Comments on Island Grids and More General Impacts of Distributed Generation

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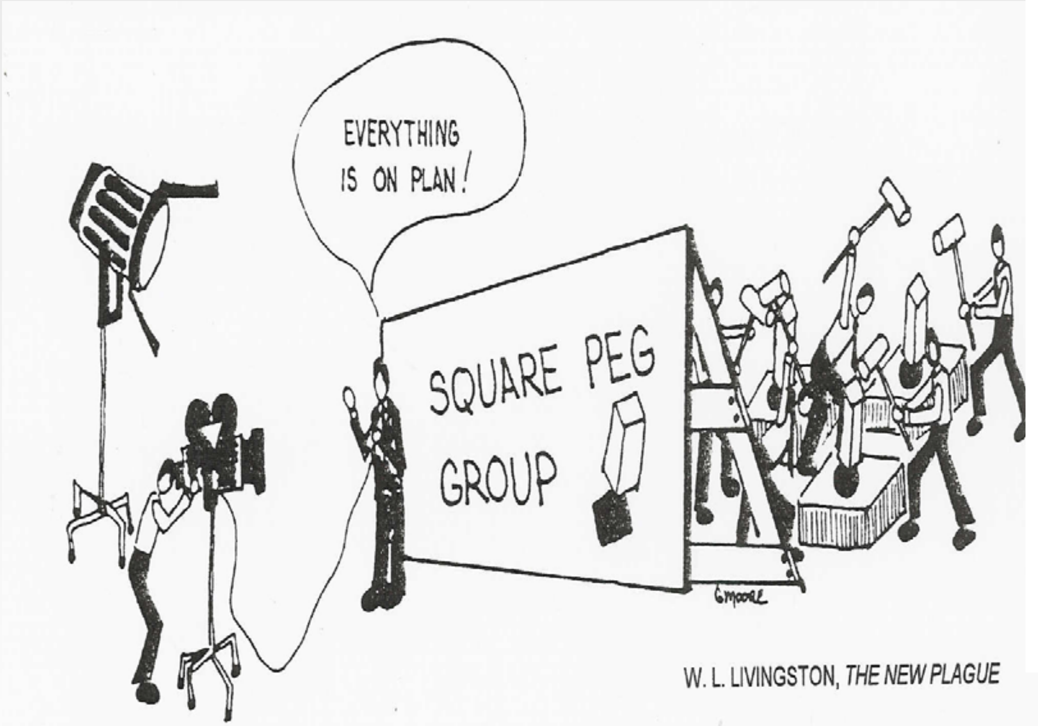
Be Prepared for Unanticipated Events

Discussion Will Touch Upon

- Growth of distributed generation Is driven by regulations and technology
  - State legislative and regulatory bodies drive change, but will need more support in the future
  - Utilities incorporating new systems, but caught in conundrum twixt regulation and new system impacts
- Impacts of distributed energy systems can be ameliorated by new technology – three examples
  - But, given caution by both the utilities and the regulatory bodies, these don't happen immediately
- Some aspects of Hawaii
- How DOE can help – QER considerations

Despite Recent Initiatives, US Energy Policy Does Not Have an Integrated Systematic Energy Policy



W. L. LIVINGSTON, *THE NEW PLAGUE*

Thus, States More Effective in Developing New Policies, Programs, and Enabling/Changing Utility Business Models

- Energy Efficiency and Demand Side Management Standards and Goals
- Renewable Portfolio Standards (RPS) in 34 of 50 states, plus DC
  - Feed-in tariffs (with an eye towards grid stability)
  - Net metering laws and regulations – key states looking at revisions
  - New laws to limit curtailing of renewable energy output
- Power Purchase Agreements (PPAs)
  - New PPAs now take into account ancillary services - grid stability, reliability, Var support
- T&D investments, access, and renewable interconnection
  - "Dueling laws" - public (ISOs, state EPA) and private intervenors can drag out interconnection time and increase costs for any IPP

Innovation for distributed renewables impacts requires systematic attention to development of new technology, business models, and regulations.

Additional Legislative Developments in California and Hawaii Are Limited By Regulatory Agencies' Ability to Implement

California Policy Landscape – Leading to 80% Emissions Reduction (from 1990) by 2050

Governor Jerry Brown's State of the State Address
January 5, 2015

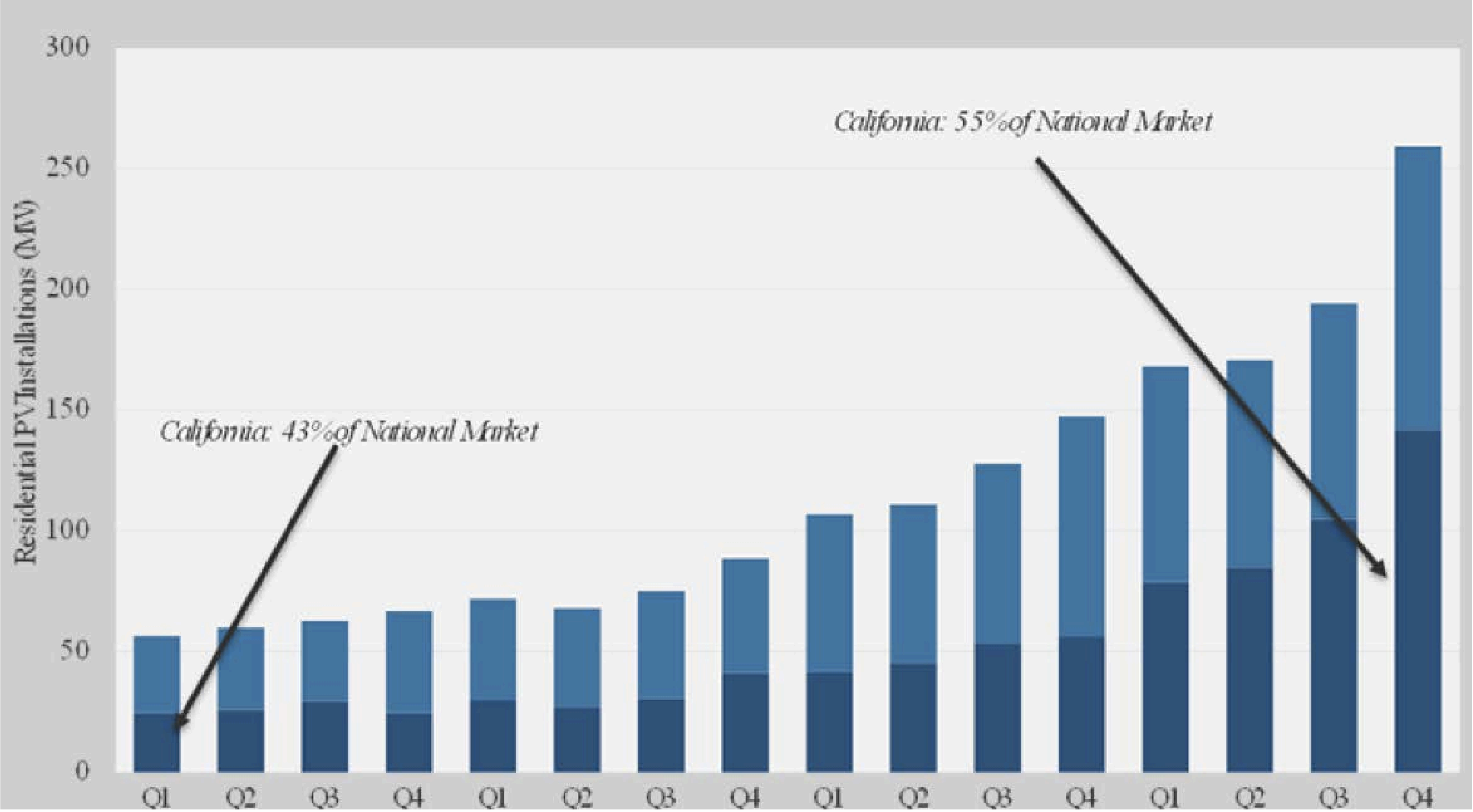
Some clean energy 2030 goals:

» Increase renewable electricity use from 33% to 50%

» Reduce petroleum use in cars & trucks by 50% (failed in legislature)

» **Aspirational goal**: all new residences net zero energy by 2020

Regulations Can Drive Growth: California Has 55% of US PV Market



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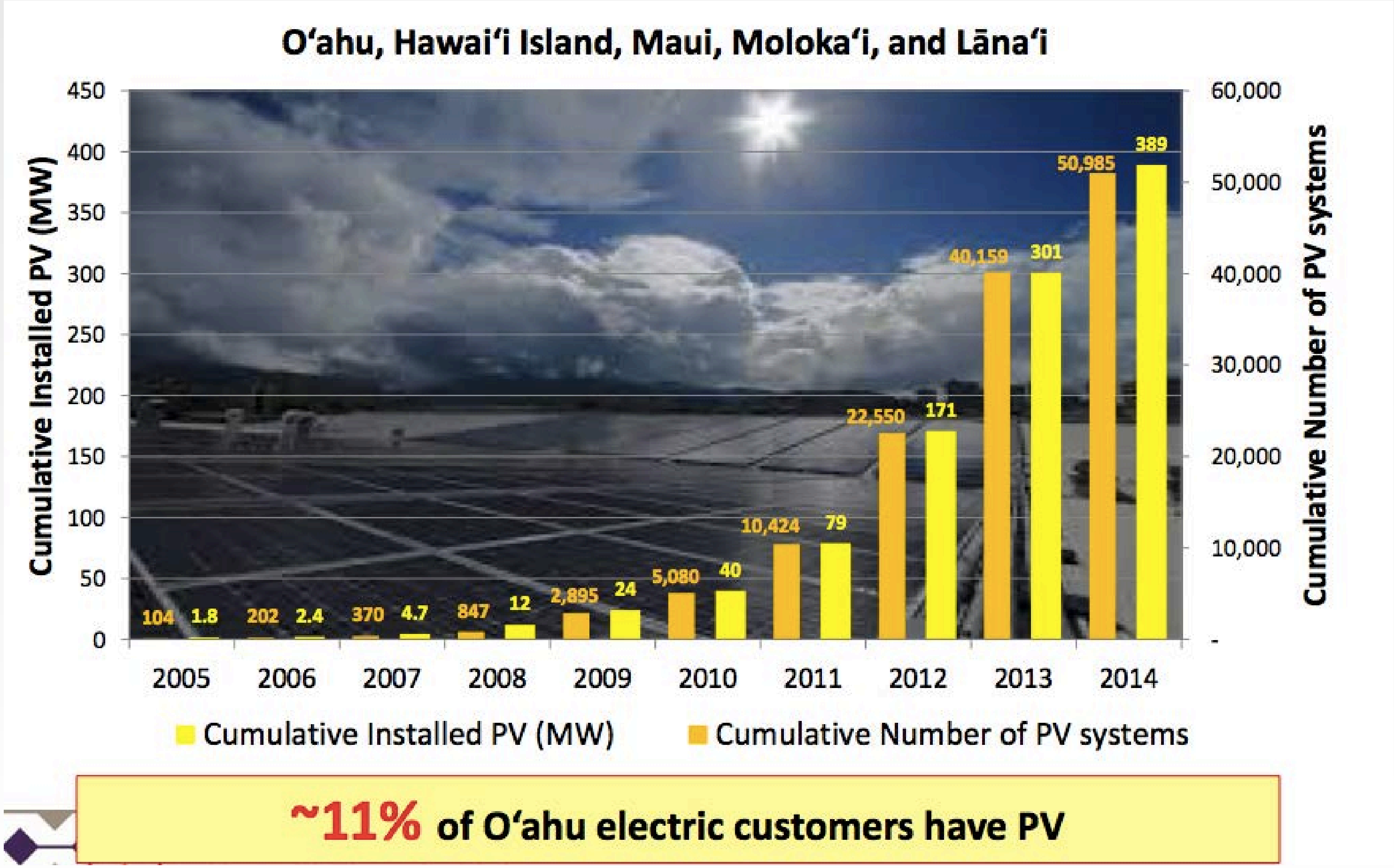
Regulations Can Drive Growth: Federal and Hawaii State Investment Tax Credits (30% Each)



California as Lead in Energy Storage Regulatory Development: 1.3GW by 2020 Under AB 2514

"The California Public Utilities Commission (CPUC) approved a long term procurement decision **ordering Southern California Edison (SCE) to procure… at least 50 MW [of] energy storage resources**, [and] **up to an additional total of 600MW** of capacity required to be procured from preferred resources **- including energy storage resources**."

"Under the CPUC's final decision… **energy storage resources must be considered** "along with preferred resources" including energy efficiency, demand response and distributed generation, consistent with… California's Energy Action Plan."

Rationale

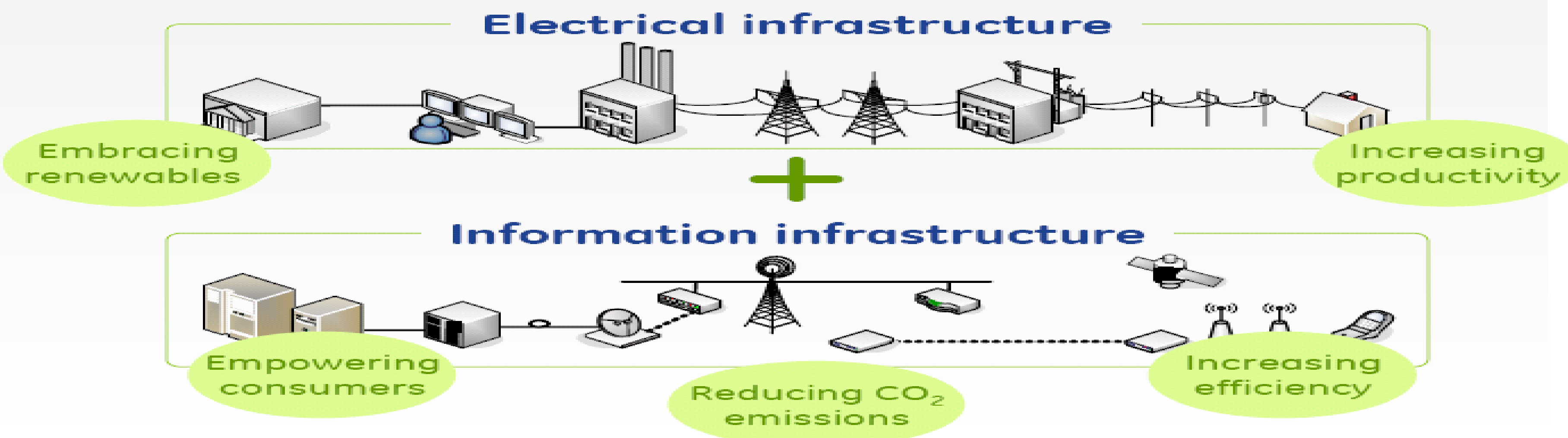
- **Power Plant Retirements (SONGS)**
- **Need for flexible capacity for increasing renewable penetration (7,500-11,000 MW)**

Renewable DG Has Most Impacts at Distribution Level, But "Blows Back" to the Grid: "Smart Grid" Solutions

- Many assets are aging, and based mostly on old (~1950s) technology:
  - Little monitoring & control ability beyond substation
- Not designed for generation at the customer level
  - Two-way power flow and potential for islanding create threats to human safety, asset protection and life, and power quality control

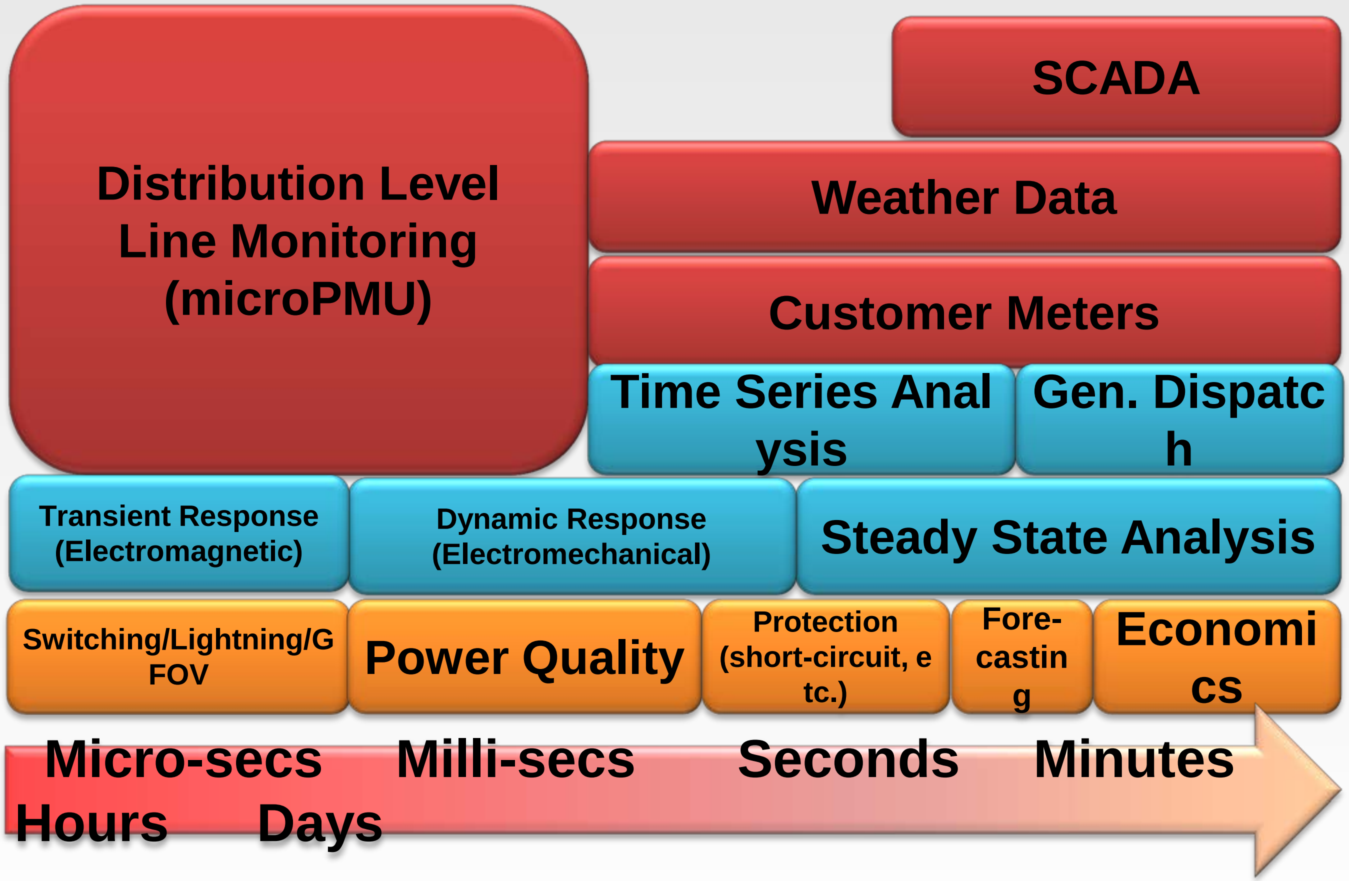
California distributed generation is "connected" to electric distribution via CA Rule 21 policy and the conservative "15%" Rule

Hawaiian Electric's Rule 14H is similar to California's Rule 21

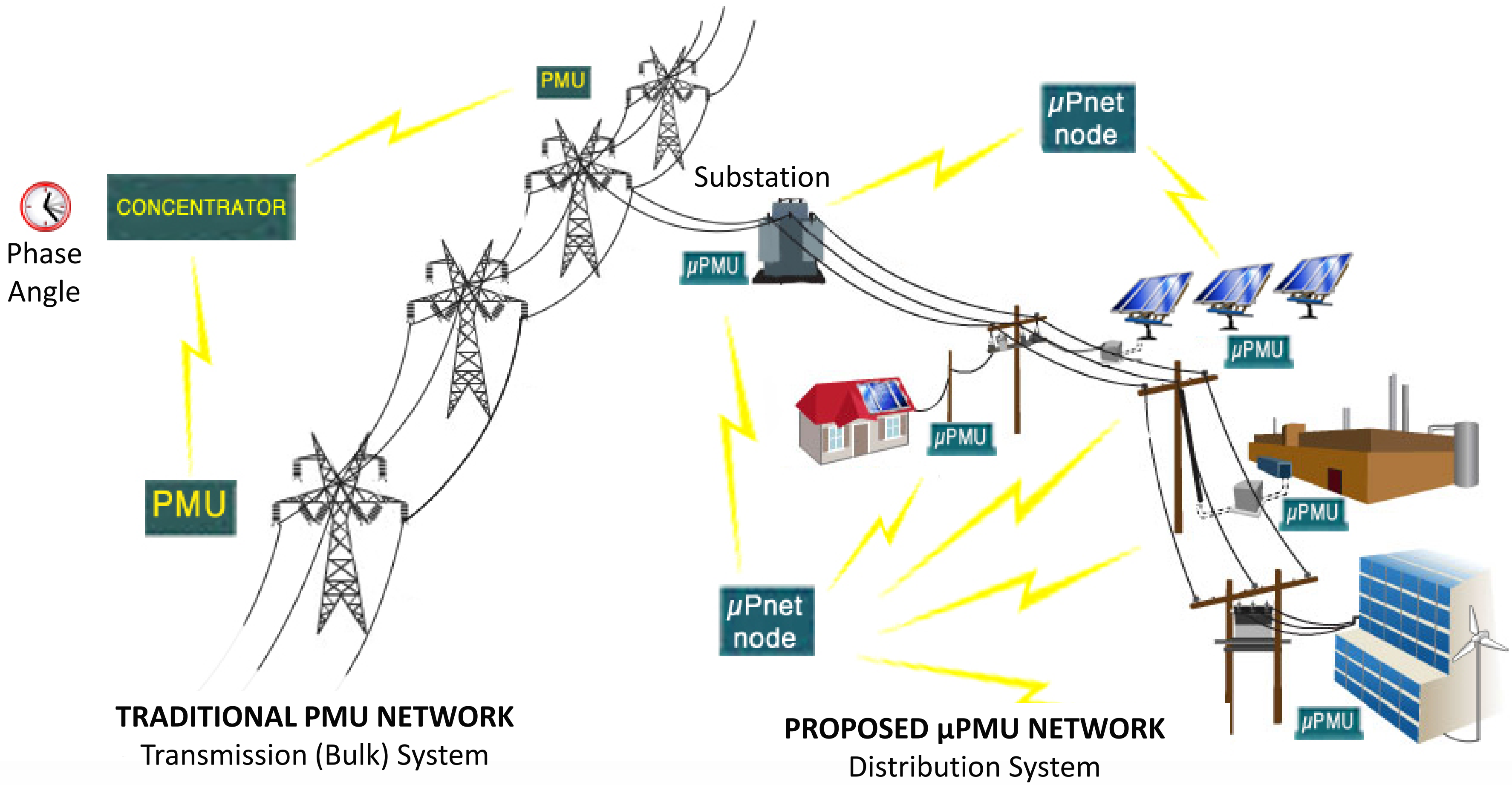


Sources: (1) UtilityPoint, By Ethan Cohen 7/18/0 (2) EPRI® Intelligrid

How Do Utilities Plan for and Manage Tsunami of Data Coming Their Way



Example: µPMUs for Distribution Applications as a Mechanism for Providing Information to System Operators



Can µPMU data improve or enable planning, diagnostics, and operations applications on the distribution system?

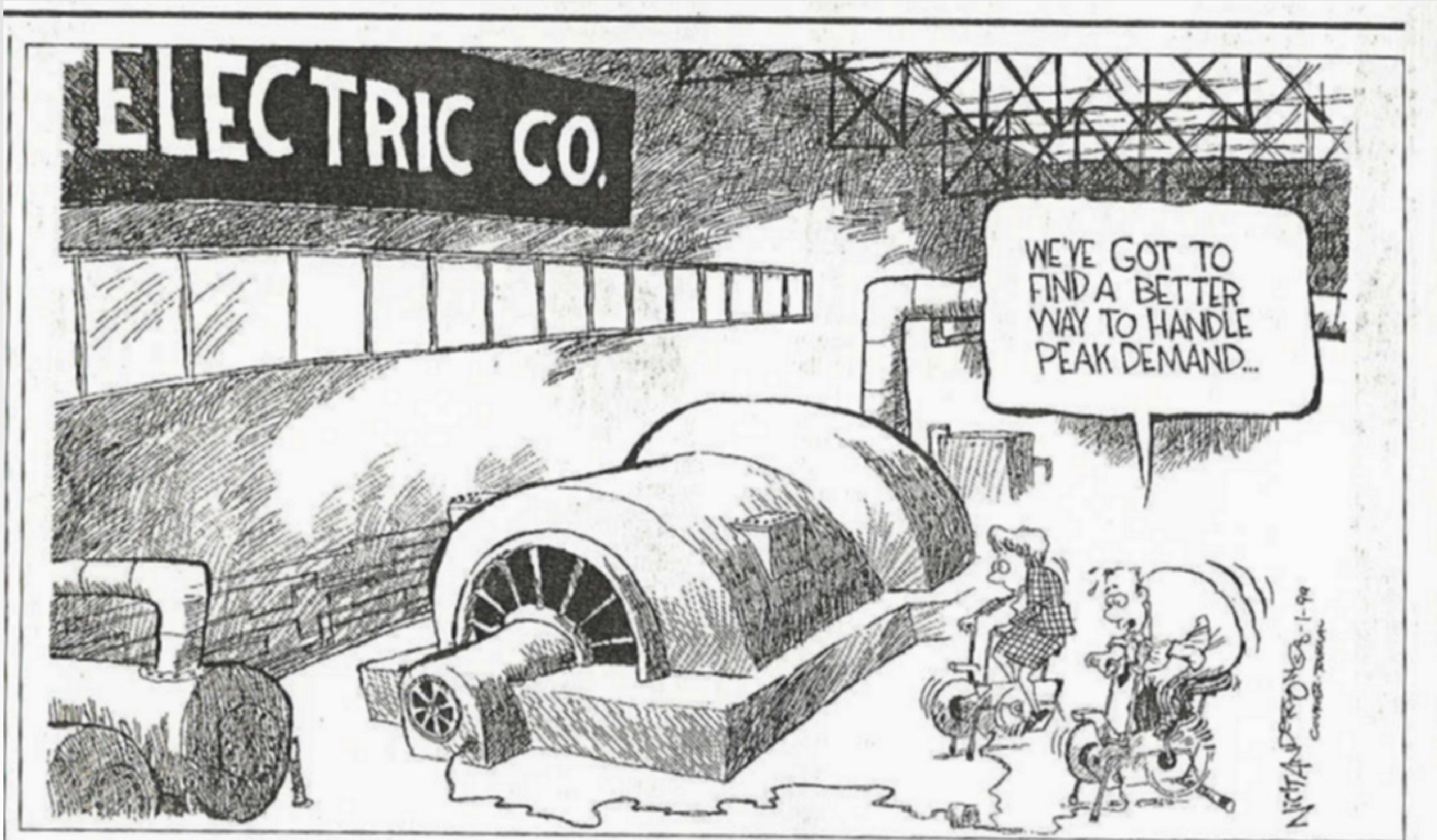
Possible diagnostic applications for µPMU data:

- island detection
- oscillation detection
- characterization of inertia
- fault location, protective relaying

Possible control applications:

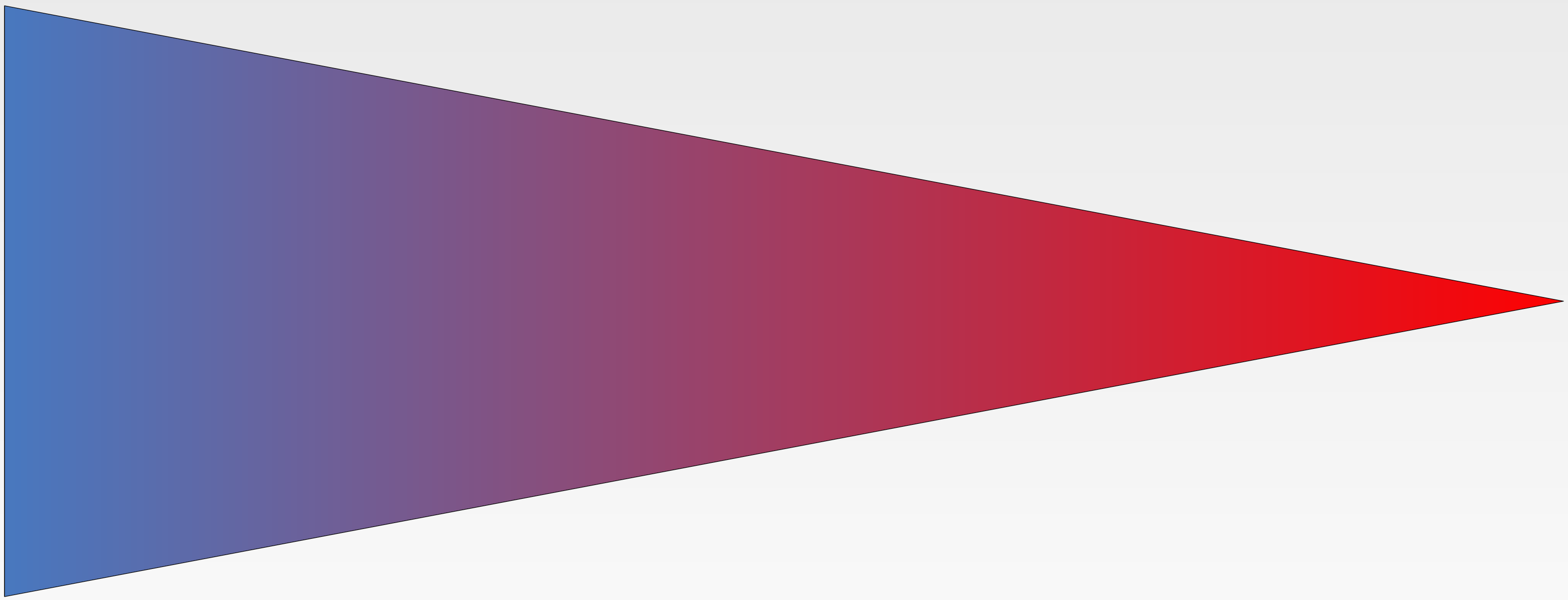
- Volt-VAR optimization
- microgrid coordination
- seamless intentional islanding and re-synchronization of microgrids
- creative recruitment of distributed resources for ancillary services

But algorithms still need to be developed to take advantage of the raw data for better decision-making



By Nick Anderson, The (Louisville) Courier-Journal, The Washington Post Writers Group

Example: Demand Response with Smart Grid Systems (Marianne Piette, LBNL)



Timeline Example: OpenADR Interoperability Progress

Research initiated by LBNL/ CEC

Pilots and **field trials**
Developments, tests (Utilities)

OpenADR 1.0 **Commercialization**
(PG&E, SCE, and SDG&E)

Official **OpenADR specification (1.0)** by LBNL/CEC*

1. **Anytime DR Pilots**
2. **All end-use sectors**

- **Over 250 MW automated in California**
- **DR in T24**
- **DR in LEED**

2002 to 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012

1. OpenADR **Standards Development**
   - OASIS (EI TC), UCA, IEC
2. NIST **Smart Grid**, PAP 09

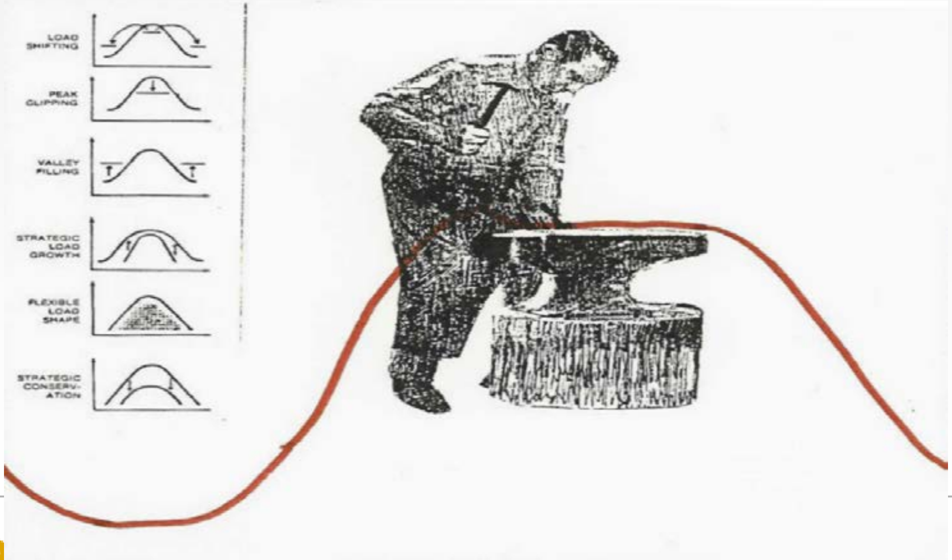
EI 1.0 standards
- OpenADR profiles

OpenADR 2.0 specifications

Certification/Testing (v2.0)

Progress in Identifying Opportunities for Industrial DR

- Refrigerated and Frozen Warehouses
- Wastewater Treatment Plants
- Data Centers
- Agricultural Irrigation



Open Smart Energy Gateway – with 11 Million Meters Installed – PG&E - 5.2M, SCE - 5M, SDG&E - 1.4M

- **Purpose** – enable greater use of both near real-time and high resolution (10 sec) meter data
- **Methods** – Gateway translates SEP 1.x to more secure protocol (e.g. WiFi)
- **Use Cases**
- **1.Energy monitoring** - Consumers can collect near real time energy consumption data
- **2. Enable near real time DR aggregation**- Time stamped energy data can be aggregated to develop controllable loads for advanced DR programs that need kW feedback
- **3. Fast DR** – May provide lowest-cost telemetry for Fast DR
- **4. Load disaggregation** – 10 sec data provides information to identify end-use loads

With All These Smart Meters: Get Consumers Involved!! Hitachi/Maui (from Yasuo Tanabe, Hitachi)

Stakeholder Involvement - Learning from Mistakes : Don't "Parachute" Technologies - Nabouwalu, Fiji: 720 kWh/day Wind/PV/Diesel Village Power System

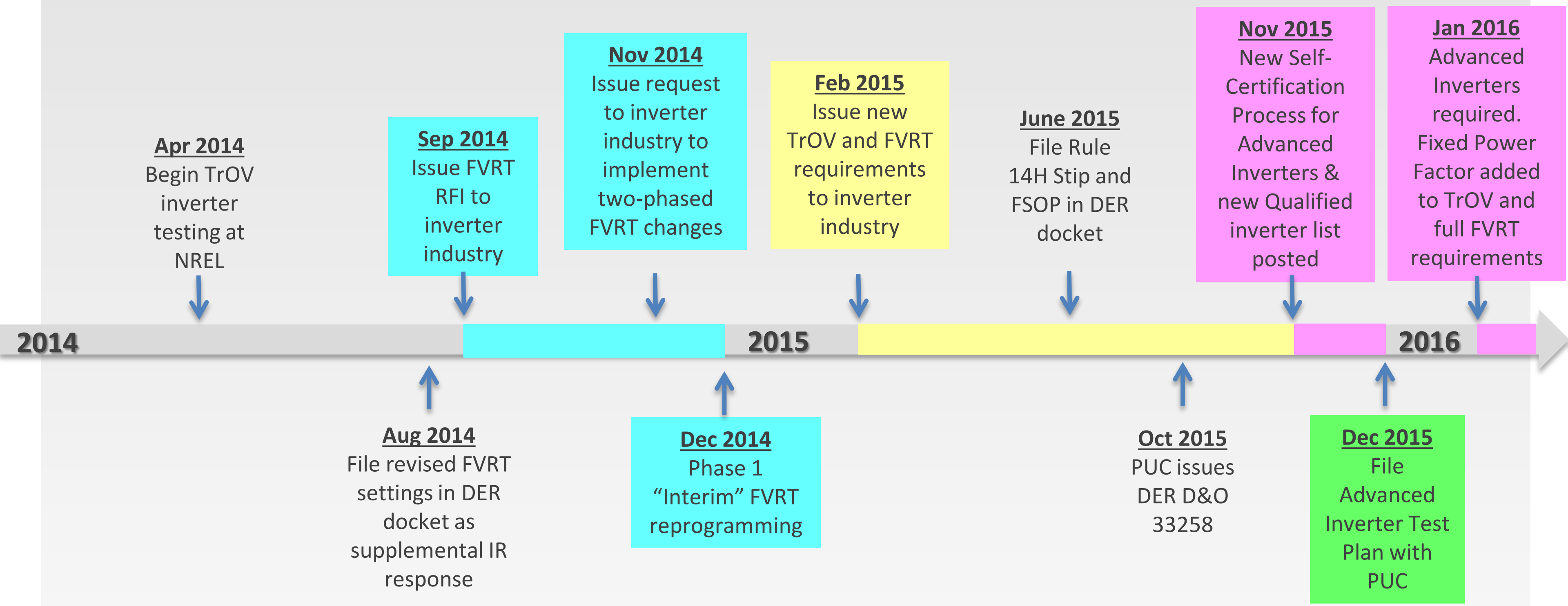
Designed and Installed by PICHTR with Fijian support and funded by Japanese Ministry of Foreign Affairs

Development of Advanced Inverters for HECO Supported by Work at NREL (from Colton Ching, Scott Seu, Darren Ishimura)

- New capabilities will benefit all customers by:
  - Allowing safe integration of higher levels of DER systems
  - Reduce risk of damaging customer and utility equipment
  - Maintain grid resiliency and reliability for customers
- Support new Customer Self-Supply, Customer Grid-Supply, and other DER programs
- Similar use of California Rule 21 approach (HECO Rule 14H) allows advanced smart inverter functions that offer system support to grid

Advanced inverter functions are important to the continued deployment of DER in Hawai‘i

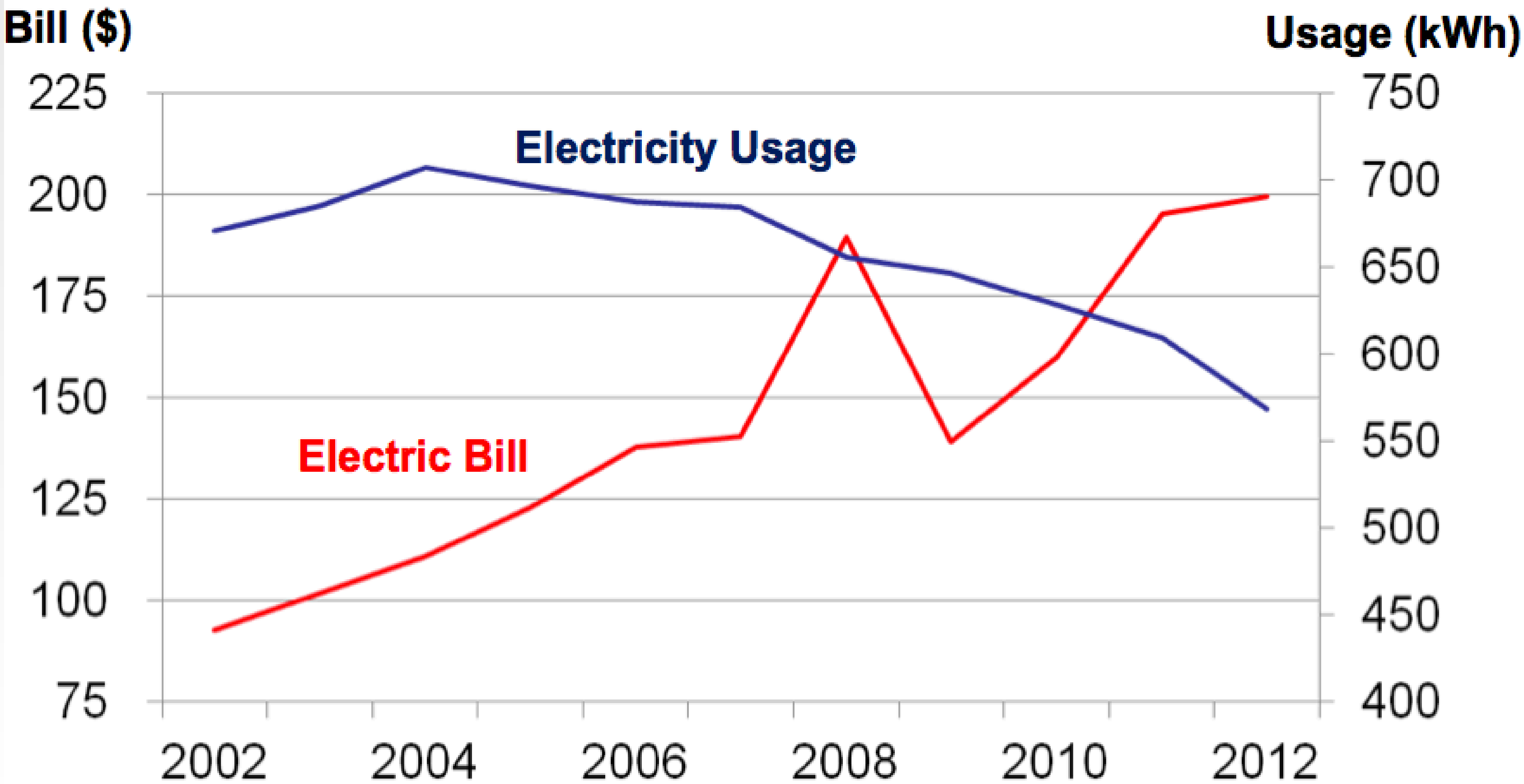
Hawaiian Electric's Advanced Inverter Timeline



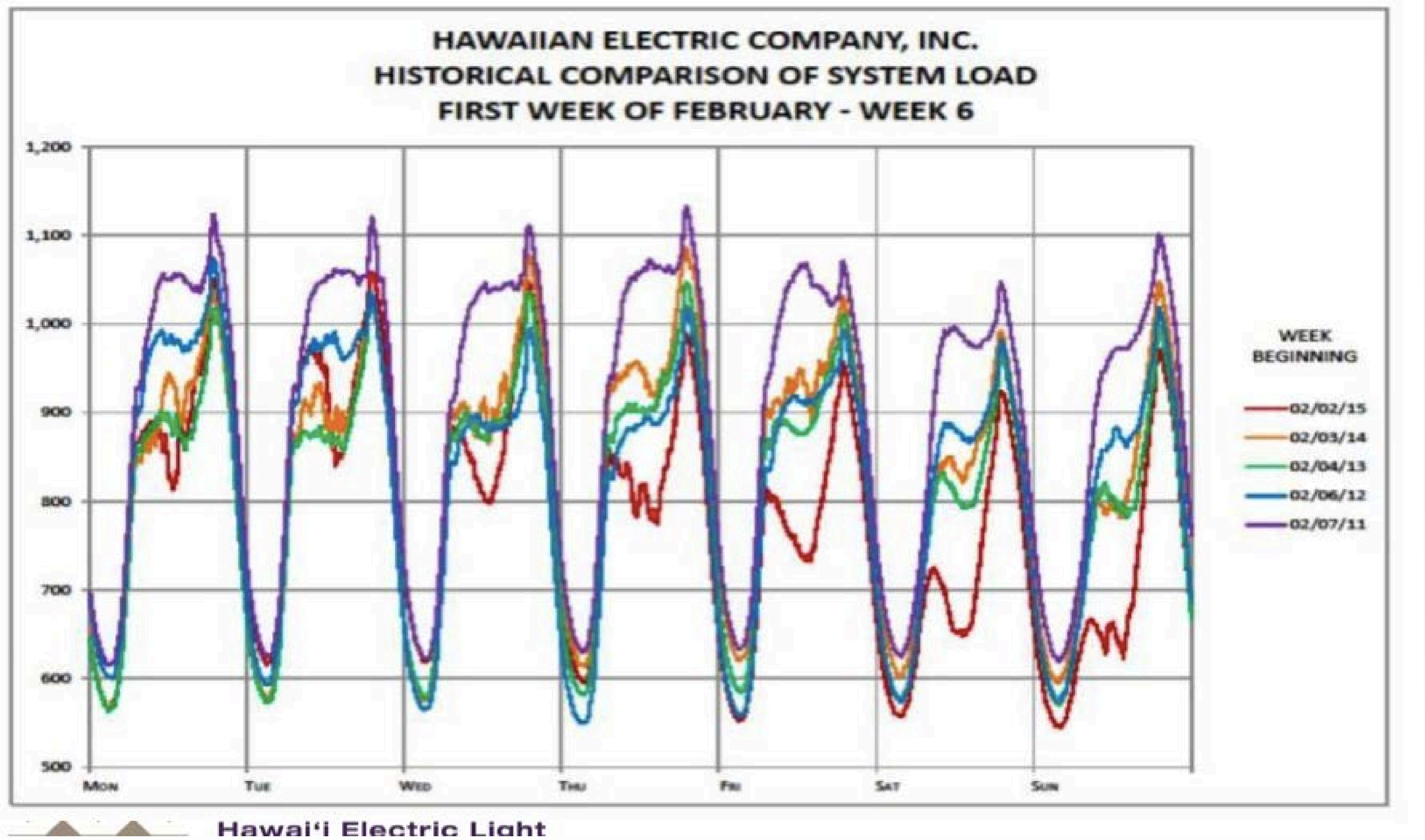
2016

- Initial report summarizing the test results within 6 months after PUC approves Test Plan – including recommendation for further testing
- Phase 2 of DER proceeding
    - Advanced inverter functionalities and activation timeline
    - Communications and control of inverters

End User Costs Up, But Conservation and Energy Efficiency Goals Increase, Negatively Impacting Utilities' Bottom Line



System Load Profiles Changed Significantly with Growth of Residential and Commercial PV (similar for California)



Grid Saturation Levels : Problems with Large Amounts of PV on Distribution Lines

Number of circuits where generation from distributed solar exceeded 100 percent and 250 percent of daytime minimum load (through April 1, 2015)

	>100% DML	>250% DML	Total Circuits
HECO	166	42	465
HELCO	51	8	136
MECO	33	1	137

Source: Hawaiian Electric Companies

Projections for Renewable Energy Impacts – "Duck's Back" in Hawaii (E3 Report)

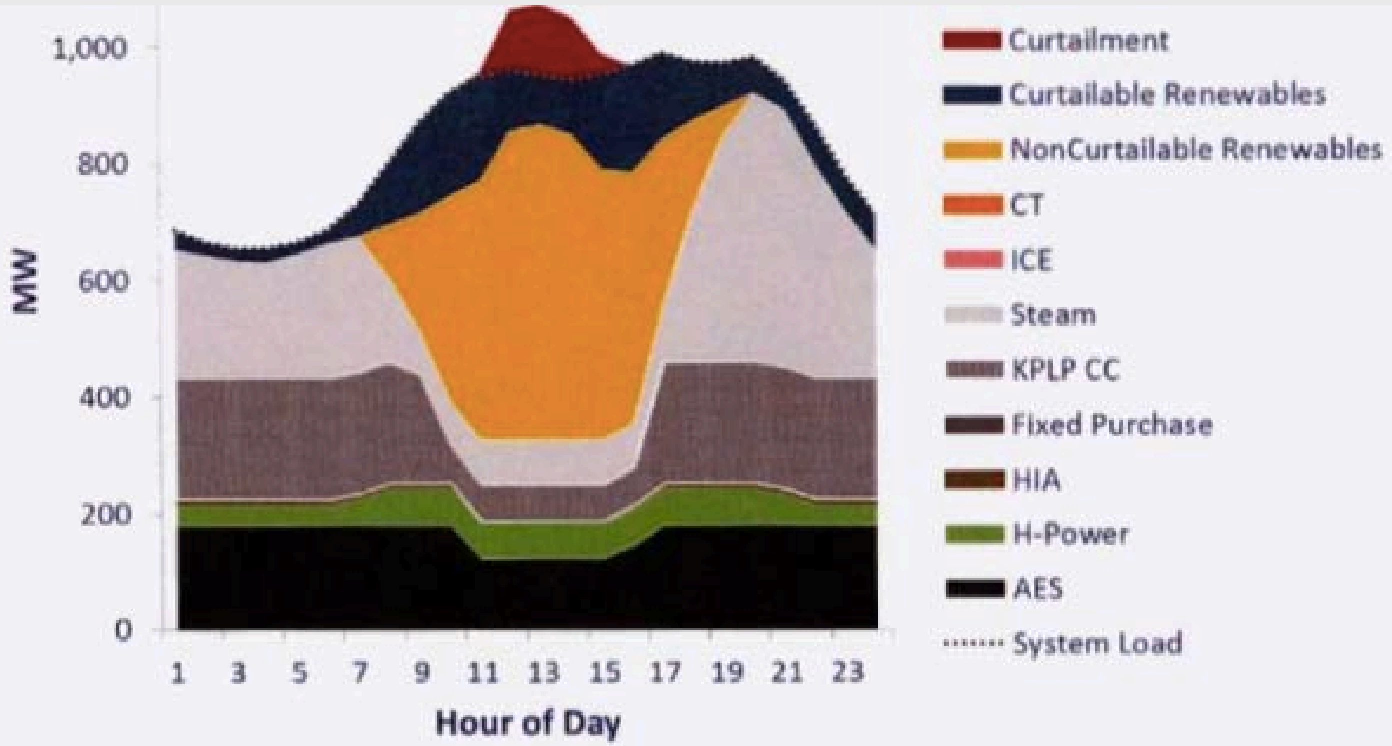


Figure 16: Dispatch for a typical curtailment day in the summer of 2018 with 698 MW of DG PV (225% of current). Note that internal combustion engine (ICE) generators turn on during hour 18 to help with ramping

What Is Occurring in Hawaii Will Be Replicated on the Mainland – CAISO Projections For Ramping Needs in 2020

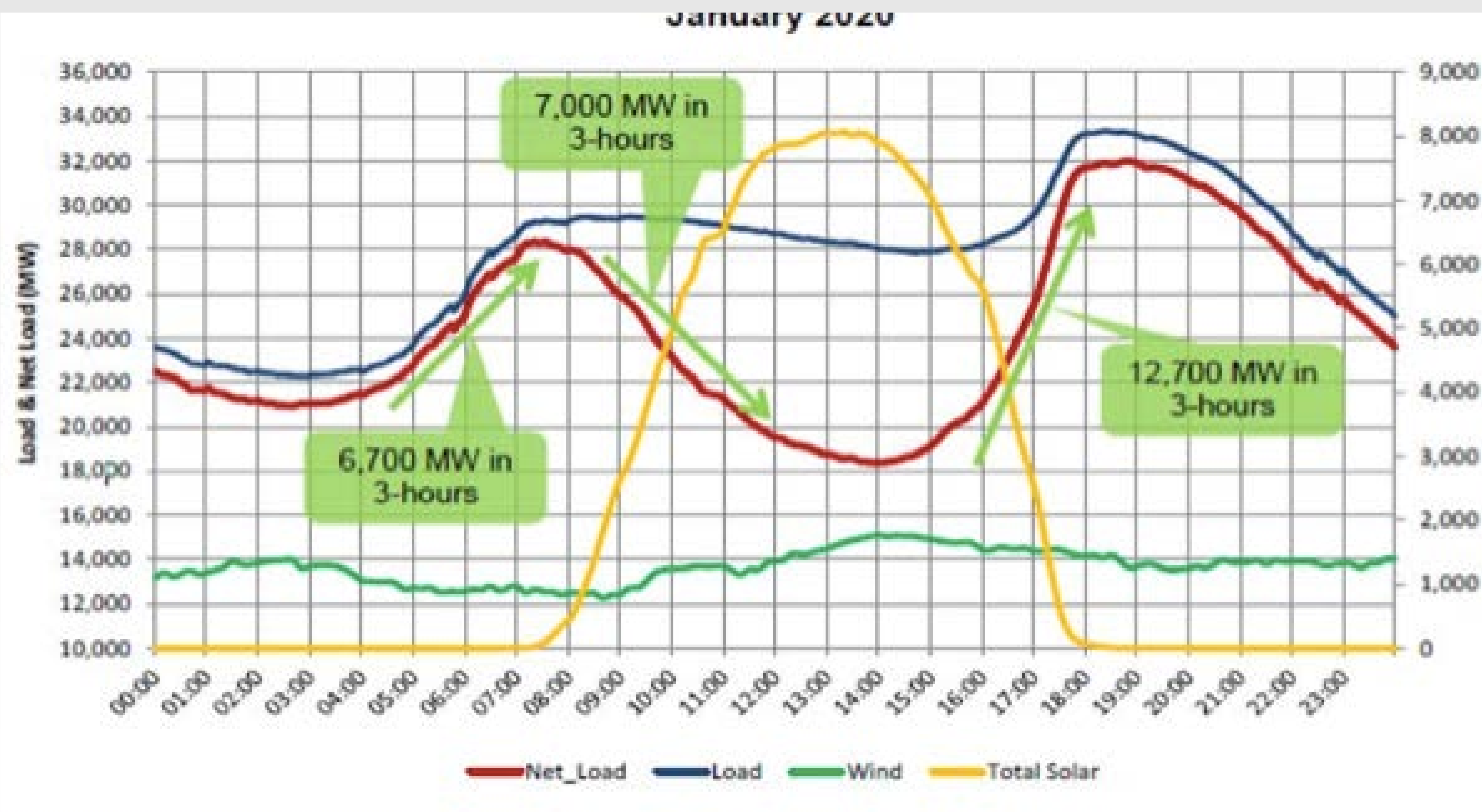
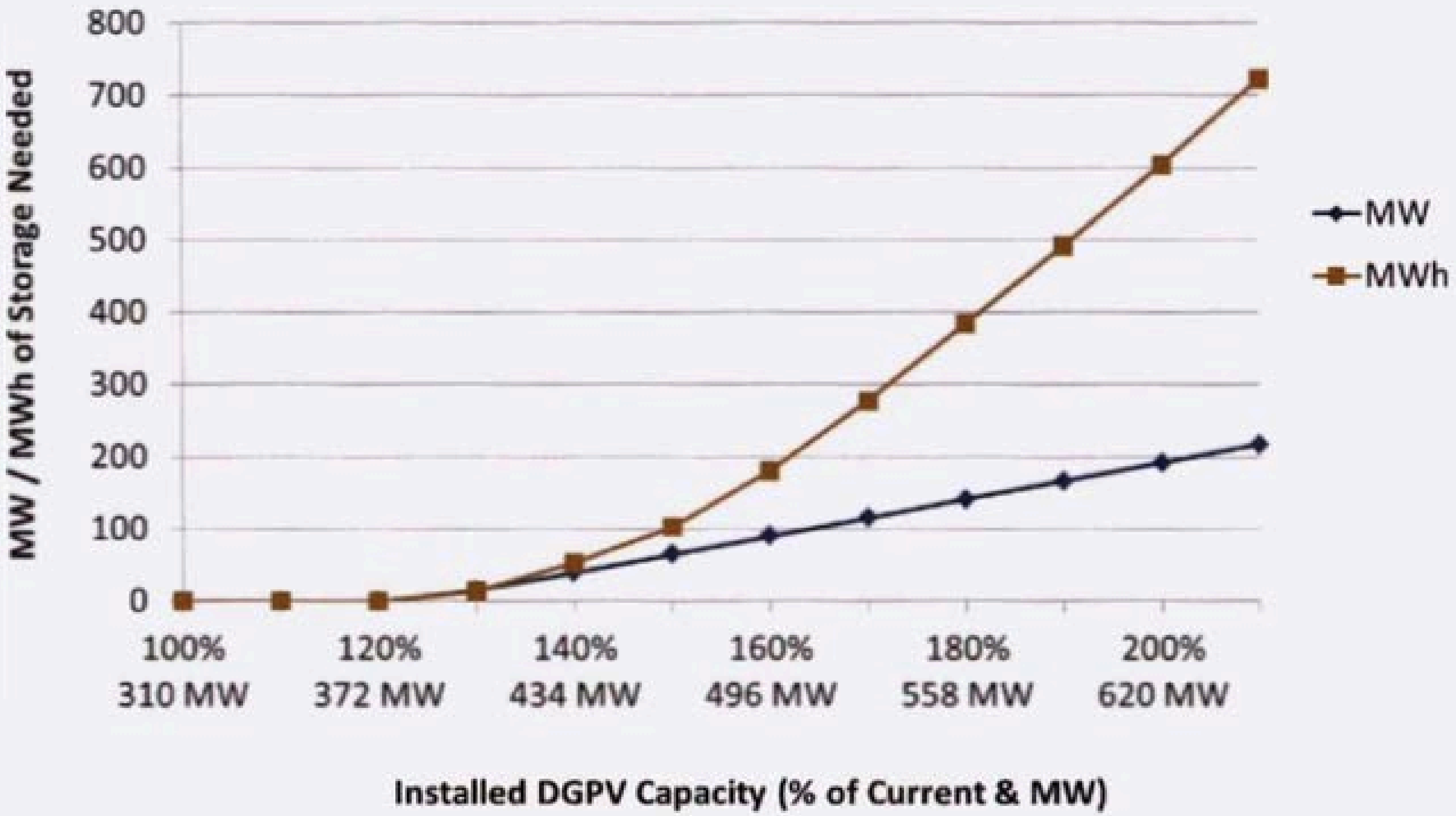


Figure 9: CAISO Load, Wind and Solar Profiles for Base Case 2020 Projections NE

Continued Growth of PV Requires Solutions with Storage the Preferred Choice (E3 report)



But, Curtailment Costs Are Significantly Cheaper than Storage (E3 report)

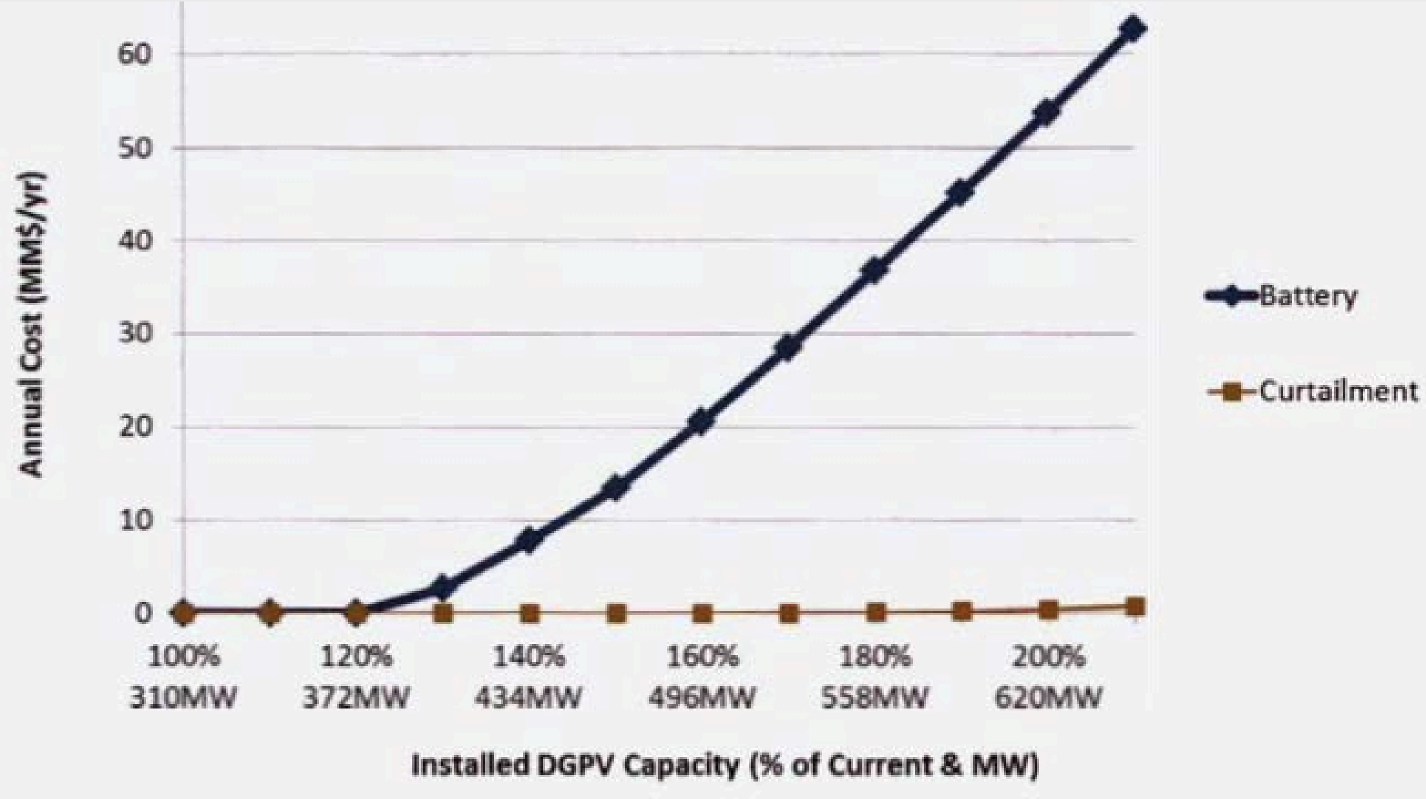


Figure 14. Curtailment costs vs storage costs at different DG PV capacities

So, It’s Not Easy Being Green

Due to Nature of Hawaii's Grids, It Ends Up Being Test Bed for Problems and Their Solutions

- **Maui Smart Grid Demonstration Project**
  - USDOE funded, HNEI led project to manage home energy usage using smart grid technology allowing peak load reduction and management of intermittent renewable energy.
- **Japan-US Island Grid Project**
  - NEDO funded, Hitachi led project to integrate advanced PV, energy storage, and EV into island wide smart grid environment to enable high penetration of central and distributed renewables
- **Smart Grid-Enabled PV Inverters**
  - Demonstration of advanced PV inverter functionality in smart grid environment (V, power quality) in both high penetration and sparse distribution lines.

Three projects have partners in common and propose to share hardware, results, and lessons learned

Maui/Hitachi Overview (from Yasuo Tanabe)

■ Project : NEDO Hawaii PJ (**Ph.1/2011~, Ph.2/2015~**)

JUMPsmartmaui
SMART ENERGY. SMART CARS. SMART GRID.

NEDO

Hawaiian Electric

Maui Electric

HNEI Hawai'i Natural Energy Institute
School of Ocean and Earth Science and Technology
University of Hawai'i at Mānoa

Sandia National Laboratories

maui economic DEVELOPMENT BOARD

NREL

MIZUHO

CyberDefense

Pacific Northwest NATIONAL LABORATORY

HITACHI Inspire the Next

This demonstration is supported by the METI (Ministry of Economy, Trade, and Industry) and NEDO (New Energy and Industrial Technology Development Organization).

■ Solution : Smart Grid System for Island

■ Distributed Energy Resources (for Ph.1)

- Bulk battery (2 Li-ion, 1 Lead Acid) and Others
- Home battery (10 set),
- Home water Heater (30)
- EV (>200)
- EV Charger (20/Fast Charger, 200/Normal Charger)

What Are Some Considerations for DOE/QER

- Need to better tie study results to doing something
  - Shorten gap between studies and production (HECO/NREL inverter example)
- Mechanisms to help regulators make changes in risk assessments for regulatory decision-making
  - "Innovations happens at the speed of regulation" (A. Oshima) - note time line for ADR
  - Retain consumer advocacy and develop programs to better inform end-users
- Enable changes to business model(s) for utilities (and regulators) in light of technological advancements, system needs and requirements, and legislative actions
- Better utilize DOE national laboratory infrastructure to expedite innovative, transformational, and disruptive (but positive) transitions
  - Strengthen and take advantage of existing interactions with industry (all sectors) and the states

Per Utility Business Models: Who Goes First or Is There True Cooperation?

- State Regulators – subject to legislative mandates
  - Evaluate societal and actual costs of various business models
  - Which type of approach best meets legislatively generated targets and consumer advocacy goals
- Utilities
  - Still responsible for keeping lights on – commitment to serve
  - Which approach(es) takes advantage of new technologies while understanding legacy systems
    - Existing and proposed new equipment on distribution circuits (protection devices, sectionalizers, reclosers, cap banks, Micro-PMUs)
    - Various strategies and architectures for operating a much more information-rich distribution grid.
  - **What are the financial implications for either an IOU or POU (or, some other model)?**

DOE Initiative to Deliver a Modernized Grid

DOE Grid Modernization will deliver tools, concepts, analytic resources and regional lessons learned to enhance the effectiveness, affordability and pace of industry and state efforts to modernize the nation's electric infrastructure …

2020 Achievements by Technical Area

- Devices & Integration
- Sense & Measure
- Resilience & Secure
- Ops, Pwr Flow & Cntl
- Design & Planning
- Institutional Support

Major Achievements & Regional Partners

- High % DER resilient distribution demos
- Lean delivery reserve margin ops demo
- Advanced analytic platform for design & regulatory speed
- Regional dialogue and demos

Grid Modernization Outcomes 2016 - 2030

- 10% lower outage costs
- Lean T&D reserve operations (1/3 lower)
- DER integration costs cut 50%
- Additional benefits

There Are a Number of National Laboratory Facilities That Can Be Utilized for High Voltage and High Power Tests

- **INL: 100+ miles of transmission and distribution network on site can test various grid components such as transformers and advanced switchgear for geomagnetic disturbances, high voltage electromagnetic interference and electromagnetic pulses.**
- **ORNL: Outdoor Powerline Conductor Accelerated Testing (PCAT) facility tests and evaluates advanced power transmission technologies with the potential to increase the capacity and the reliability of the U.S. transmission and distribution network. The technologies being characterized include new and conventional conductors, advanced sensors and controls, and power electronics.**
- **NREL: Electrical Systems Integration Facility (ESIF) in which HECO has successfully tested advanced inverters.**
- **SNL: The Distributed Energy Technologies Lab (DETL) can test PV components and inverters up to 1 MW, and energy storage systems also up to 1 or 2 MW in a grid-tied or islanded model**
- **SRNL: NIST-Approved facility for very high amperage testing**

With or Without DOE Help, Substantive Changes in Electricity Delivery Will Happen

- New "Smart Grid" systems are a vital part of:
  - Government strategy to address carbon reduction goals and grid resiliency
  - Government must work with industry and regulators to enable business model modifications
- Many new technology projects are complex
  - Technology developers will want to promote their solutions, but will they meet system requirements?
- Utilities and regulators must consider approaches to consumer concerns
  - Distributed PV as a "regressive tax"

Insertion of new technologies must be considered from a systems perspective!! – lead in for Rick!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GLOBAL WARMING WORSE THAN WE THOUGHT