Staff Workshop

Microgrid Assessment and Recommended Future RD&D Investments for the State of California

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The Basis for My Views on RD&D

- Founded the small business Advanco which set in 1984 the World's Records for sunlight to grid connected electricity and received an R&D 100 Award
- CEO of CleanTech Due Diligence Company for 20 years serving VC's, utilities, World Bank, National Laboratories
- Joined UCSD's Microgrid in 2006
  - Self Generates 85% of its electricity at ~27% lower GHG emissions than the CA Energy Mix with Annual Savings of $10M compared to Direct Access importing
  - Receives exceptional market based intelligence by conducting more than 60 "Early Adopter" site visits/year
- Sole sourced as Chief Architect in 2013 for a Sustainable Microgrid of the Future for the Hawaiian Island of Lana`i

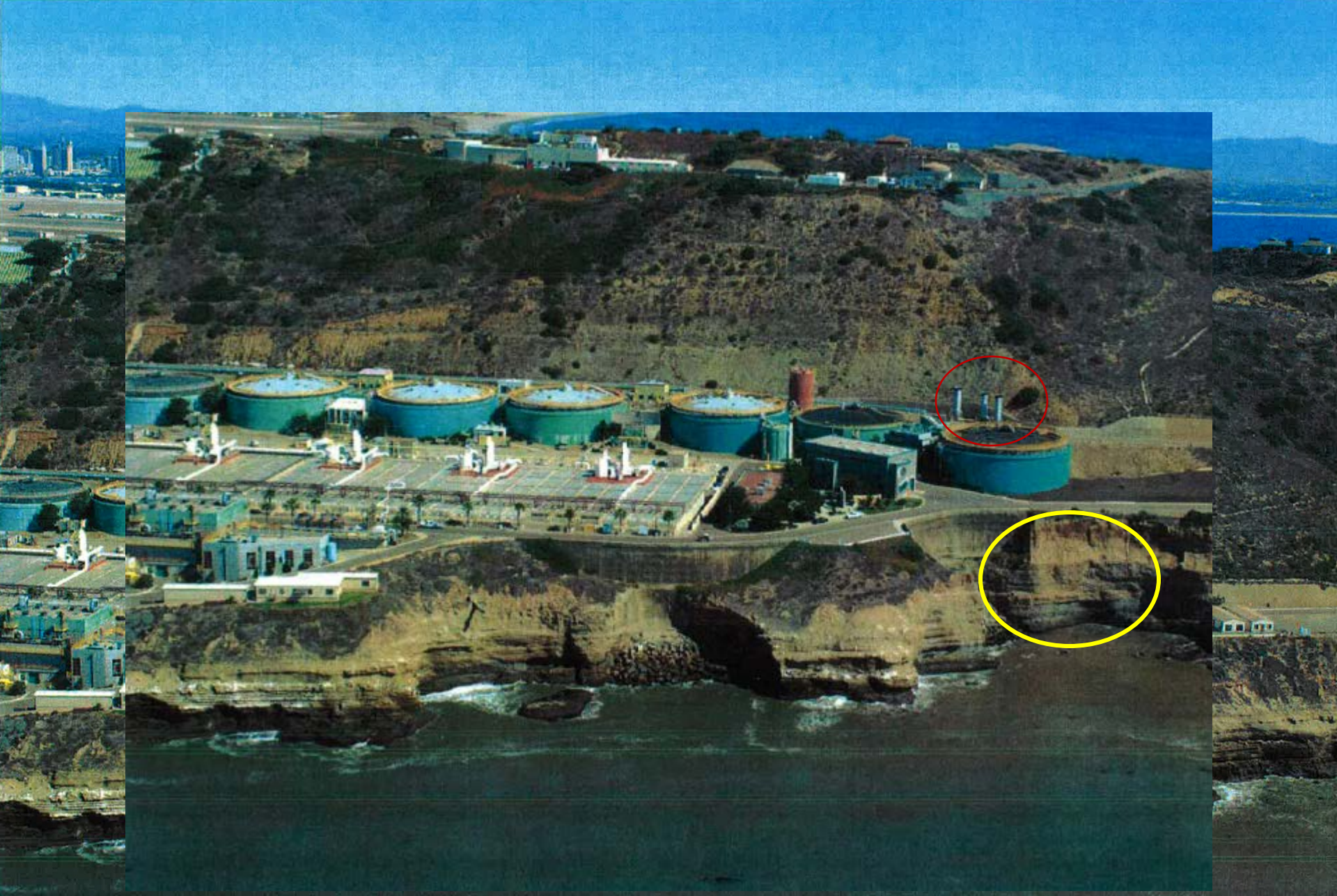
There is a positive attribute in the due diligence business, “He comes with dirt underneath his fingernails.”

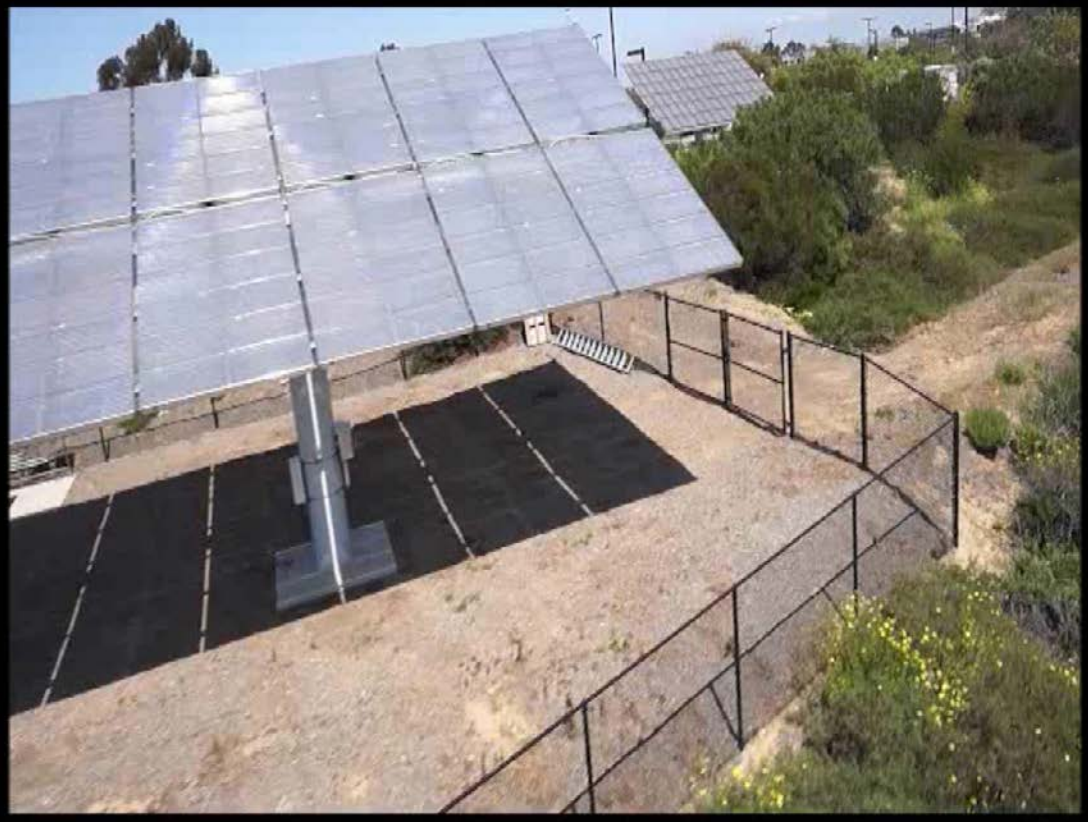
UCSD's Microgrid Distinctively Similar to the Original EPIC Goals

CA's future electricity system will consist of near zero net energy buildings, highly efficient businesses, low-carbon generation, sustainable bioenergy systems, more localized generation, and electrification of transportation, supported by a highly flexible and robust distribution and transmission infrastructure.

Motivation for the UCSD Microgrid is Reflected in the Performance Metrics

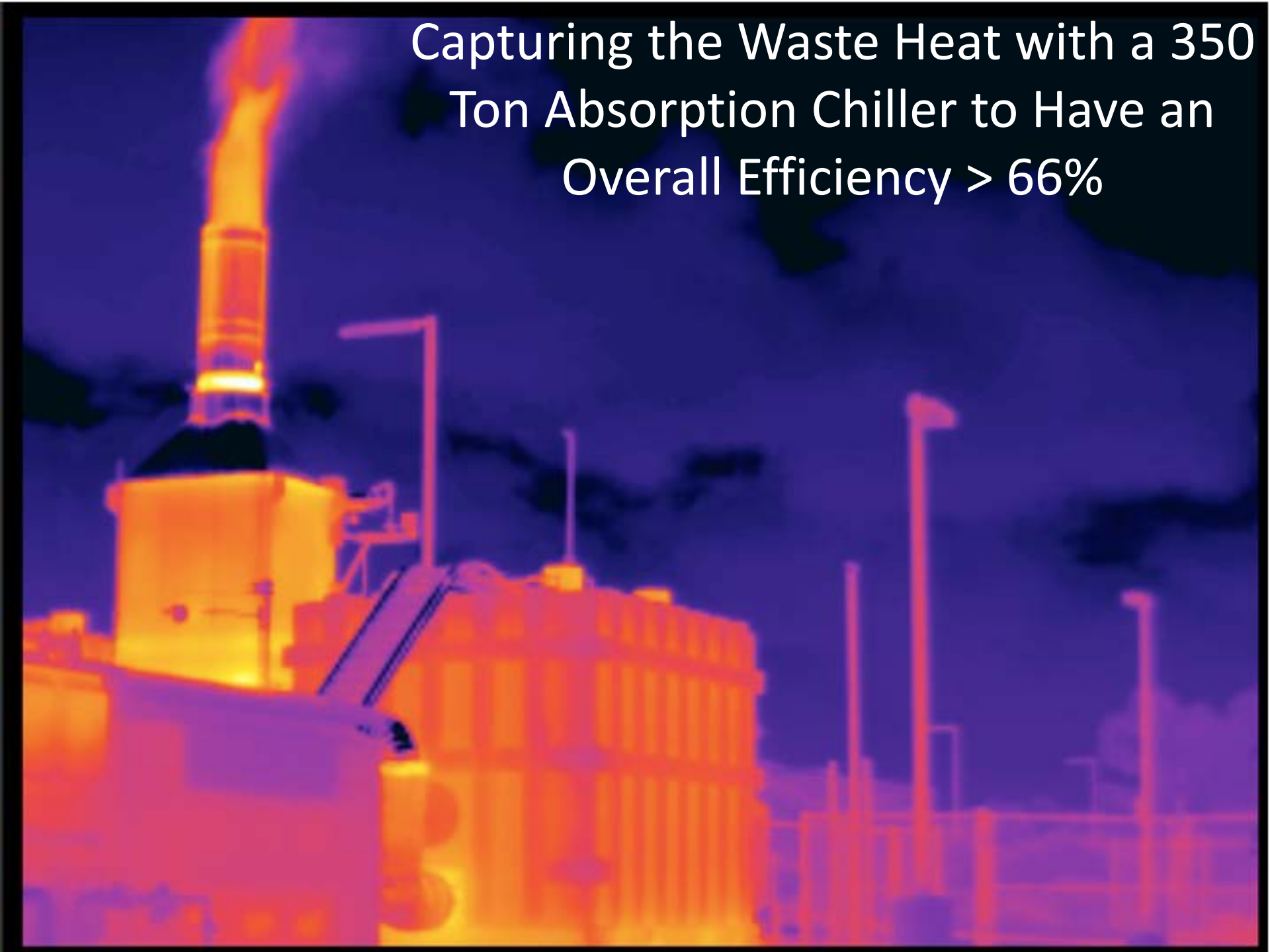
- Reliability: MAIFI and SAIFI
- Surivability and Resiliency
- Power Quality
- Regulatory “Tailgating” and Compliance
- Economic Benefits
- Environmental and Public Health
  - UC Mandate to be Carbon Neutral by 2025
- Optimization of Indigenous Renewable Energy
- Optimization of CCHP and Thermal Energy Storage
- Decarbonization of Transportation Sector
- Safety



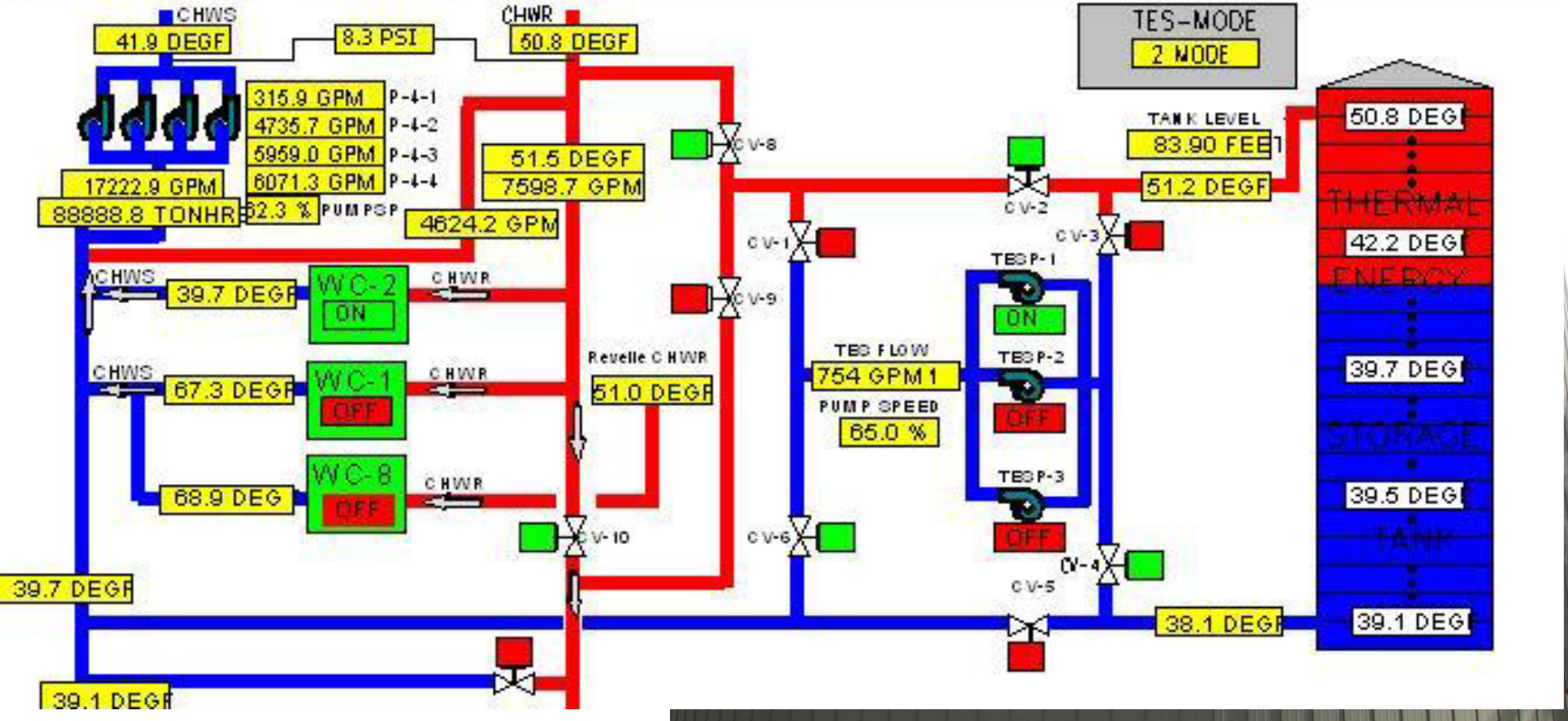


2.8 MW Fuel Cell supplies 8% of baseload power with directed biogas renewable fuel on the footprint of a tennis court

Capturing the Waste Heat with a 350 Ton Absorption Chiller to Have an Overall Efficiency > 66%



FUEL CELL
EXHAUST
Cell Energy
GROVE



CHWS
41.9 DEGF
8.3 PSI
CHWR
50.8 DEGF
TES-MODE
2 MODE
315.9 GPM
P-4-1
4735.7 GPM
P-4-2
5959.0 GPM
P-4-3
6071.3 GPM
P-4-4
17222.9 GPM
88888.8 TONHR
62.3 %
PUMPSP
51.5 DEGF
7598.7 GPM
4624.2 GPM
CV-8
CV-2
TANK LEVEL
83.90 FEET
51.2 DEGF
50.8 DEGF
THERMAL
42.2 DEGF
ENERGY
39.7 DEGF
STORAGE
39.5 DEGF
TANK
39.1 DEGF
CV-1
CV-3
CV-9
TESP-1
ON
CHWS
39.7 DEGF
WC-2
ON
CHWR
CHWS
67.3 DEGF
WC-1
OFF
CHWR
Revelle CHWR
51.0 DEGF
TES FLOW
754 GPM1
PUMP SPEED
65.0 %
TESP-2
OFF
TESP-3
OFF
68.9 DEG
WC-8
OFF
CHWR
CV-10
CV-6
CV-4
CV-5
39.7 DEGF
38.1 DEGF
39.1 DEGF

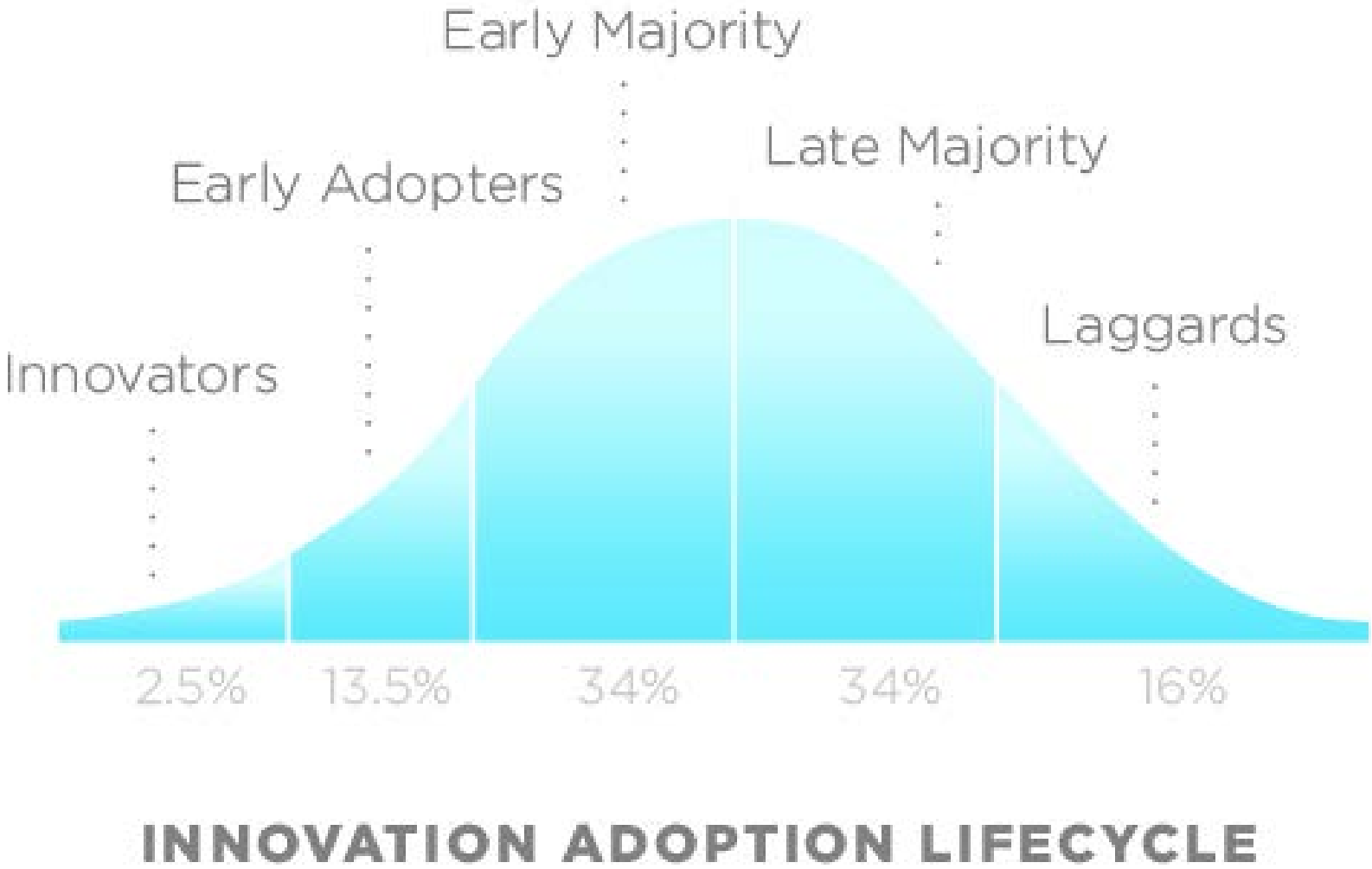
MEDICAL CENTER DRIVE

Adjacent ISO 15118 Compliant EV Charging for the Workplace

RWE/AV DC Fast Chargers

RWE ISO 15118 Level II EV Chargers

Microgrid RD&D For "Early Adopters" Commercialization?



Apple New Campus

Google New Campus Announced

The most prevalent questions from Early Adopter Site Visitors?

- What is the field performance of the Distributed Energy Resource?
- How long has the Distributed Energy Resource been operating?

East Campus Utility Plant: Future Home to the World's Largest, Most Diversified Portfolio of Energy Storage Systems

$3.3M, 4 Yr ARPA-E Grant to Be a National Laboratory and Field Test Site for the Most Advanced Batteries

With respect to Energy Storage,
"What makes me lose sleep at night?"

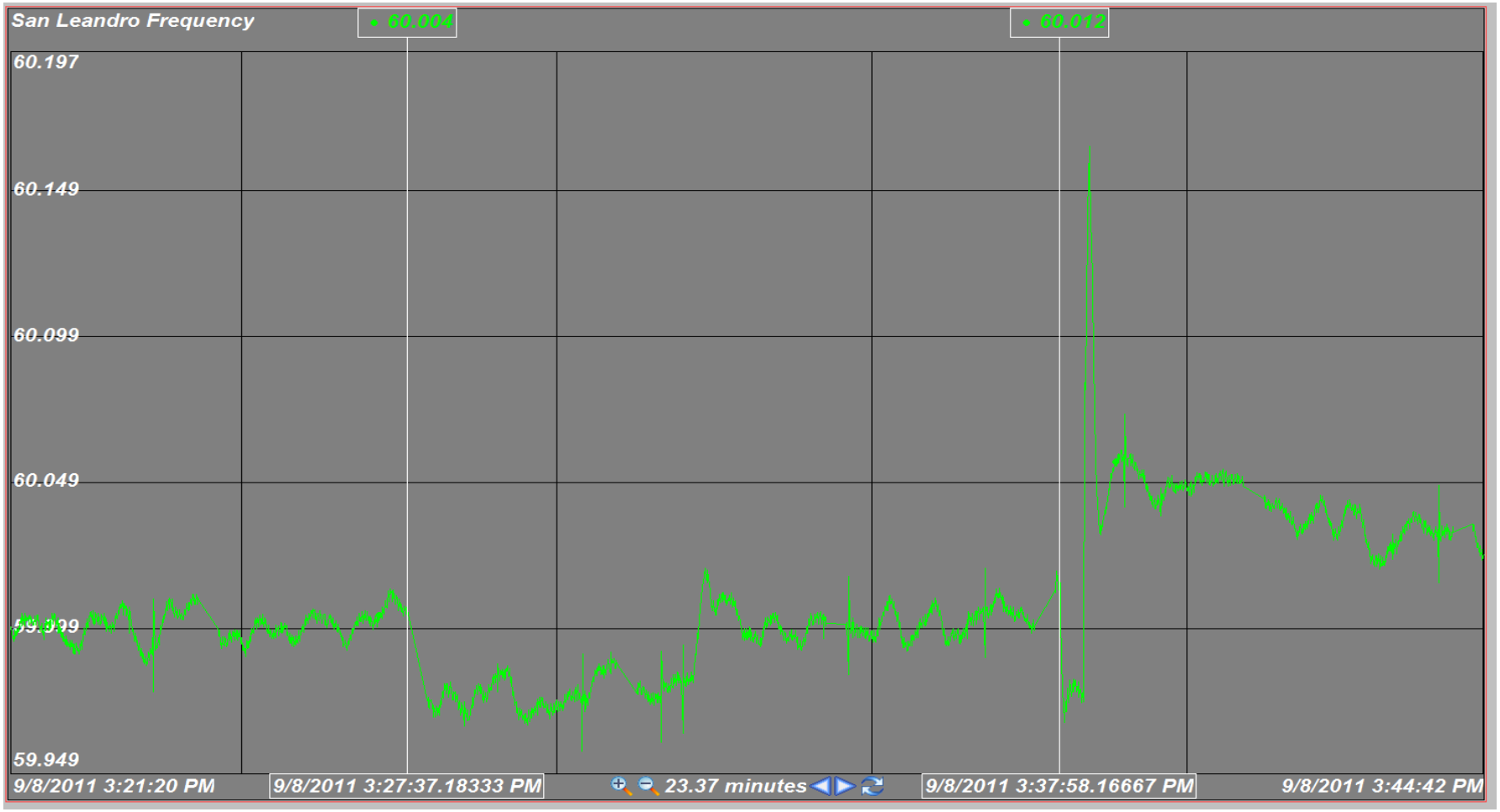
- Fire Suppression
- Safety
- Environment and Health

These could become issues that significantly slow the current rapid pace of energy storage early commercialization.

Answer to just about every question posed on RD&D Needs

For the Early Adopter Market dominated by High Reliability Customers, there is no substitution for accessible, vetted, granular, high fidelity, long term, interoperable, performance data of the DER

Improved PMU Monitoring Would Have Provided a 10 Minute Warning on the September 8, 2011 Outage



Islanding Protocol will be Key

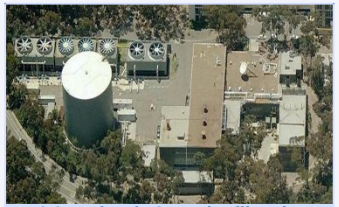
2012 Microgrid Goal: Replicate@Scale

UH – Maui College, Rural Site

UCSD's Subcontractors Top 5 out of 700 Proposals to DOD for 3 Virtual Power Plants of San Diego Navy Bases

The Family Tree from UCSD RESCO

Legend: Blue = Advanced R&D
Yellow = Early Commercialization



UC San Diego's Central Utility Plant

R&D and Early Commercial Opportunities by UCSD in Distributed Energy Resources & Grid Integration from CEC's Renewable Energy Secure Communities Funding to UCSD (2010-2014)

R&D and Early Commercial Opportunities by UC San Diego's Subcontractors Resulting from CEC's Renewable Energy Secure Communities (RESCO) Funding to UC San Diego (2010-2014)

UCSD East Campus Utility Plant

"The UCSD Microgrid provides insight into how the future California smart grid can operate with higher penetrations of renewable resources, integrate more distributed energy resources, and achieve higher levels of energy efficiency (including demand response) into a smooth operating electrical system. Understanding how and when microgrids draw from and sell back to the grid is essential for an evolving energy paradigm. By working with the CEC and other partners, the UCSD microgrid has become a superior advanced-knowledge transfer system that can educate others about the value of an integrated and functioning microgrid for years to come." Clean Energy States Alliance's State Leadership in Clean Energy (SLICE) Award to CEC, 2012"

Renewable, Combined Heat & Power (CHP) Fuel Cells

- 2.8 MW Directed Biogas Fuel Cell
- Integrated 350 Ton Absorption Chiller

Solar Forecasting

- $1M CEC for High-Fidelity Solar Power Forecasting Systems for the 392 MW Ivanpah Solar Plant (CSP) & the 250 MW CA Valley Solar Ranch (PV)
- $1M Comprehensive Grid Integration of SDG&E Solar CSI IV
- $2.4M from DOE & CEC for Improved Modeling Tools for High Penetration Solar
- $0.3M Sub from $1.4M Mitigating Measures to High Ramps Rates of Soitec Concentrating PV & Maxwell Ultracapacitor
- $1.4M CEC to Accelerate Distributed Renewable Resources Deployment
- $1.6M CEC to Expand Distributed Energy Resources Deployment; $1.5M match
- $2M R&D CA Solar Initiative (CSI) I & III
- $0.5M DOE SUNRISE w/SMUD
- $0.7M from Panasonic/Sanyo for Battery Storage Integration
- $0.3M Sub from Enernex on CEC's Utility-Scale Renewable Energy
- UC Merced-UCSD RESCO (Coimbra)

Next GenSmart Inverters

- $0.3M Site Host to $1.5M CPUC/NRG DC Fast Chargers & Grid Integration
- $0.6M Sub from $2M SunSpec Alliance CEC grant for Smart Inverter Interoperability Standards
- Joint working relationship with Underwriters Laboratories (UL) (pending)

High Solar Penetration

- 140 MW Permitted in CA
- $25M DOE SUNSHOT Manu Award to Soitec for San Diego Facility
- Site Host for initial 25 kW Soitec Concentrating PV prototype
- $1.8M CEC/South Coast AQMD/EPA/SDG&E for Solar Forecast Based Optimization of DER in the LA Basin & UCSD Microgrid. $.2M match
- $0.6M Site Host from $2M SunSpec Alliance's CEC Smart Inverter
- 7 kW Soitec CSP

Maximize Grid Benefits

- $0.3M Site Host from $1.5M NRG's CEC Vehicle-to-Grid Grant (PON 14-301-3)
- $0.5M Site Host from NRG's $1.5M CEC Integration of EVs to Maximize Grid Benefits (Pending)
- LOST: CEC High Reliability Microgrid for Critical Infrastructure, PON 14-301, $5M + $9M Match Funding

Solar Commercialization

- Co-Lead $154M of Clean Renewable Energy Bonds awarded to San Diego Institutions; $15M to UCSD
- 2 MW PV installed on campus and .8 MW off campus

Microgrid Controller (Power Analytics)

- $3.2M DoD Env Security Tech Certification Progrram (ESTCP) for 3 San Diego Naval Bases
- Confidential Client List for North American, Pacific & Europe to be Disclosed in 2015
- Acquired by Causam Energy 8/2014
- Sub to UCSD on DOE SUNSHOT/CEC High PV Penetration Mitigation
- BMW 2nd Life EV Battery Interface

Economic Optimization (Viridity)

- Philadelphia Navy Shipyard Redevelopment
- Con Edison Solutions
- Southeastern PA Trans Authority (SEPTA)
- Sub to SEPTA for battery & Supercapcitor for freq reg
- Sub to Power Analytics on DOE ESTCP
- $1.6M from CA Solar Initiative (CSI) for Innovative Bus Models, Rates & Incentives that Promote Integration of High Penetration PV with Real-Time Mgmt of Customer Sited Distributed Energy
- Sub Secure Interoperable Open Smart Grid Demo
- $.9M PA Energy Dev Auth
- Former CEO now Chair NY Public Service Comm

Big Data (OSIsoft)

- SDG&E's Borrego Springs I Microgrid
- SDG&E's Borrego Springs II Microgrid
- Sub to Power Analytics on ESTCP with NAVFAC
- Sub to ComED/IL Institute of Technology Microgrid Controller
- Sychrophasors R&D

Energy Storage

Thermal

- Augment 4 M gal with new 1.2 M gal Thermal Storage integrated with Renewable Combined Heat & Power (CHP) Fuel Cell w/ SEP and CPUC Permanent Load Shifting Incentive

Electric

- Early Commercial 2.5 MW/5 MWH battery from BYD of China w/CPUC Self-Generation Incentive Program (SGIP)
- Tesla PV Integrated 200 kW/400 kWh Storage at Warehouse Application
- $3.3M, 4 Yrs ARPA-E Cycling Hardware to Analyze and Ready Grid-Scale Electricity Storage (CHARGES)
- Site Host 30 kW/30 kWh Panasonic/Sanyo PV Integrated Storage Demo
- Site Host BMW 100 kW/180 kWh Repurposed EV Battery
- Site Host NREL/CSE Repurposed EV Battery Life Test Cells
- Site Host 100 kW/300 kWh ZBB Flow Battery Demo

Mechanical

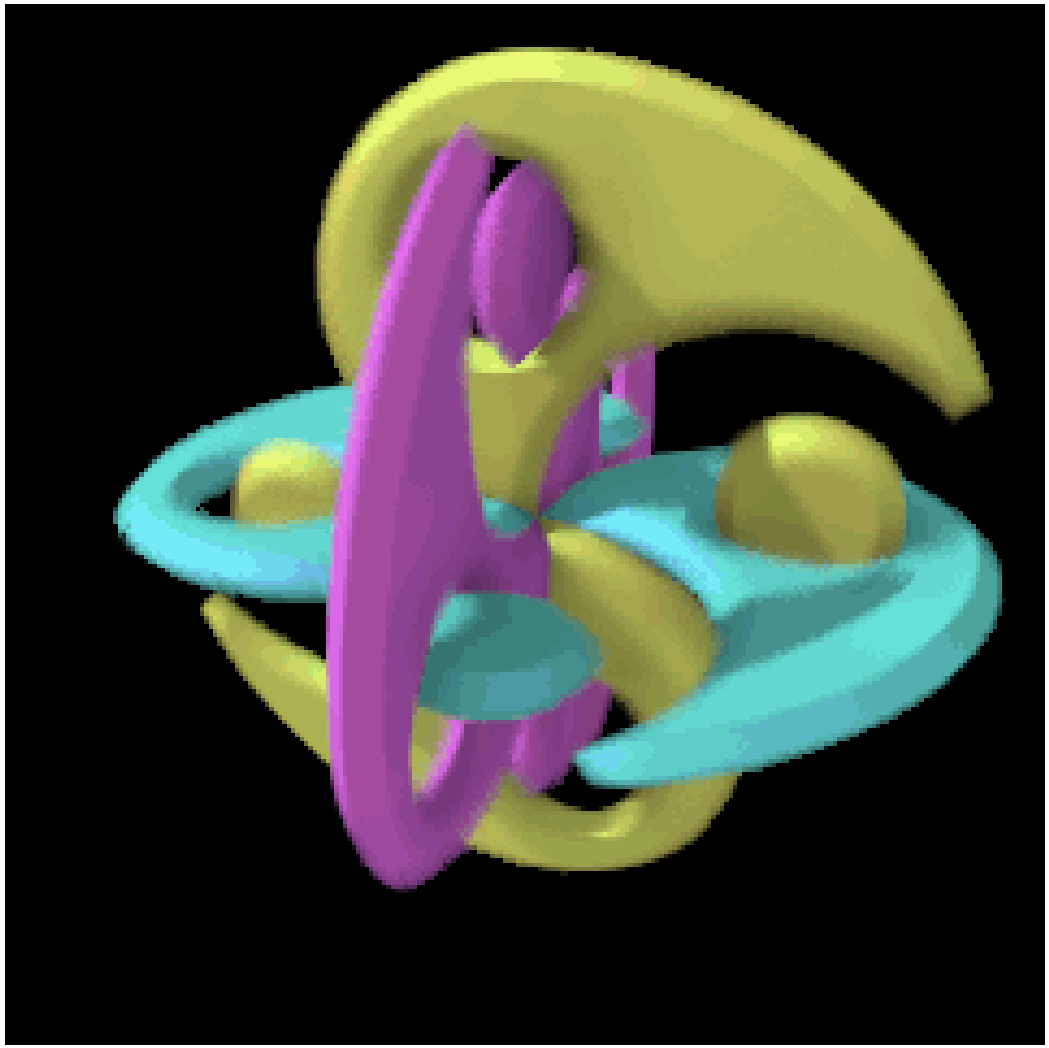
- Site Host to $1.8M CEC grant to Amber Kinetics' 100 kW-15 minute Flywheel (pending)

Washom's Consulting

- Chief Architect of Lana`i Hawaii Microgrid

PUC Statute 769 a Major Force

- **The integration and optimization of the "distributed resources" defined as distributed renewable generation resources, energy efficiency, energy storage, electric vehicles, and demand response technologies.**
- **State for the benefit of the IOUs' distribution resources plan proposal the findings that indicate optimal locations for the deployment of DERs.**
- **Evaluate locational benefits and costs of distributed resources located on the distribution system. This evaluation shall be based on reductions or increases in local generation capacity needs, avoided or increased investments in distribution infrastructure, safety benefits, reliability benefits, and any other savings the distributed resources provides to the electric grid or costs to ratepayers of the electrical corporation.**

- **Propose or ID standard tariffs, contracts, or other mechanisms for the deployment of cost-effective distributed resources that satisfy distribution planning objectives.**
- **Propose cost-effective methods of effectively coordinating existing commission-approved programs, incentives, and tariffs to maximize the locational benefits and minimize the incremental costs of DERs**
- **Identify any additional utility spending necessary to integrate cost-effective distributed resources into distribution planning consistent with the goal of yielding net benefits to ratepayers.**
- **Identify barriers to the deployment of distributed resources, including, but not limited to, safety standards related to technology or operation of the distribution circuit in a manner that ensures reliable service.**

Orchestration of Harmony Supply, Storage & Demand