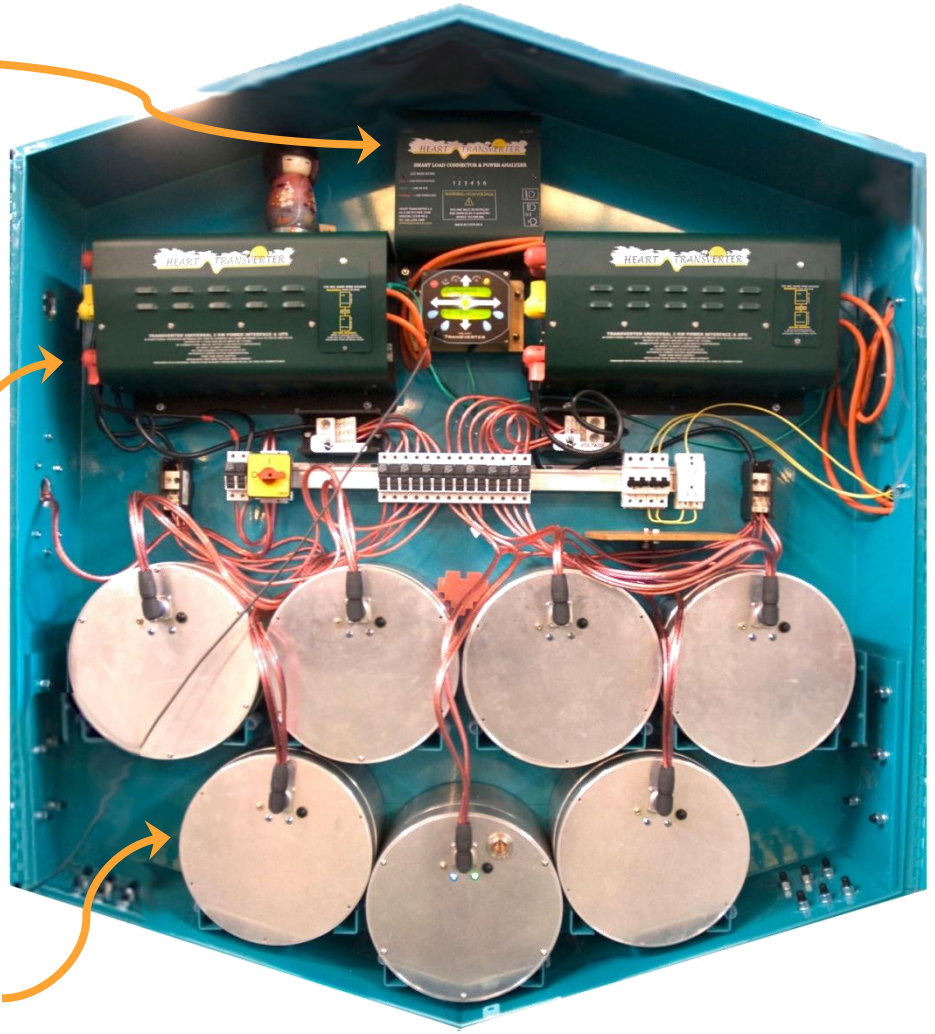
Community Energy Storage (One House at a Time)

T13X SMART GRID

4 kW OF POWER MODULES

Growing Energy Labs CES installation in San Francisco

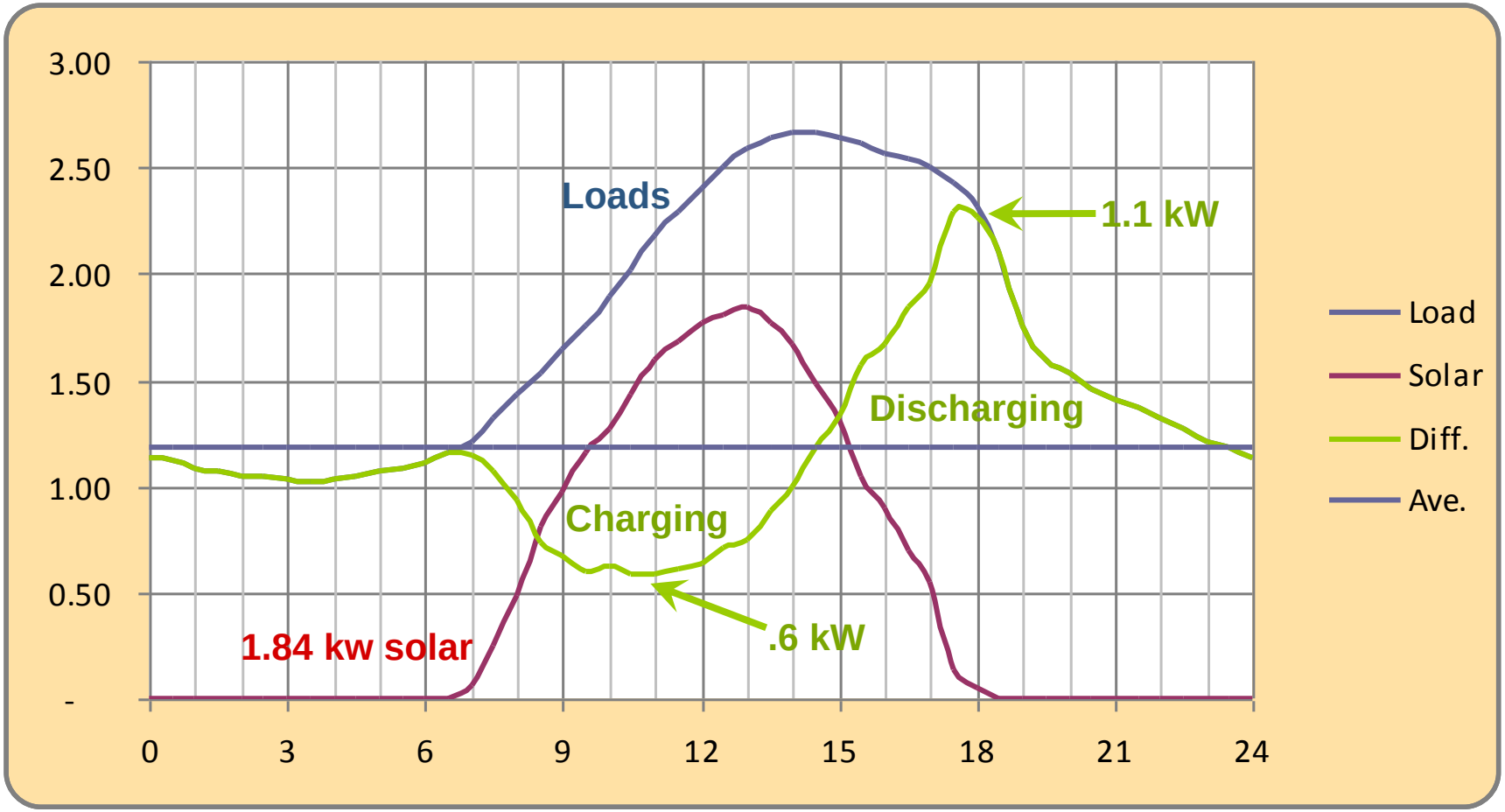
14 kWh LI-ION BATTERIES
Cycle Life > 10,000



Balancing Loads with Solar, One House at a Time

Daily Charge-Discharge 3.9 kWh = 65% of 6 kWh battery
Charge @ C/10 Discharge @ C/5

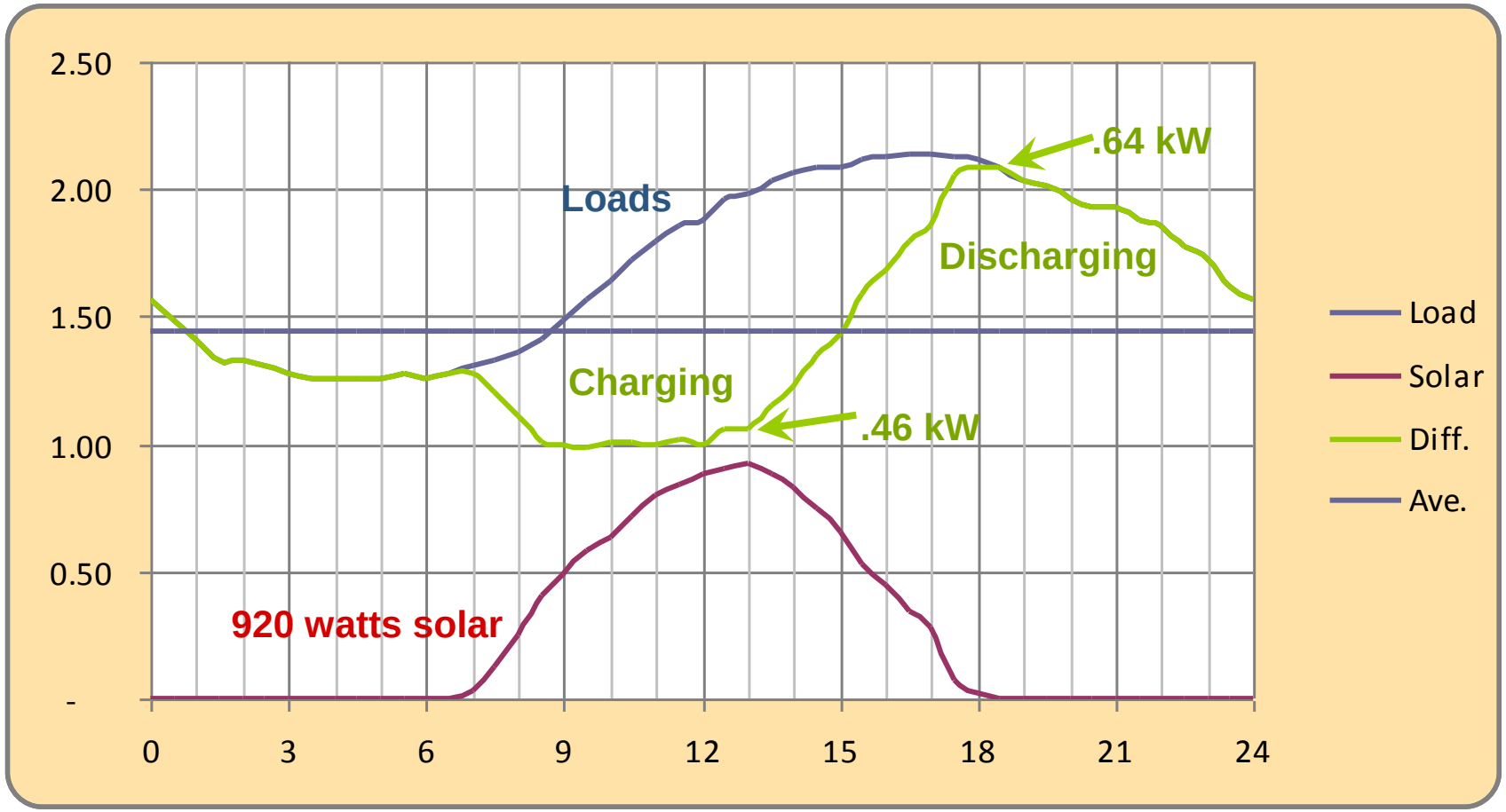
NREL Model



Balancing Loads with Solar, One House at a Time

Daily Charge-Discharge 3.7 kWh = 62% of 6 kWh battery
Charge @ C/14 Discharge @ C/9

CA July 8th



Two of Today's Real CES Options

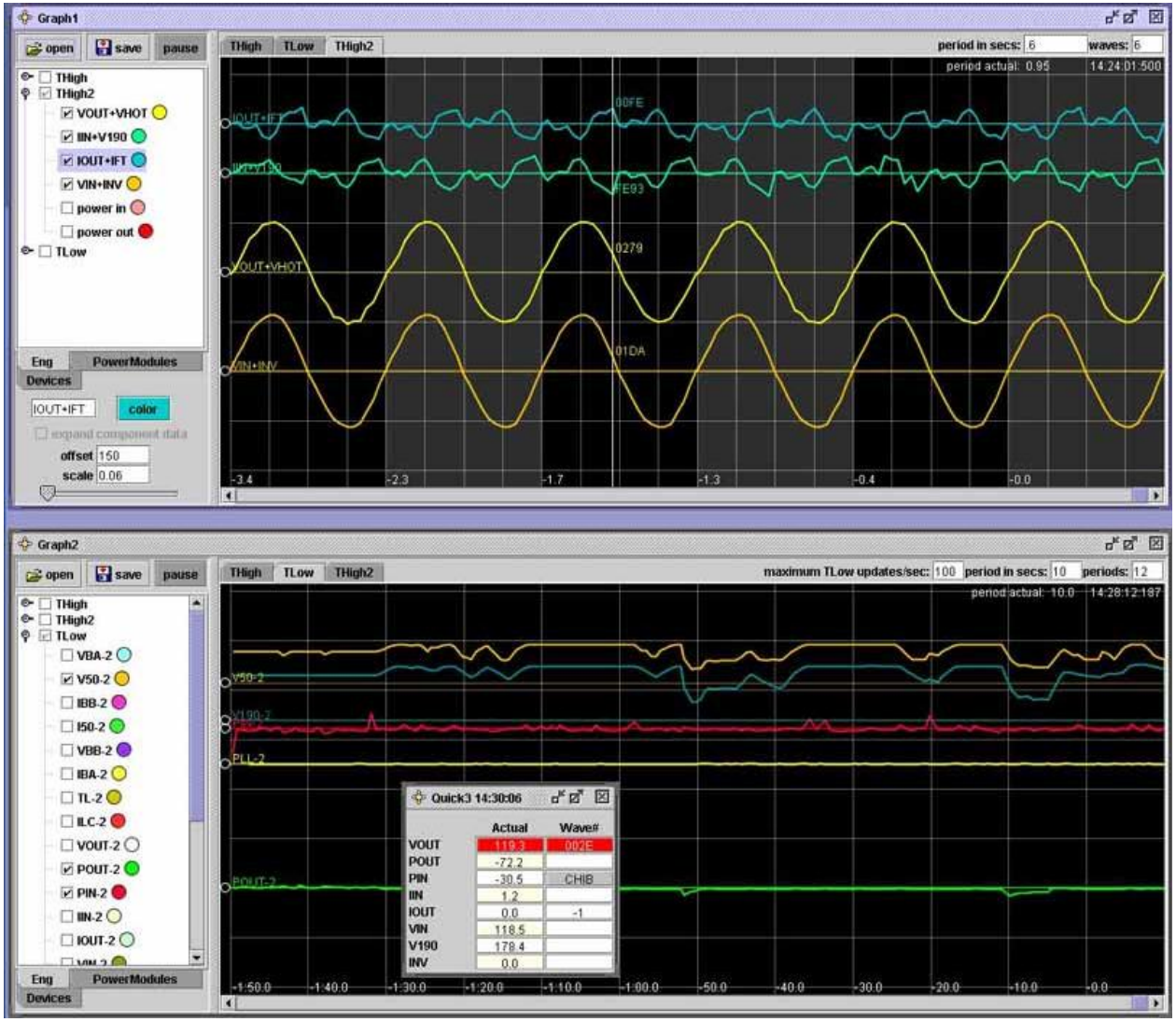
1 MW CES Price $1 M

You need to pay the people who operate and maintain it. Real estate also extra. Installation costly and complicated.

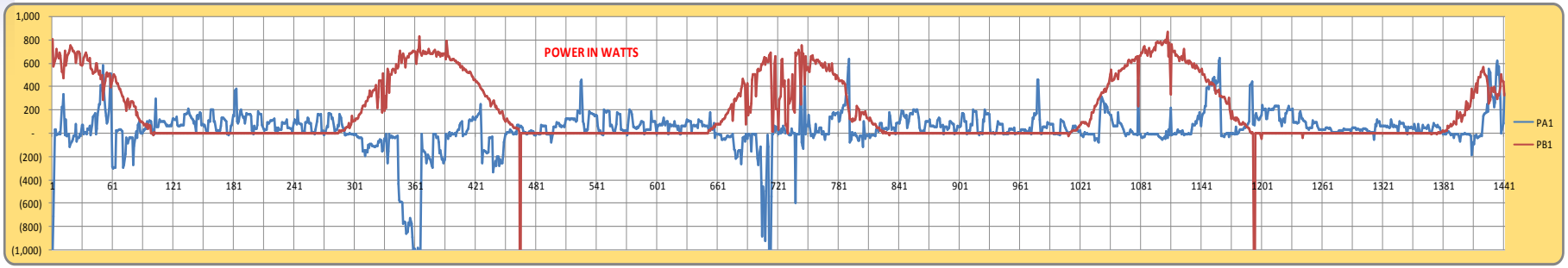
400 kW CES Price already paid for by the owners. The people who operate and maintain it work for free. Real estate included. No installation.

Advanced Waveshape Analysis & Mathematical Models

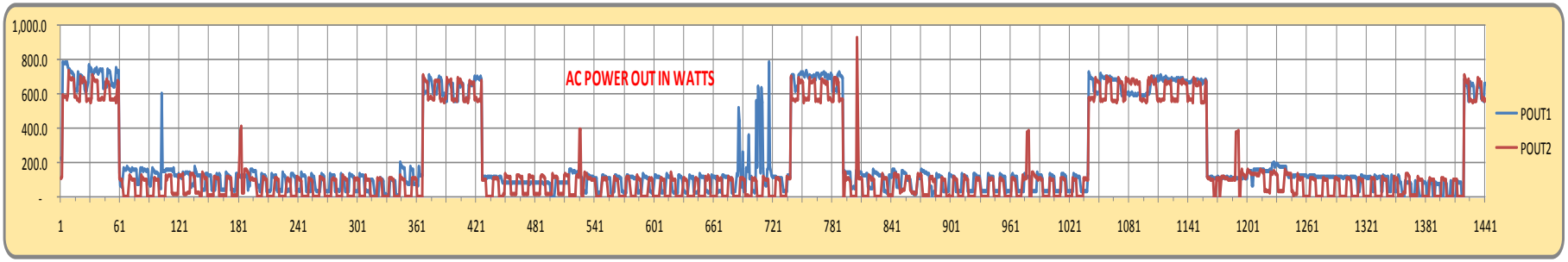
- **Dense FPGA logic enables new levels of performance.**
- **Immune from system lockups that plague microcontrollers**
- **Emulates all test equipment via USB to PC.**
- **Creates both the most detailed live data plus the most compressed math models.**
- **Detailed real time power factor and harmonic analysis.**
- **Seamless updates of all logic via internet**



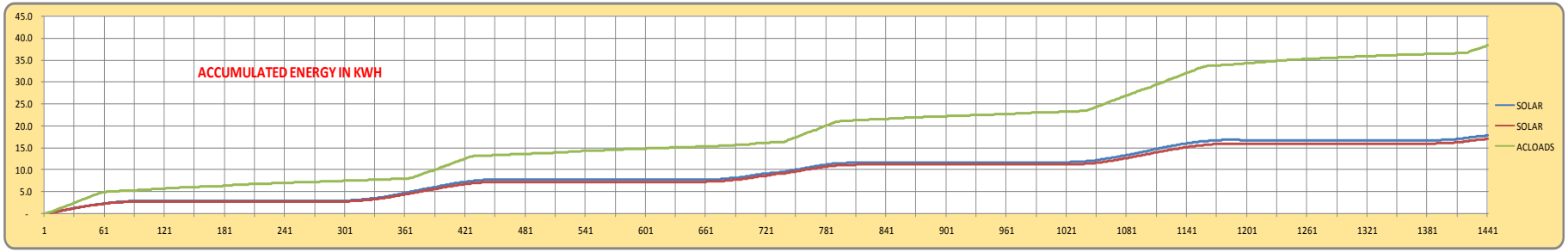
Advanced Data Logging (One House at a Time)



AUTOMATIC ADVANCED DATA ANALYSIS & MODELING STORED IN FLASH



PRODUCT IMPROVEMENT & FAULT PREDICTION

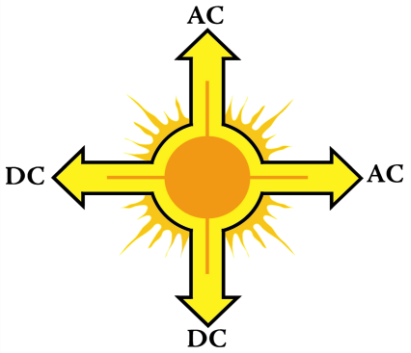


SERVICE LEVEL AGREEMENTS

Where do we go from here?

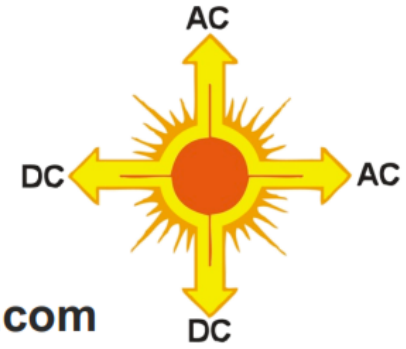
HEART TRANSVERTER

Implement 100 house test projects in every state and province. This will:



- **Engage the individual home owners.**
- **Reduce the grids actual cost to provide each kWh.**
- **Lower the cost of the electrical infrastructure.**
- **Integrate RE for the lowest possible cost with the highest stability.**
- **Provide individual house and office autonomous energy security.**
- **Provide Smart Grid benefits to the grid companies while minimizing the data processing burden.**
- **Create a real test bed environment for Smart Grid software developers.**
- **Provide a state of the art energy lab for every "2 guys in a garage".**

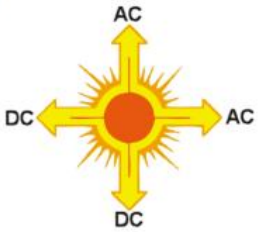
An Evolutionary Solution for High-Density Solar Integration on the Distribution Grid

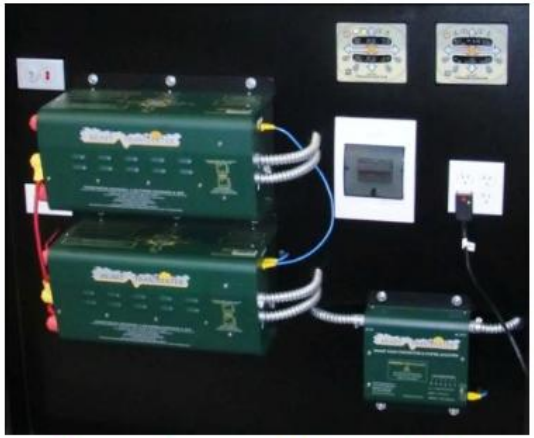


Presented by **Heart Akerson**
CEO Heart Transverter **www.transverter.com**

Redesigning the Bee rather than the Beehive

Often, we can perceive big problems and then envision big solutions but sometimes, if we just open our eyes a little wider, we can see that most of the elements of the big solution are already there, but in small pieces. We have designed the Transverter to connect all of those small pieces together so that we can have a realistic effective restructuring of the electrical energy sector that can be deployed immediately.





Business Challenge

- High Integration Solar is forcing the Grid to implement Peaker Plants.
- Smart Grid data is overwhelming the communication structure and data processors.
- Most consumers want solar energy yet there is public resistance to the Smart Grid.
- No one wants to increase budgets.

Solution

- Thousands of small smart autonomous systems integrating energy storage, solar & demand response.
- Aggregate data and control parameters into a hierarchy of larger, easy to perceive & control, blocks.
- Super fast response times enable new levels of stability.

Results and Benefits

- Infinitely Scalable in small increments for comparable cost.
- Higher quality precision deep data with vastly less data burden.
- Autonomous operation enables microgrids which increases security.
- Practically eliminates transmission loss.

PV Integration Issues

Utility Issues

- Voltage Regulation
- PV Intermittency Mitigation
- Real and reactive power support
- Dynamic VAR injection
- Protection Coordination
- Phantom Generation Management
- Communications capability

Consumer Issues

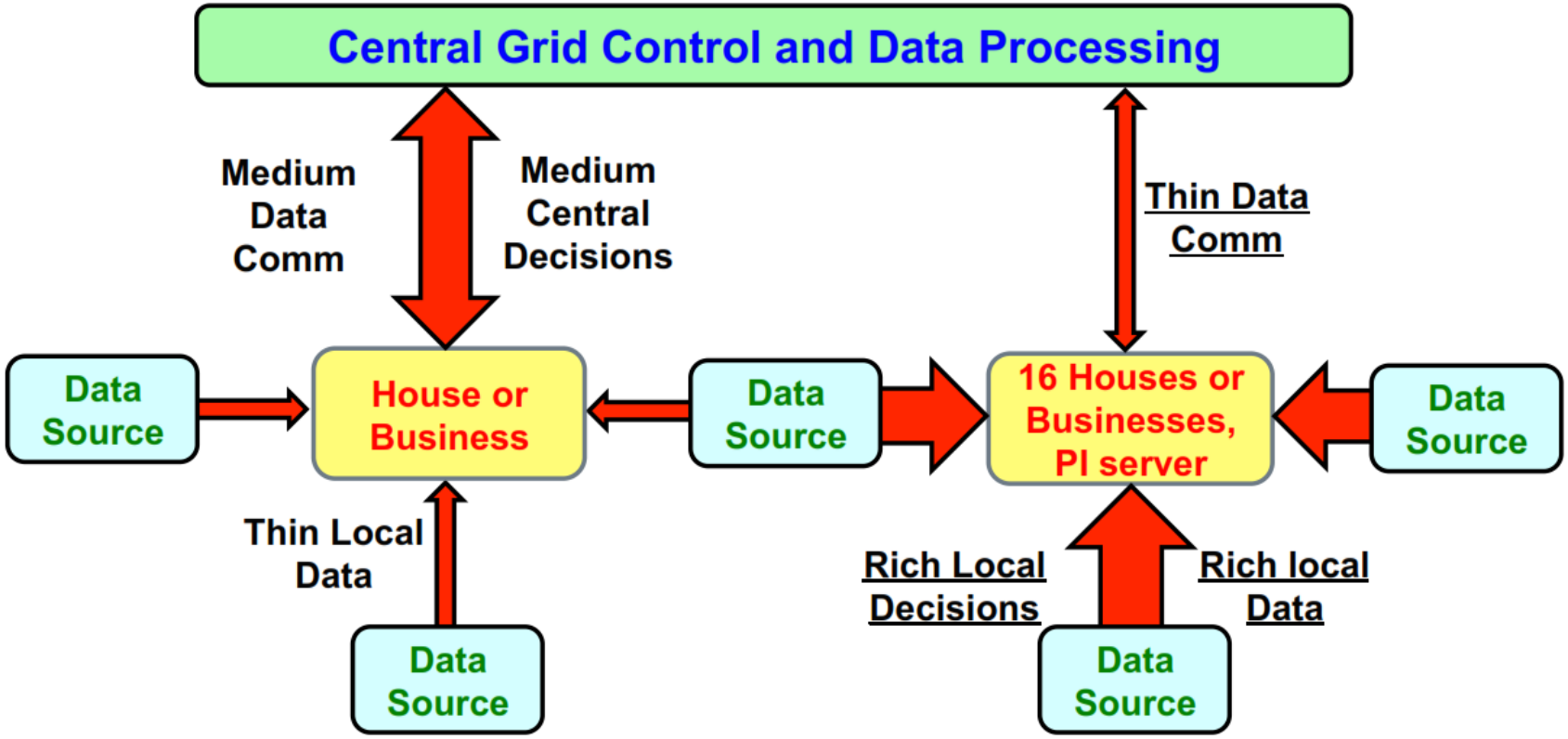
- Under-frequency trip out
- Low voltage ride through
- KWh Generation missed opportunities
- End of Feeder Voltage Regulation
- Use of Solar during Blackout

THE CONSUMER DATA SHEET

1. Most consumers want green solar energy.
2. They are suspicious of privacy and control issues with the Smart Grid.
3. They value autonomous backup power.
4. Nobody wants to pay for anything.
5. Some consumers, like Cell Towers, are very sophisticated and <u>will</u> pay.

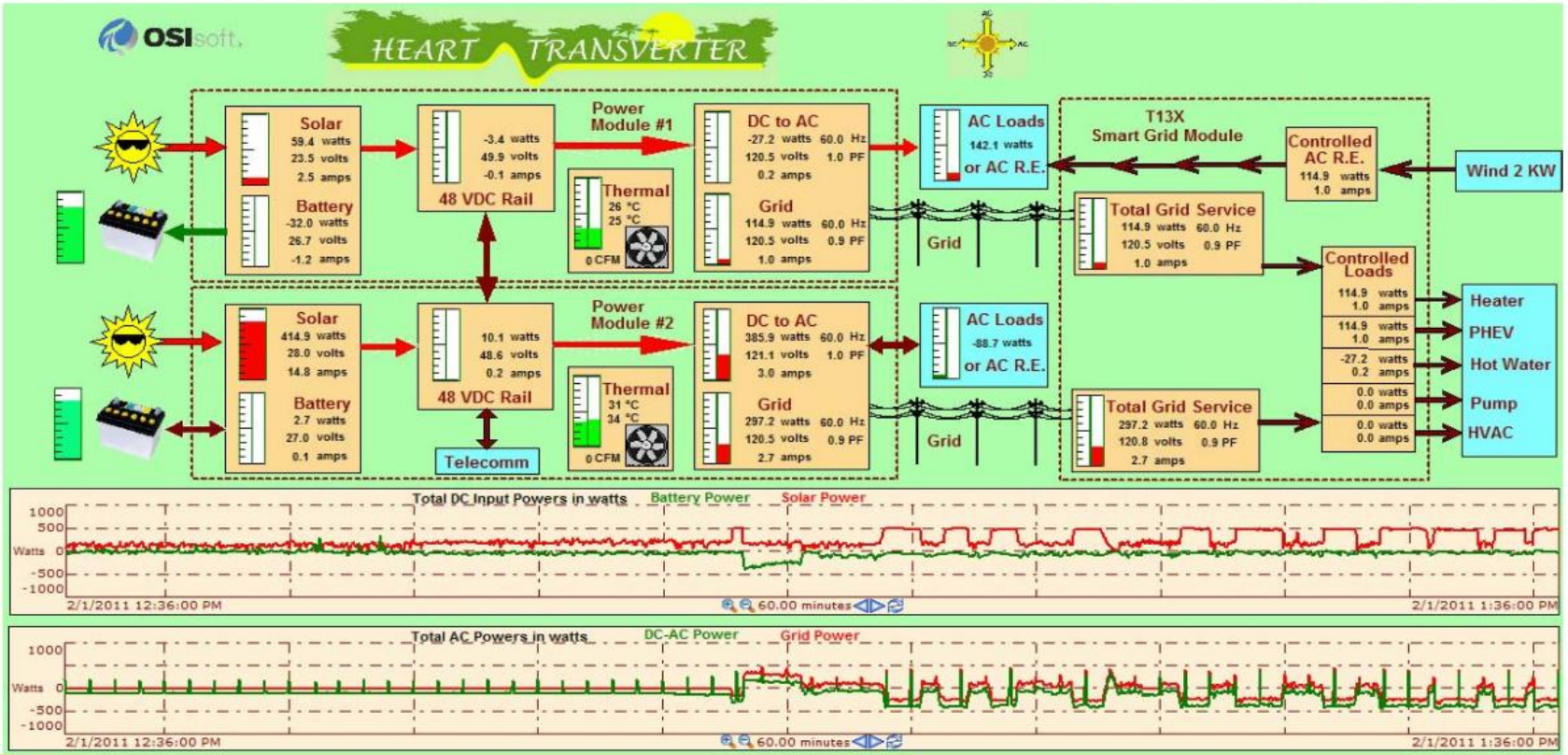
The Utility Companies can easily be the Hero here if they play their technological cards right.

The Real Cost of Central Processing

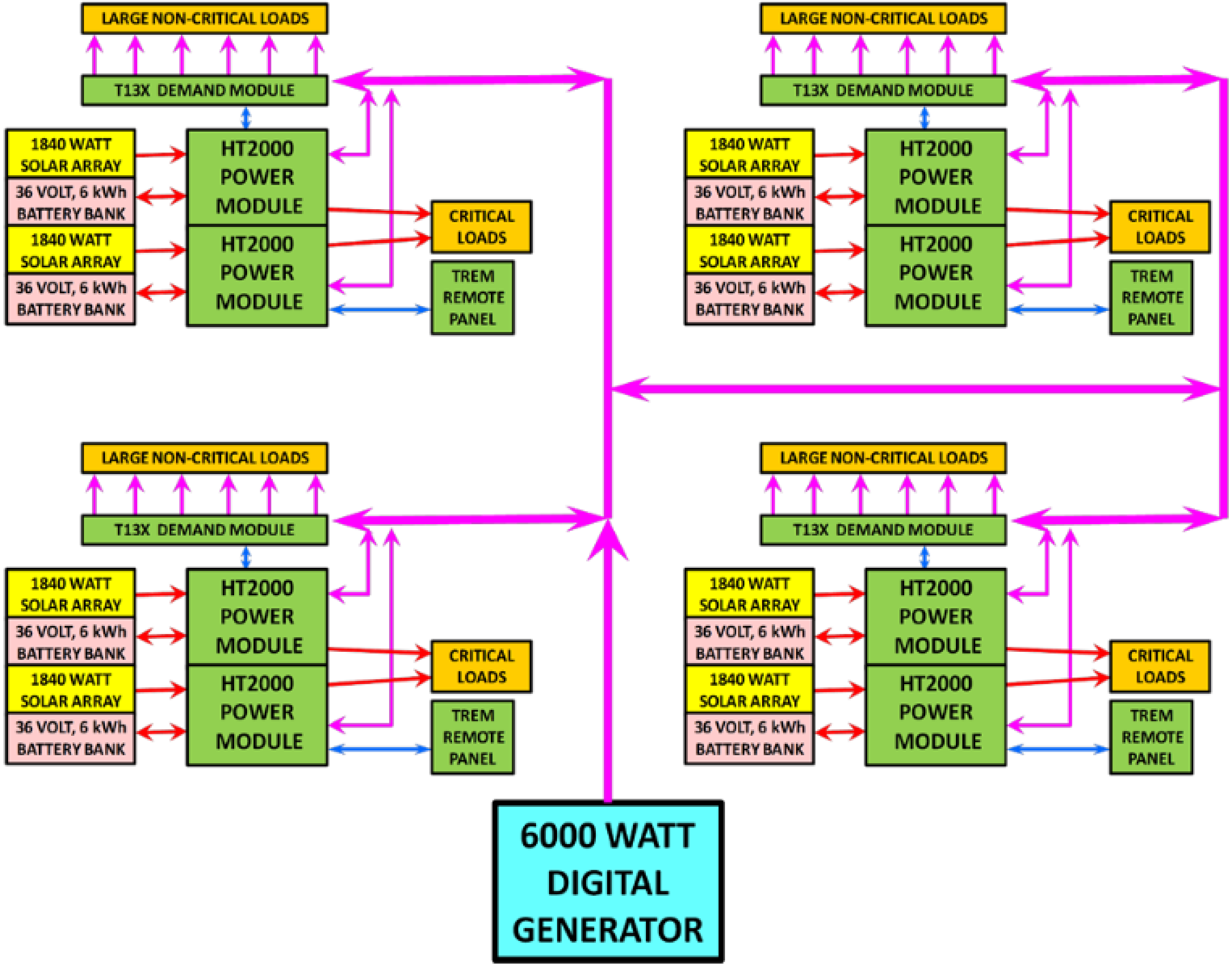


Full Screen
Close Full Screen

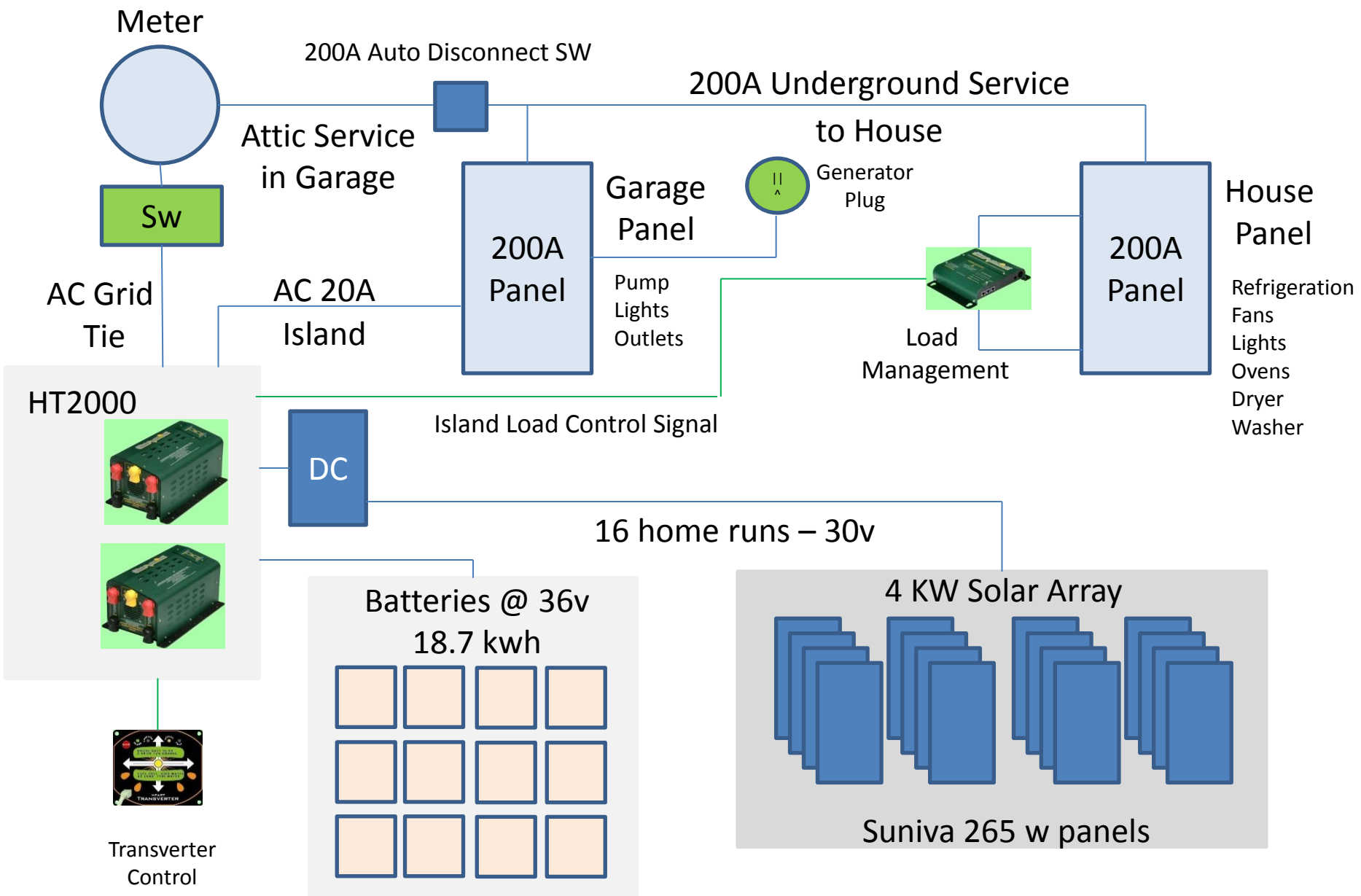
ProcessBook, WebPart & CoreSight Displays



Microgrids with Transverter Solar and Digital Generators Combined.



Pistorese Design



Control Number: 4009679 **Authorized by:** For

Thomas J. Patterson, Certification Manager

This document supersedes all previous Authorizations to Mark for the noted Report Number.

Intertek Testing Services NA Inc.
545 East Algonquin Road, Arlington Heights, IL 60005
Telephone 800-345-3851 or 847-439-5667 Fax 312-283-1672

Standard(s):	UL 1741 Standard for Safety for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources. Second Edition, Dated January 28, 2010 CSA C22.2 No. 107.1 Issue: 2001/09/01 Ed:3 General Use Power Supplies - (R2011)
Product:	Transverter
Models:	HT2000

ATM Issued: 04/03/14

CEATI • 1010 Sherbrooke Street West, Suite 2500, Montreal, Quebec, Canada H3A 2R7
www.ceati.com • info@ceati.com • Phone +1 (514) 866-5377 • Fax +1 (514) 904-5038

David Katz
Sustainable Resources Management
dkatz@sustainable.on.ca
T: 416-493-9232
C: 416-618-4651

Heart Akerson
Costa Rica
001-506-8892-7019
Heart @transverter.com