

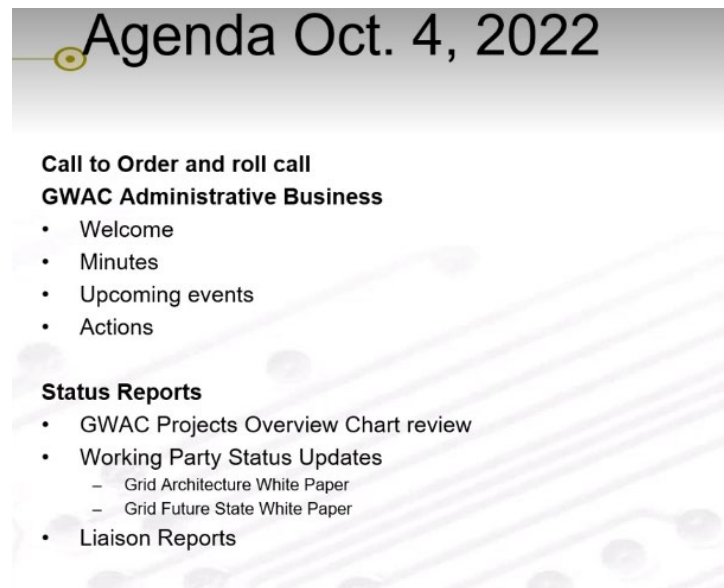
GWAC F2F San Diego – Tuesday, October 4, 2022

Attendees:

F2F: Ron Bernstein, Ron Melton, Seemita Pal, Jaime Kolln, Ron Ambrosio, Ron Cunningham, Marc Costa, David Forfia, David Wollman, Ahlmahz Negash, Kay Aikin, Rahul Bahadur, Anthony James, Susie McGuire

Online: Farrokh Rahimi, Leonard Tillman, Hayden Reeve, Mark Paterson, Dave LeVee, Ayad Abdelrahman, Andrew Bordine, Wade Troxel, Larisa Dobriansky

Ron Bernstein opened the GWAC Administrative Meeting.



Agenda Oct. 4, 2022

Call to Order and roll call
GWAC Administrative Business

- Welcome
- Minutes
- Upcoming events
- Actions

Status Reports

- GWAC Projects Overview Chart review
- Working Party Status Updates
 - Grid Architecture White Paper
 - Grid Future State White Paper
- Liaison Reports

The September Meeting Minutes will be sent out in time for the next meeting.



GRIDWISE

Actions

The F2F Organizing Committee: The committee members are Ron Melton, Ron Bernstein, David Forfia, Ron Cunningham, Farrokh Rahimi, Jaime Kolln and Marc Costa

August Actions:

Action: Kay and Susie to collaborate on the next blog post for Rahul Bahadur

✓ **Action: Possible speaker from SEPA on future blockchain and TE related initiatives**

Action: GWAC attendees who have suggested topics or presenters for the F2F meeting, please let Ron M. and Ron B. know and copy Susie.

Conferences and Events

Date	Event	Location	Attend	Speak	Topic
Sept 19 - 22, 2022	RE+, Sept 21 – SEPA Working Group Forum (GAWG and TEWG)	Anaheim, CA	Ron Melton, Ron Cunningham, Farrokh Rahimi ?	Yes	GAWG Primer and Ontology overview
Oct 4 - 6, 2022	GWAC F2F	San Diego, CA	ALL	Yes	The Next Big Thing
Oct 4 - 6, 2022	UCA OpenFMB Plugfest	Charlotte, NC	No	No	
Jan 16 - 19, 2023	IEEE ISGT	Washington, DC		Yes	
Jan 5 – 8, 2023	Consumer Technology Assoc.-CES 2023	Las Vegas, NV			Global Stage for Innovation
Feb 4 - 8, 2023	ASHRAE (Co-sponsor with IEEE) / AHR Expo	Atlanta, GA	Ron Bernstein, Farrokh Rahimi (tent)	Yes	Standardized Building Datasets for Benchmarking Control Algorithms, Energy Efficiency, Modeling, and Decarbonization, Possible GWAC F2F
Feb 7 – 8, 2023	GWAC Seminar and F2F (co-located at AHR Expo)	Atlanta, GA	All		GWAC Seminar. AHR has reserved a free meeting room for a F2F meeting.

Jaime Kolln asked to add IEEE Grid Edge Technologies Conference, April 10-13, 2023, San Diego, CA

Key Aikin asked to add gridCONNEXt 2022, to be held December 5 - 6, 2022 in Washington DC.

Action: Add these conferences to the conference slide (done)

Ron B. replied to a question by Farrokh Rahimi, he has not yet heard back from ASHRAE about acceptance of the GWAC panel at the AHR Expo, but he expects to hear soon. Ron noted that the GWAC panel talk would likely be scheduled on Feb. 7 and then we could host the GWAC F2F meeting on Feb. 8, 2023, the location is Atlanta, GA.

Ron M. asked about the next GWAC Blog post. Rahul has one ready to go except for final touches, he will talk offline with Kay offline about the next blog.

Ron Melton reminded the group that in a few weeks we will open the GWAC new member selection process. Ron encouraged the group to think about possible candidates and invite them to apply. Those who have had some involvement with the GWAC are preferred so that the group has some idea about their experience. Those who work in the grid industry with background relevant to the GWAC would make good candidates. Ron will talk with those who have terms that will be expiring in January.

GWAC members should please tell Ron Melton if they wish to continue or are ready to transfer to emeritus. Ron is hoping to talk to all of those with expiring terms by the end of October. A message will go out to the GWAC mailing list and the application process will be posted on the GWAC website.

New Candidates will apply in October through December.

The selection committee will meet in late December or early January to review the submitted applications.

The Selection Committee will consist of five people. Dave Wollman with NIST agreed to again be an external reviewer. Two GWAC members whose terms are not expiring will also be needed along with Chris Irwin, DOE, and Ron Melton as GWAC Administrator.

Ron M. noted that if enough applications come in, the committee will meet in late December or early January. If not, the process could be extended to allow more time for applicants. The time commitment is about 20% time. Applicants should check with their employers to be sure they will support the effort. Applicants have four to five pages to complete as part of the application process. The application process will be posted on the GWAC website.

Seemita Pal, PNNL, gave an update on the progress of the grid architecture white paper. She noted that the edits provided from feedback have been made. She is working with PNNL Communications to update some of the diagrams, and she is working on finalizing the draft. It is almost ready for review. She has had some time constraints this fall but she is pushing the paper along.

Ron Bernstein reported that the TESC 2022 conference ended with a final net positive balance of \$1500 this year.

Ron B. asked Anthony James, SCE if he thought the SDGE offices might be a possible location for the next IEEE TESC Conference. He asked if SCE would be interested in providing space for the conference? Anthony replied that he will look into it and get back to Ron

David Forfia asked if the PNNL TSP project would still be willing to support the TESC conference. David suggests we look at when to get started and when to hold it with an on existing meetings such as AHR, IEEE T & D and the ISGT conferences. He suggested the months of February, late May, or early June as good candidates but he noted 2023 would be too soon.

Ron B. said that depending on what GWAC comes up with for the next big thing it might be appropriate to change the name from TESC to something else, if the GWAC is moving on from Transactive Energy.

Ron M. said that would need to be a discussion for the group and we would need to be sure that Chris Irwin agrees.

David Wollman will save his liaison report for the later discussion.

Day 1 Speaker highlights -

Ron Melton introduced Marc Costa with the Energy Coalition as the first speaker of the day. Marc is presenting on his perspective as a GWAC Associate member.

◉ Getting Oriented

- Understanding member perspectives
 - In regulatory world, perspectives are complicated
 - In technical world, solutions are steeped in a spectrum of experience
- Determining where my perspective can be useful
 - DOE BTO data standards and tool development
 - CPUC \$10B of regulatory investment evolution over the last decade
 - Local government as a critical stakeholder

Marc gave an introduction of his experience noting that he works more on the demand side, and with DOE BTO and other research organizations. He commented about interoperability data on the regulatory front. His primary experience is with local government, public safety, and local infrastructure. On the DSO side there should be some intersection of these elements.

On the load changes – if there is no impact for net peak load – behind the meter, how can we bridge the gap? A multi-lab effort that NREL leads tries to mesh these two things. NOVA in CA just filed to be a micro utility. There are goals on the books, we have seen a radical uptake in CCAs. We can challenge the assumptions. We are realizing there are underserved communities.

Bill Gates said we won't solve a challenge by asking people to consume less of something. If you challenge these assumptions, there are interesting targets, moving targets.

It comes down to what is the ultimate goal – what if we achieve our goals? It's interesting to think all the way out and then look backwards.

If we have abundant, cheap energy – what is the upper limit? What is the max load?

Role of GWAC

- Diffusion of Innovations?
 - Definition: An innovation communicated to a market over time
 - Can we articulate the innovation needed?
 - Who needs to adopt the GWAC innovation?
 - How does that message resonate with various adopters over time?
 - How do we measure it and when is our job done?

With all the available funds, with all the knowledge and GWAC expertise, what should we do?

Jaime Kolln presented the next talk –

GridWise Architecture Council: A Brief History

Jaime Kolln, PNNL - GWAC Origin
Ron Ambrosio - Interoperability
David Forfia - Transactive Energy
Ron Cunningham – Electric Industry Visions and Future States

Jaime Kolln would like to recognize GWAC experience, from many diverse innovators

Steve Widergren, PNNL has been a mentor for Jaime at PNNL. The value that he sees with GWAC is in outreach, innovation, and contributions to the smart grid mission and vision. GWAC has provided both education and impact.

Jaime spent some time looking at how this group evolved over time. The GWAC started under Eric Lightner, DOE Office of Electricity.

Jaime explained the difference between GWAC and the GridWise Alliance, also started under Eric Lightner, which is the industry lead. GWAC is the “brain trust,” piece.

Ron Melton added that GridWise was the DOE smart grid program. He added that Battelle Memorial Institute owns the registered trademark.

Jaime said that in his study of the GWAC products and history, he is impressed by the fact that we are still using basic tenants first developed by the group in 2003.

GridWise Architecture Council - Origin

- Funded by DOE
 - Sponsor Eric Lightner –Director of the Office of Electricity Federal Smart Grid Task Force in the Office of Electricity Delivery and Energy Reliability
 - GridWise Initiative activity but **not to be confused with the GridWise Alliance**
- GridWise Architecture Tenets & Illustrations – Steve Widergren2003
 - **Mission Statement:** *“The Architecture Board gathers great minds in related fields of interest to capture and describe the abstract underpinnings for information exchange and control of a society of devices, subsystems, and businesses, that by the nature of their transactions and local decisions will improve the performance of the electric power system as a whole. This board must do this with the full knowledge of the existing and emerging mechanisms for information exchange that serve collaboration between organizations in the economy in general”*

Demand Response can be used different ways – it doesn’t describe the service. This work has been built on the GWAC foundational documents.

Jaime has reread the GWAC stack, and the Interoperability context setting documents, and said that he has gotten new information from it each time. He can see the roots and long-term vision when he reads them. He’s impressed with the forethought. He noted that GWAC’s aspirational goals – and advanced grid architecture – he sees us moving faster than the utilities in classifying interoperability needs.

Jamie charged photos from the 2005 Interoperability “Constitutional Convention” held in 2005:

Interoperability Constitutional Convention December 2005



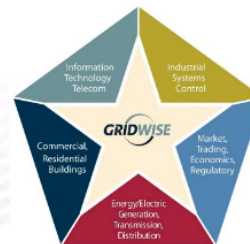
Ron Ambrosio added that GridWise was a DOE program under Eric Lightner, in 2003. The first face to face meeting was held in May 2004. Steve Widergren formed the council around different segments of

industry and then brought their perspectives together. It the group took six months to figure out that their disagreements were because they all used different terms to describe the same thing.

The constitution was an attempt to talk to industry and gather perspectives on what is needed, and what challenges and issues they faced. It's still a relevant document. It has been updated a couple times. It was always intended to be a living document. GWAC is now in its 18th year.

—○ Consensus through multiple revisions

- The Constitution: a work in progress
 - Initial principles were assessed, commented and revised
 - A broad spectrum of interviewees were consulted (close to 100 to date), representing each sector
 - Iterations of feedback and revision
- The constitution is not perfect or finalized, but is in reasonable shape to discuss with an even greater audience



→ The Constitutional Convention

At the start GWAC members spent a lot of time talking with industry to form its foundation.

Constitution:



Interoperability Statements of Principle



“B04- (v2.0) Interoperability approaches must consider implementation costs/benefits and impacts to the parties involved in the transaction.”

The group had been together for one and a half years before the constitutional convention meeting. The context setting framework meeting was held in was May 2005 By Sept 2006 the GWAC Interoperability Framework was substantially defined.

☉ Constitutionally Consistent

Based on statements in the GridWise Interoperability Constitution

- Focus on interaction at the boundary (B01)
 - Respect each party's privacy and independence
- Support changes w/o system disruption (B02)
- Support verification and audits (B05, R02)
- Go to system-safe corner in event of communication failure (U02)
- Communicate concepts across stakeholder base (U03, R01)
- Adopt broadly applicable (cross-sector) best practices (I02)
- Heterogeneous environment (I10)
 - Coexistence of multiple IT standards and technologies
- Consider needs of the full range of stakeholders (G01)
- Be practical (I09, B04)

Framework can incorporate checklist for GridWise interoperability evaluation

GWAC used the constitution to validate the framework.

☉ Multiple Audiences

- Interoperability Framework Document
 - Experts familiar with large system integration and interoperability issues
 - Does not replace enterprise architecture frameworks (e.g., DoDAF, TOGAF, Zachman, RM-ODP, etc.)
 - Layers and crosscutting issues support various views / approaches
 - Input from review of over 45 system integration experts
 - **Workshop held in April 2007**
- Other targeted audiences
 - Designers, business decision-makers, policymakers, across various industry sectors
 - Executive summaries, checklists, cross-cutting issue papers, use case scenarios

Ron Ambrosio mentioned the GWAC stack.

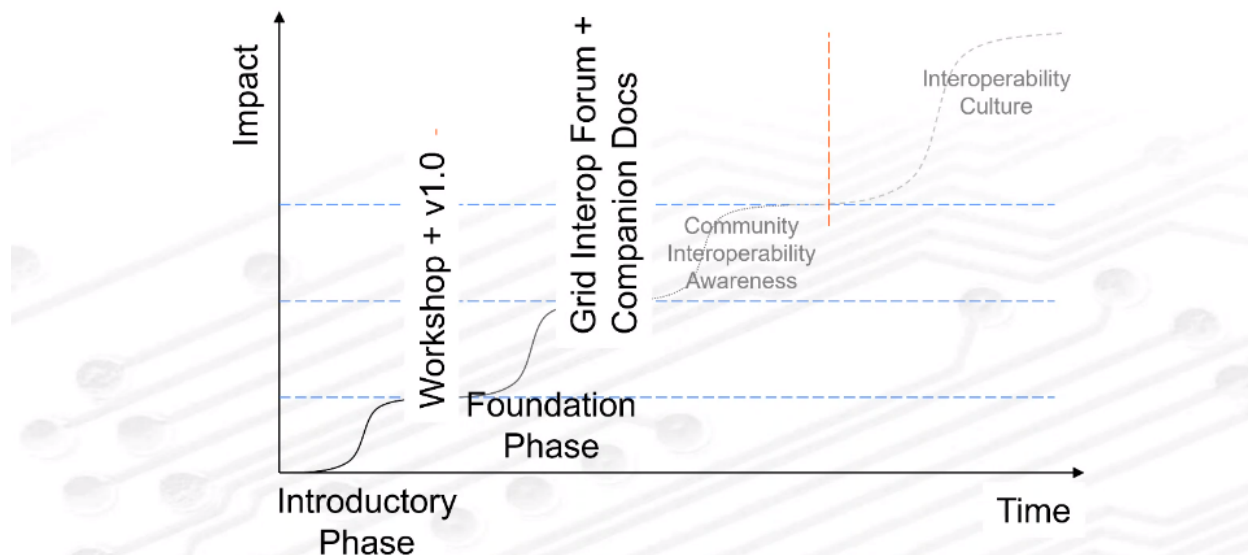
He showed early versions of the Framework.

Interoperability Framework



First interop forum in 2007

Framework Progression



There was a series of meetings held from 2007 to 2012 on the topic of building interoperability awareness. At some point we'd pass the red line and move to interoperability culture. In 2012, or 2013

they declared victory. In 2009 there was funding to get things formed; SGIP had recently formed, and interoperability had its own momentum.

In 2007 the EISA legislation was the first time that GWAC was called out as an organization and impressively was called out first in the list. There was recognition that what we were doing was key at that time.

Gerry Fitzpatrick at NIST was a key player. They got started by organizing around what GWAC was doing. GWAC was very involved. At the time Ron Ambrosio was head of the grid architecture committee.

Dave Wollman said that NIST had an EISA task to work with congress in 2006 and 2007. Gerry was also involved, he more on the technology side and Dave with working with funding. There was discussion about what should be DOE and what should be NIST (Dept of Commerce). They had a chance to get involved in something their stakeholders cared about and needed.

NIST and GWAC had to figure out what each was doing. NIST wanted to do standards coordination.

ARRA Act money helped NIST get going and then they added some initiatives.

Dave Wollman and Ron Melton tackled business and policy with DNP Duke. SGIP was designed to build on stakeholder needs. They wanted to welcome all stakeholders. Gary Locke and Steven Chu were the HQ leads. Grid Architecture was something Ron Ambrosio grew to love. Architecture was the glue that held everything together. They worked with NEMA and others for testing certification. Cybersecurity was a factor. Logical interfaces and how to apply cybersecurity was considered.

Ron Ambrosio noticed that at one NIST conference all the rooms had people with their own battles. Dave Wollman and Erich Gunther developed a teaming model and instilled more structure and involvement. They leap frogged some things and figure out effective partnering that created a more cohesive and effective group.

This led to a series of SGIP organizations. They brought in some initiatives at about \$2M in total. SGIP had to transfer to industry.

🕒 NIST Smart Grid Interoperability Panel (SGIP)

- Congress directed NIST to engage GWAC in the 2007 EISA Legislation
 - The NIST lead was Jerry FitzPatrick, with Dave Wollman as his second in command
 - GWAC helped NIST organize the SGIP based on the Council's work
- GWAC members served on Governing Board and formed and led the Architecture Committee and Testing & Certification Committee
- GWAC members were actively involved in the Domain Expert Working Groups (DEWGs) and the Priority Action Process (PAP) activities, often in leadership positions

Day 2 Speaker highlights -

Ron Melton, Ron Bernstein, David Forfia, Ron Ambrosio, Ahlmahz Negash, Seemita Pal, Jaime Kolln, Susan McGuire, Ron Cunningham, Lorenzo Kristov, Anthony James, Rahul Bahadur, Marc Costa, Kay Aikin, David Wollman

David Forfia gave a brief history of the GWAC

Ahlmahz Negash asked about how often the GWAC products are downloaded from the website.

Action: Susie and Jaime will talk with the PNNL GWAC website administrator about setting up some analytics.



GRIDWISE


TESC History

- 2011 – Transactive Energy Workshop – OATI, Redwood Shores, CA
- 2012 – Transactive Energy Workshop – T.J. Watson Research Center
- 2013 – 1st International Transactive Energy Conference – Portland, OR
- 2014 – 2nd Transactive Energy Conference – Portland, OR
- 2016 – 3rd International Transactive Energy Systems Conference – Portland, OR
- 2017 – 4th International Transactive Energy Systems Conference – Portland, OR
- 2018 - 5th International Transactive Energy Systems Conference – MIT Cambridge, MA
- 2019 – 6th International Transactive Energy Systems Conference – University of Minnesota, Minneapolis, MN
- 2020 – 7th International Transactive Energy Systems Conference – Virtual
- 2022 – 8th International Transactive Energy Systems Conference – Virtual



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- Performance and non-performance of DER
 - PV doesn't output as forecasted (also cloudy days, 90% not metered, etc.) – drives, and is the input for 10 GMS use-cases (switching, outage mgmt., load shed, DR, state estimation, FLISR, OPF, market integration)
 - Diversify portfolio to include more DR, in addition to storage
- Storage
 - Reliability of California fleet
 - Control systems scaling from 10-100-1000 MW
 - Interoperability (obsolescence)



TE Publications

- 2011 – Transactive Energy Workshop
- 2012 – Transactive Energy Workshop
- 2013 – 1st International Transactive Energy Conference –
- 2014 – 2nd Transactive Energy Conference
- 2016 – 3rd International TES Conference –
- 2017 – 4th International TES Conference –
- 2018 - 5th International TES Conference -
- 2019 – 6th International TES Conference -
- 2020 – 7th International TES Conference -
- 2022 – 8th International TES Conference -
- 2014 – Transactive Energy Principles
Transactive Energy Infographic
Transactive Energy in < 1000 Words
- 2015 – Transactive Energy Framework 1.0
Valuation of Transactive Energy
- 2016 – TE Decision Maker's Checklist
- 2017 – TE Roadmap Draft
- 2018 - TE Roadmap
- 2019 – TE Framework 1.1
- 2020 – Smart Buildings as Transactive Hubs
Transactive Energy FAQ
Reliability and Resiliency Considerations for TES

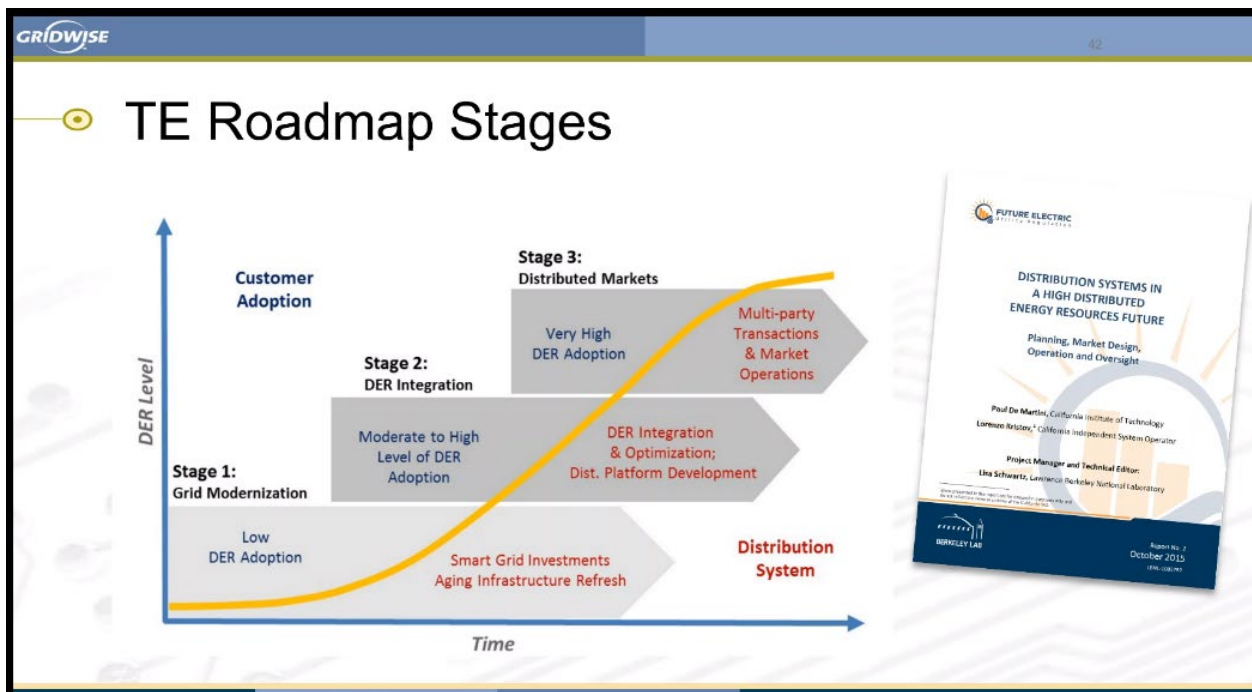
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Past GWAC Chair David Forfia recounted some of the impromptu discussions at previous meetings that have been the genesis of many key GWAC documents such as the TE Framework.



Mark Knight had created a You Tube video at one of the past conferences.

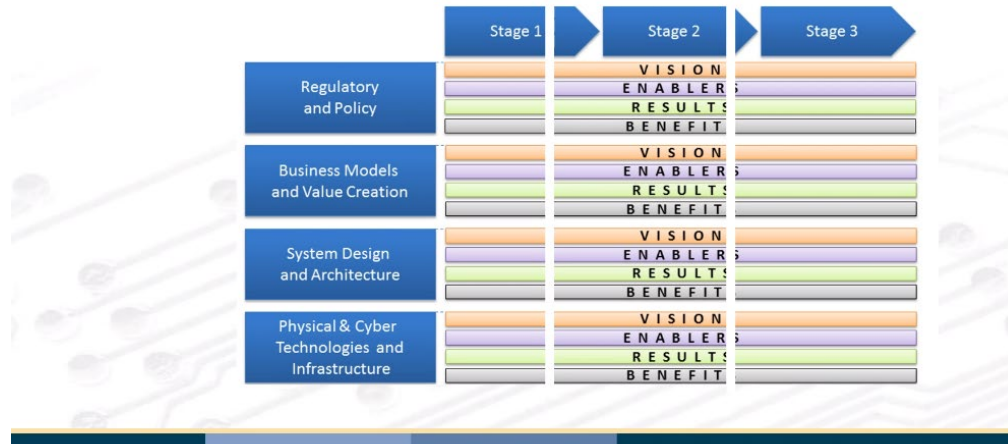
David noted how much he learned from the late Erich Gunther, a former GWAC member. He quoted Erich with “the pesky laws of physics.” David also noted the value of networking and thought leadership to the GWAC.



David noted that the line to get to the next step is not going to be a straight line. He referred to the three stages of the TE Roadmap.

David said we need to look at what needs to happen in each stage.

Roadmap by Stages & Framework Areas



Smart Buildings as Transactive Hub

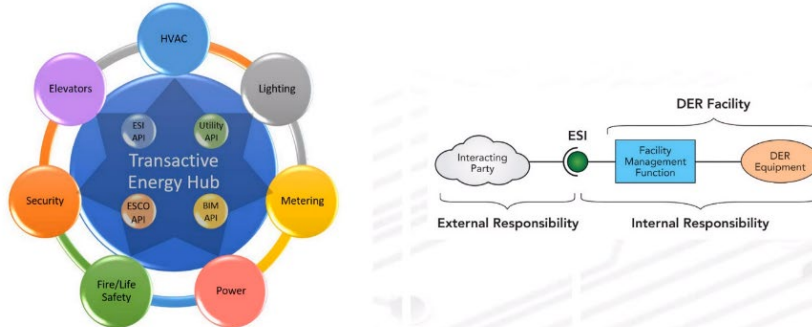


Figure 1.2. Building Systems and the TE Hub API Interfaces

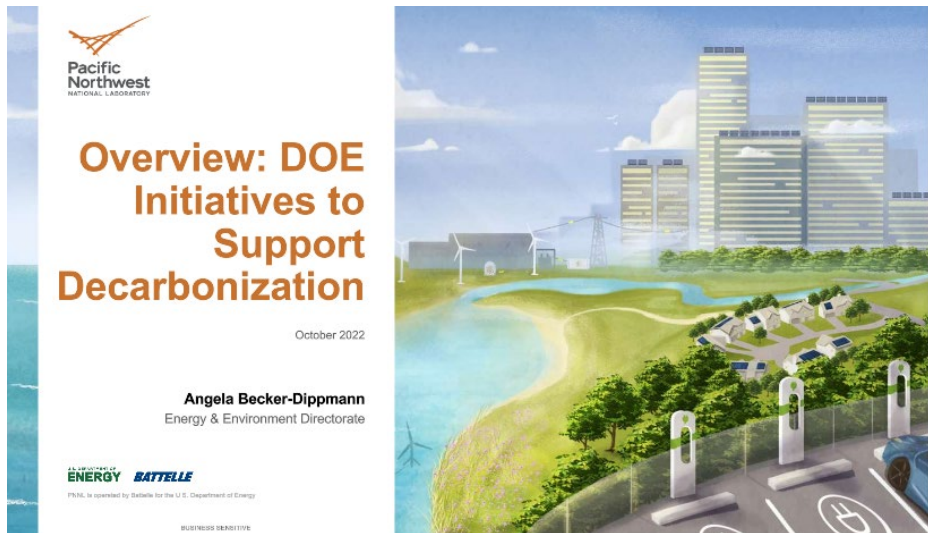
In this slide Ron Bernstein had created the TE hub and the other diagram is from a paper by David Hardman from 2010 or 2011 which is on the GWAC website.

Jaime noted that all the products are the foundation of future work.

Ron M Introduced Angela Becker-Dippman who re-joined PNNL in 2019. She has been chief of staff for the US senate energy committee. She is part of the EED Sector team. She will give us a high-level view of DOE priorities for the Lab. This could help GWAC to better understand the DOE perspective.

She highlighted some new offices and changes in staffing on the DOE organizational chart.

The bipartisan infrastructure law has gone into effect and has created changes in staffing and strategy. There will be 65B in infrastructure spending.




Ron Melton commented that the GWAC meeting held in person was in January 2020 in Orlando. Angela noted many things have changed since then.

Angela Becker-Dippman noted that she had been involved in 2006 and 2007 in appropriations during the timeframe of the Oly Penn Demo by PNNL and the EISA.




Administration priorities are clear



THE WHITE HOUSE

- **2030** – 50-52% reduction from 2005 levels in economy-wide net greenhouse gas pollution
- **2035** – 100% carbon pollution-free power sector
- **2050** – net-zero emissions, economy-wide





New initiatives: Energy Earthshots

Energy Secretary Granholm Announces Long Duration Storage Shot at American Public Power Association Conference
 ...reduce the cost of grid-scale **energy storage** by 90% for systems that deliver 10+ hours of duration within the decade.

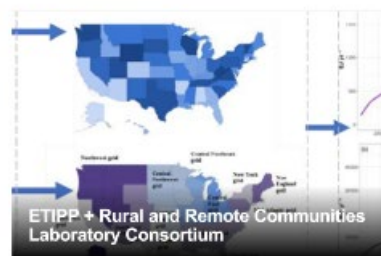
Secretary Granholm Launches Hydrogen Energy Earthshot to Accelerate Breakthroughs Toward a Net-Zero Economy
 ...reduce the cost of clean **hydrogen** by 80% to \$1 per kilogram in one decade

Secretary Granholm Launches Carbon Negative Earthshots to Remove Gigatons of Carbon Pollution from the Air by 2050
 ... remove gigatons of **Carbon Dioxide** from the atmosphere and durably store it for less than \$100/ton

Angela Becker-Dippman gave a briefing of each of the initiatives shown including Net zero world initiatives and other initiatives:



Many new cross-cutting DOE initiatives

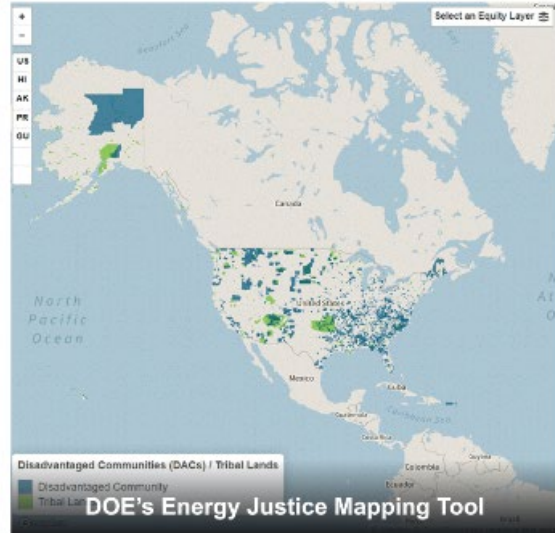




Implementing Justice40

Office of Economic Impact and Diversity identified eight policy priorities to guide DOE's implementation of Justice40:

1. Decrease energy burden in disadvantaged communities (DACs).
2. Decrease environmental exposure and burdens for DACs.
3. Increase parity in clean energy technology (e.g., solar, storage) access and adoption in DACs.
4. Increase access to low-cost capital in DACs.
5. Increase clean energy enterprise creation and contracting (MBE/DBE) in DACs.
6. Increase clean energy jobs, job pipeline, and job training for individuals from DACs.
7. Increase energy resiliency in DACs.
8. Increase energy democracy in DACs.



Angela told the group that the question, “what is 40% of a benefit” is a key question right now within and outside of the DOE.

She added that we plan the grid for reliability and least cost – but there are tradeoffs. This creates a debate for the DOE and with its stakeholders. Concepts like TE and how to provide for it as well as who shares the benefit bear additional discussion. Connecting communities looks at some of this.



Office of Clean Energy Demonstrations: \$21.5b

[T]he Office of Clean Energy Demonstrations...shall conduct administrative and project management responsibilities for the demonstration projects ...[and] shall consult and coordinate with technology-specific program offices to ensure alignment of technology goals and avoid unnecessary duplication

Office of Clean Energy Demonstrations

- Energy Storage Demonstration Pilot Grant Program: \$355m
- Long Duration Demonstration Initiative & Joint Program: \$150m
- Advanced Reactor Demonstration Program: \$2.477b
- Carbon Capture Large-Scale Pilot Projects: \$935m
- Carbon Capture Demonstration Projects: \$2.537b (6 projects: 2 each from coal, natural gas, industry)
- Industrial Emission Demonstration Projects: \$500m
- Clean Energy Demos on Current and Former Mine Land: \$500m
- Regional Clean Hydrogen Hubs: \$8b
- Grid Upgrade/Resilience Program: \$5b
- Energy Improvement for Rural/Remote Areas: \$1b

Angela noted the new Office of Clean Energy Demonstrations – and noted how quickly they are trying to ramp up. She went through the list of demonstration projects.

Kay asked about the S4 position above EERE and others. She asked about the structure.

Angela confirmed that Pat Hoffman is in the new grid deployment office for now. She does have a new boss but it's the same number of layers.

Angela said an integrated approach is needed. With some grants to states initiatives will need to set priorities in line with state objectives and needed investments. She said projects will be expected to be “shovel ready” as with the past ARRA initiatives.

Ron Bernstein said that GWAC participants could act as reviewers for EERE proposals. He is doing that as a volunteer. Ron said reviewers should not just review for capability and cost but also for the fit to overall objectives including energy justice and equity issues or resilience issues.

Marc Costa would like to have the opportunity to act as a reviewer.

Ron Melton noted some plans like cyber technology was with ARRA, and asked if there will there be requirements for tech elements in future plans or calls?

Angela said yes for smart grid investment grants – like with cyber and transportation electrification – there is opportunity. She noted the need for coordinated control at a systems scale, coordinating is very important. Ron M. said he would be glad to talk with her more on this topic.

Rahul Bahadur noted funding at the local level is creating demand with incentives for homeowners – she said the IRA is using the tax code and tax credits for home issues. Individual homeowners don't know

how to leverage opportunities. She noted the challenge even in Seattle of installing a heat pump water heater.

Marc Costa asked about societal transformation and the grid – what bubbles to the top of mind?

Angela said it's a tough question – she said scaling the work force such as with IBEW analytics. It's a major barrier of difficulty. Also, a strategic effort state by state to increase regulatory innovations will be needed. We might ask how do we transform technical assistance – how to lower barriers with planning paradigms? Solutions might include shifting the priorities of utility spending to adopt new models that will be needed in the future. State and federal conflict has been a barrier. It can be well informed by architecture. Such was where to put communications investments in the state of Washington as an example.

Lorenzo Kristov added that regulatory innovation is extremely important. Customers are adopting DERS because they like them for security and power quality, and the incentive may not matter to them. A regulatory framework to capture that value – he sees that as a lag in state regulatory committees.

Anthony James gave a presentation on highlights from Southern California Edison

What are the Challenges for Achieving Deep Decarbonization? Projects, Research, Programs from a CA Utility Perspective

Mark Martinez and Anthony James, Southern CA Edison

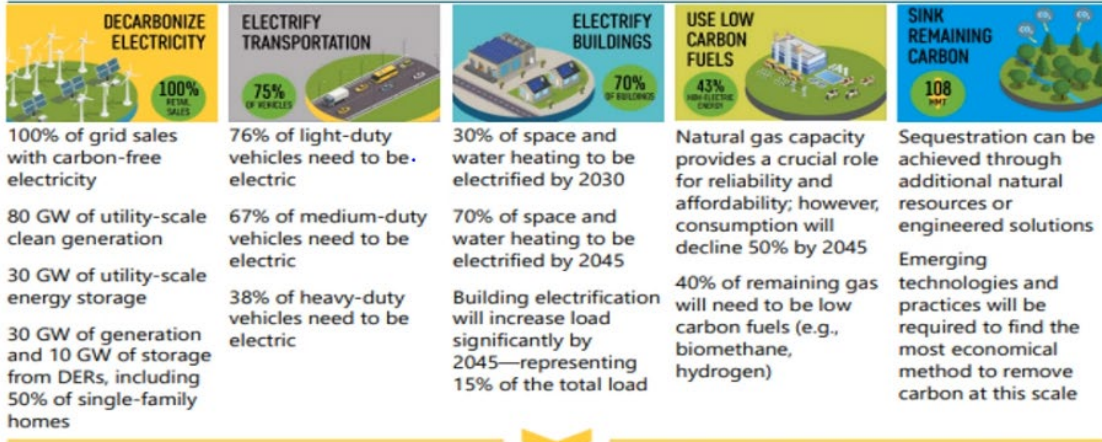
Energy for What's Ahead™



Anthony noted that Southern California Edison is an investor-owned utility serving southern California.

Reaching California's 2045 GHG goals requires a near-complete transformation of energy use economy wide

Pathway 2045: Key steps California must take to reach carbon neutrality



Edison will continue working in partnership with state and federal governments and with other stakeholders, including the communities we serve, to advance policies that rapidly cut GHG emissions

They are working with EPRI to design

They hope to decarbonize all electrical systems.

Edison International has one of the strongest electrification profiles in the industry

Transportation Electrification

Largest U.S. IOU EV charging programs with over \$800 million of approved funding

Substantial state budget commitments to accelerate zero-emission vehicles

~1 in 7 U.S. EVs are in SCE's service area¹

Current trajectory of 4.7 million EVs in CA (1.7 million in SCE's area) by 2030, and need to achieve 7.5 million²

Represents ~6.7 million MWh of incremental load in SCE's area by 2030 and ~50 million MWh by 2045

Building Electrification

SCE has proposed \$677 million plan to accelerate adoption of 250,000 heat pumps

Governor's proposed \$962 million investment in building decarbonization complements SCE's plan

Target to have 24 million residential heat pumps in California by 2045

Represents ~2.2 million MWh of incremental load in SCE's area by 2030 ~9.8 million MWh by 2045

Energy Storage

SCE has installed or procured ~3.3 GW of storage capacity

SCE constructing ~535 MW of utility-owned storage to support reliability

Project 30 GW of utility-scale storage needed California-wide by 2045

Growing energy storage capacity supports reliability as economy increasingly relies on electricity

1. As of May 2022. Source: DMV on data provided by EPRI
2. Based on SCE analysis, SCE's Pathway 2045 analysis estimates that 7.5 million light-duty EVs are needed by 2030 for California to meet its decarbonization target

Anthony replied to a question from Ron Melton that the ES factor is about 10% of their capacity.

EV Growth

- By 2045, on average EV Penetration will grow 34x (GWh) from today in SCE's service territory
- Charging load for medium and heavy duty vehicle fleets may change location unpredictably and rapidly
- 1kW on average per home vs. 1.44kW to 17kW+ for EV's.

They are looking at residential homes with one or two EVs.

- Different magnitude, shape and variability of customer load to be served, driven by timing, speed and geographic distribution of customer adoption
- Different physical characteristics of carbon-free resources (e.g., intermittency, lack of inertia), and access to transmission system to connect supply to load centers
- Different operating performance and risks of physical assets under climate stress, climate-driven changes in customer loads and needs, and impact from climate mitigation measures (e.g., PSPS)

Some weather challenges affect production such as a hot day with cloud cover.

- Transmission and distribution systems will need to handle an increasingly variable power supply profile
- Loss of system inertia and other grid services that ensure system reliability today

Southern California Edison is planning for anticipated climate change influenced weather conditions.

2050 CLIMATE EXPOSURE TRENDS AND POTENTIAL IMPACTS ON THE ELECTRICAL SYSTEM



AVERAGE TEMPERATURE

5°F projected increase relative to historical averages

AVERAGE TEMPERATURE IMPACTS

- Existing infrastructure will become less efficient, especially inland, resulting in reduced capacity on lines and higher losses in transformers
- Useful life of assets will decrease due to increased exposure and usage



EXTREME HEAT

7X more likely, on average, for SCE service area to experience temperatures as hot as or hotter than the historical 99th percentile temperature

EXTREME HEAT IMPACTS

- Worker safety standards will need to account for heat
- Peak load could increase significantly
- Equipment will not cool overnight during intense heatwaves, reducing capacity and useful life of some equipment



PRECIPITATION

40% projected decline in snowpack and more variable year-to-year precipitation with more intense drought and fewer, more intense precipitation events

PRECIPITATION IMPACTS

- Infrastructure will need to be designed to withstand more intense storm surges and flooding
- Hydroelectric generation could become less reliable if the current drought continues or in the event of future prolonged droughts



WILDFIRE

23% more land projected to burn during summer fuel-driven wildfires and wildfire season is expected to become longer

WILDFIRE IMPACTS

- Conditions will be more conducive to wildfire ignition and spread
- Impacted service centers may not be able to operate or perform key functions during wildfires or droughts



SEA LEVEL

2.6 feet projected sea level rise relative to the year 2000

SEA LEVEL IMPACTS

- Infrastructure and communities in some coastal areas will be at higher risk of flooding



CASCADING EVENTS

A range of high-impact, low-probability events can occur from the interaction between exposure variables such as post-fire mudslides (debris flow) and rain-on-snow events

CASCADING EVENTS IMPACTS

- Communities in or near high fire risk areas could be exposed to increased landslide risk
- Hydroelectric planners need to account for early snowmelt and extreme runoff

- California's clean power goals
 - 100% carbon-free electricity by 2045
 - 75% of light-duty vehicles and 70% of building space and water heating will need to be electric by 2045
- External challenges that must be overcome
 - Wildfires and climate adaptation
 - Increased reliance on intermittent and distributed resources
 - Changing customer behavior and expectations
 - Rapidly increasing CCA demand
 - Cybersecurity threats
 - Increased regulatory scrutiny and desire for real time transparency
- Internal challenges that must be overcome
 - SCE assets and systems are complex and interdependent
 - Leveraging asset data
 - Being proactive in decision-making verses reactive
 - Continuing to ensure a high level of customer satisfaction (outages, power quality, ..)

These challenges require a fundamental shift in how we operate and how we are organized.

Ron M asked about EV charging options for housing situations where people don't have a garage, or driveway to charge from.

Anthony said it's come up and he could put Ron in touch with someone at SCE. Ron M said this has been an issue for the city of Seattle.

Ron B asked if with large fleet EVs, is extra maintenance needed for transformers to support more EV charging?

Anthony said it is a capacity issue, and Ron M. said that the load level, duration, and ambient temperature do have a long-term effect on the life of transformers.

- Performance and non-performance of DER
 - PV doesn't output as forecasted (also cloudy days, 90% not metered, etc.) – drives, and is the input for 10 GMS use-cases (switching, outage mgmt., load shed, DR, state estimation, FLISR, OPF, market integration)
 - Diversify portfolio to include more DR, in addition to storage
- Storage
 - Reliability of California fleet
 - Control systems scaling from 10-100-1000 MW
 - Interoperability (obsolescence)

Ron B. asked what the enabler is, and Anthony replied that it helps to affect change in the environment. He added that they are selling space, comfort is a selling point.

Ron B. said ESA interfaces on the buildings side, to shift power from one application to another when needed. Anthony said that SCE did a pilot with EPRI last year and noted how load was affected by a change in the weather.

Ron B. said tracking load and correlated weather changes may help and the information should help in decision making.

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- Demand Flexibility
 - Need for pilots to validate technology and demand flexibility from DERs (Electric Vehicles, Energy Storage, Buildings), price elasticity and participation from customers
 - Needs and benefits are likely to be locational
 - DER markets
 - As penetration of manage charging grows the value to the customer decreases, after a market price saturation occurs at some level of participation

Ron B mentioned social and cultural changes from buildings as customers adapt.

Ron M gave the example of a balance sheet with an energy (or carbon) bank. Customers may buy or sell with that bank. The bank through an Energy services agent or ESA may “ask” the building for something.

They will need pilot programs to help them better understand flexibility.

Seemita asked about vehicle to grid issues and Jaime noted that commercial vehicles can discharge to the grid but so far manufacturers have been reluctant to do that. Ron M and Ron B noted this can be possible and Kay A noted it can be an electrical code issue.

- **Communications and Networking**

- FAN (Field Area Network) - Larger DER penetration. How much more bandwidth?
- What is the plan to managed devices
- Remote configuration management decisions at the edge (eg FLISR)
- How to secure edge devices
- Can the edge devices trust each other
- Edge computing (how deploy, manage, be part of distributed control)
- Can we better optimize at the circuit level

- **Cyber**

- Cybersecurity (Peer to peer)
- Customer participating DERs (non-utility owned)

Ron A gave an example of a transformer that was still in use at 70 years.

Seemita mentioned transformer reliability is used in grid planning.

Anthony noted the many factors involved in planning including EV reliability.

Anthony told the group that he is happy to take questions even after the meeting.