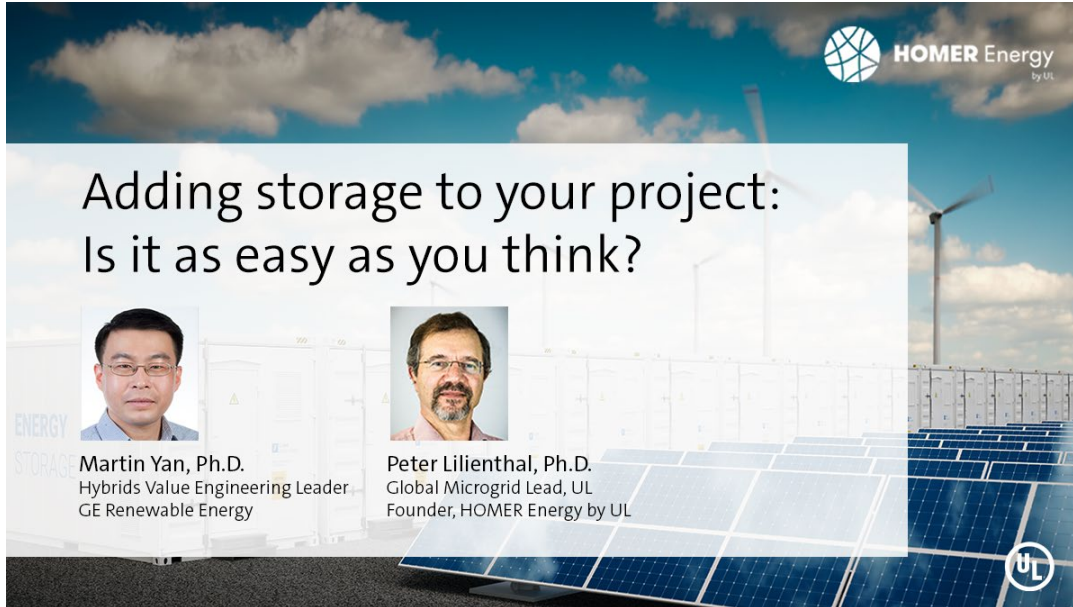


Welcome to the webinar.
We will begin at the top of the hour.



The slide features a background image of a renewable energy farm with solar panels in the foreground and wind turbines in the distance under a blue sky with clouds. In the top right corner, there is a logo for 'HOMER Energy by UL' consisting of a globe icon and the text 'HOMER Energy by UL'. The main title 'Adding storage to your project: Is it as easy as you think?' is centered in a white semi-transparent box. Below the title, two speaker portraits are shown side-by-side. The left portrait is of Martin Yan, Ph.D., with his title 'Hybrids Value Engineering Leader, GE Renewable Energy' below it. The right portrait is of Peter Lilienthal, Ph.D., with his title 'Global Microgrid Lead, UL Founder, HOMER Energy by UL' below it. A small UL logo is visible in the bottom right corner of the slide image.

HOMER Energy
by UL

Adding storage to your project: Is it as easy as you think?

Martin Yan, Ph.D.
Hybrids Value Engineering Leader
GE Renewable Energy

Peter Lilienthal, Ph.D.
Global Microgrid Lead, UL
Founder, HOMER Energy by UL



Adding storage to your project: Is it as easy as you think?

Speakers



Martin Yan, Ph.D.

Hybrids value engineering leader
GE Renewable Energy

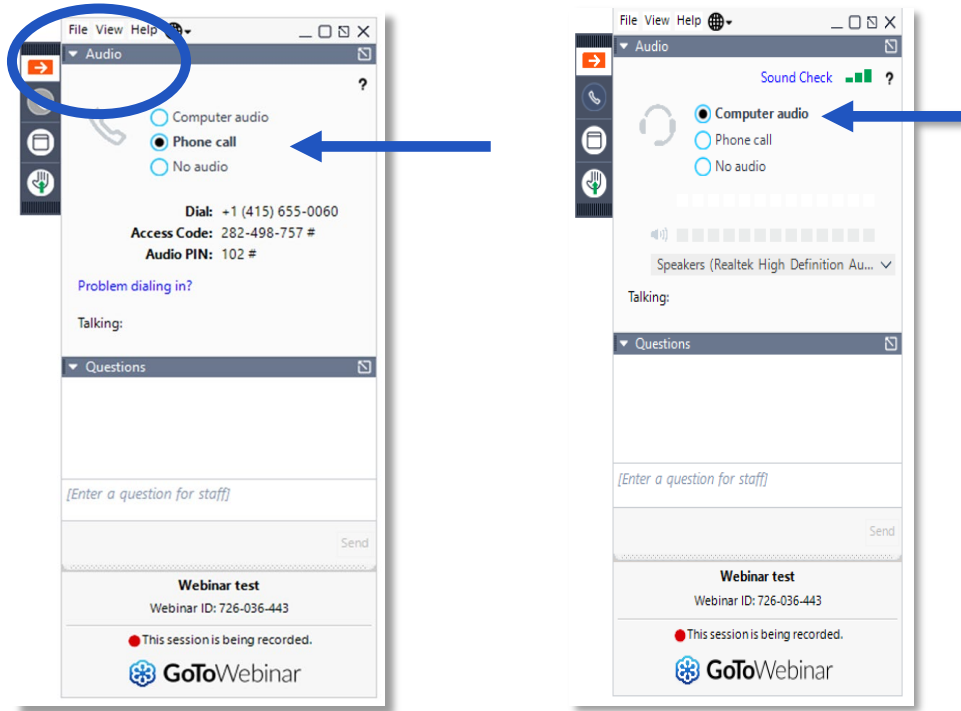


Peter Lilienthal, Ph.D.

Global microgrid lead, UL
Founder, HOMER Energy by UL



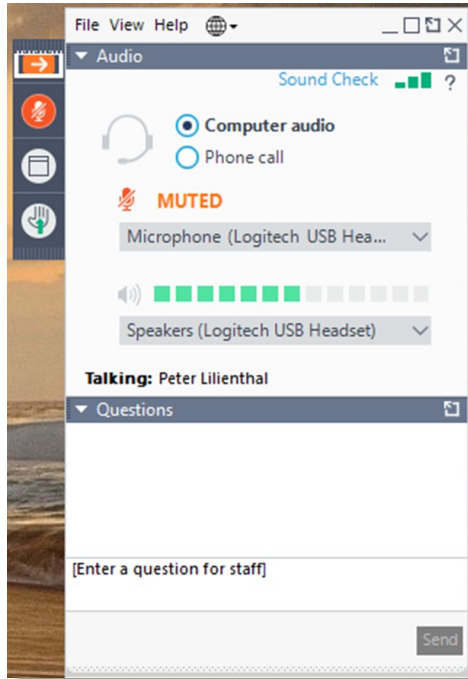
Can't hear the audio?



If you do not have sound:

1. Go to the audio tab
2. Click on the phone bubble
3. Then click on the computer bubble

Your questions are welcome



Adding storage to your project: Is it as easy as you think?

Presented by



Martin Yan, Ph.D.

Hybrid value engineering leader
GE Renewable Energy



Peter Lilienthal, Ph.D.

Global microgrid lead, UL
Founder, HOMER Energy by UL

Complexities of modeling storage

Peter Lilienthal, Ph.D.

Global microgrid lead, UL

Founder, HOMER Energy by UL

September 2021

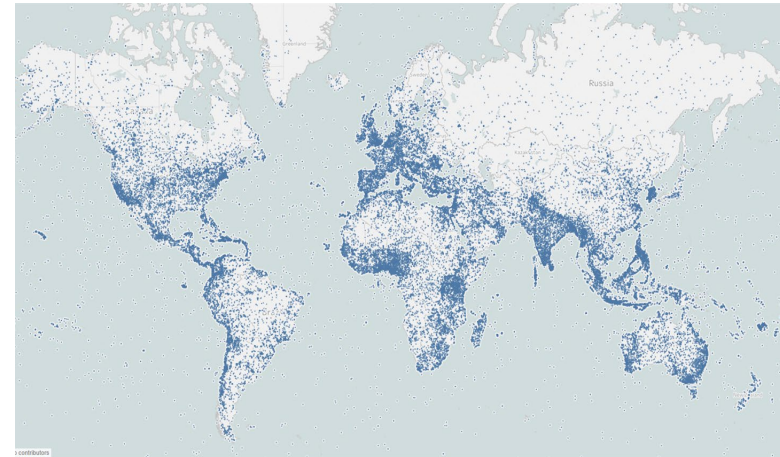
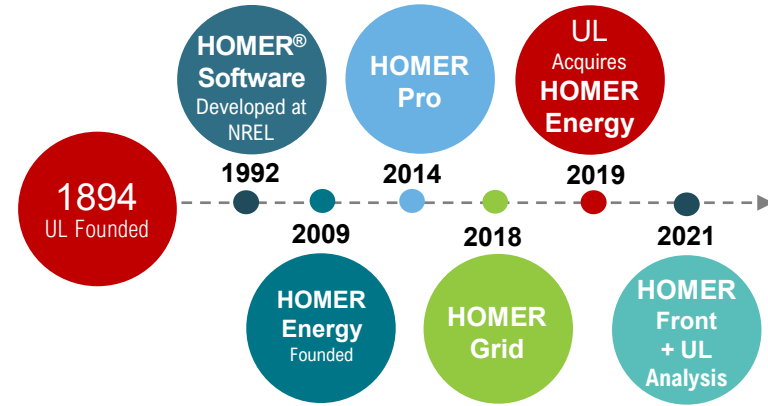


“Hybrids are the future...”

Mike Bowman, CTO at GE Renewable Energy

... but HOMER has been modeling hybrid systems for 30 years

- Starting at NREL with small off-grid systems
- Then island utilities 1 – 100 MWs
- In the last few years, our focus has been connected commercial and industrial (C&I) facilities in developed countries
 - Utility-scale hybrids
 - Time of use arbitrage
 - Grid-connected microgrids for resilience
 - Batteries for demand charge management
 - Electric vehicle



Why isn't this easy?

- Storage is crucial for future projects
- Hybrid projects have become much larger
- Finance for commercial projects is more demanding
- The modeling challenge is intensified
 - Models must simulate real-time storage decision
- Spreadsheets are inadequate

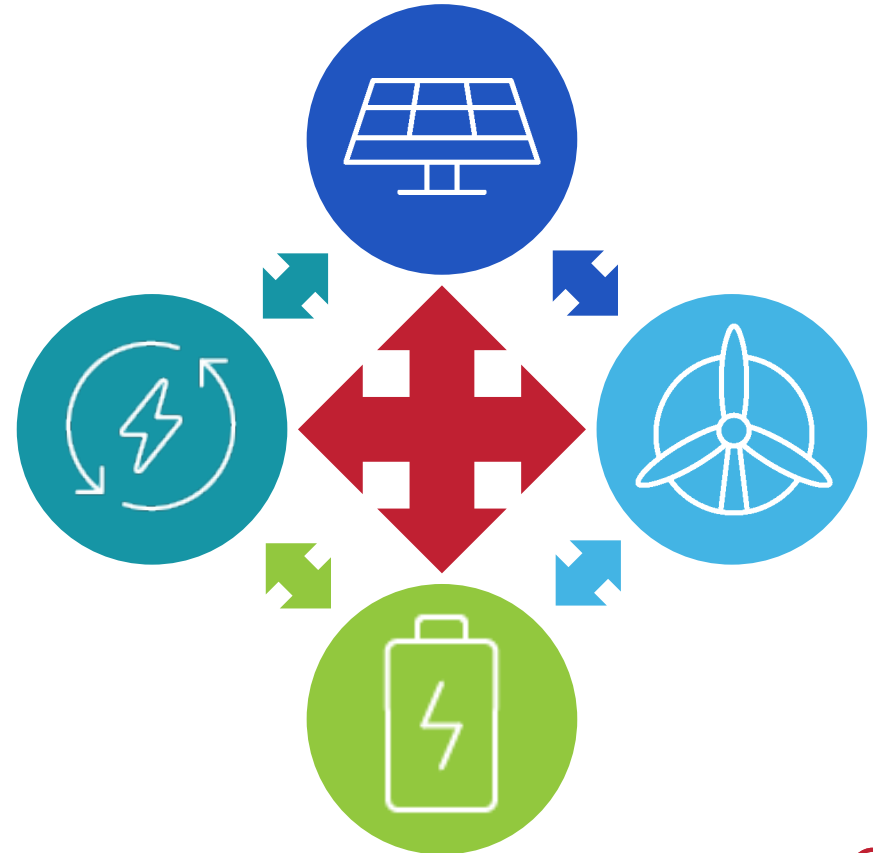


Complexities

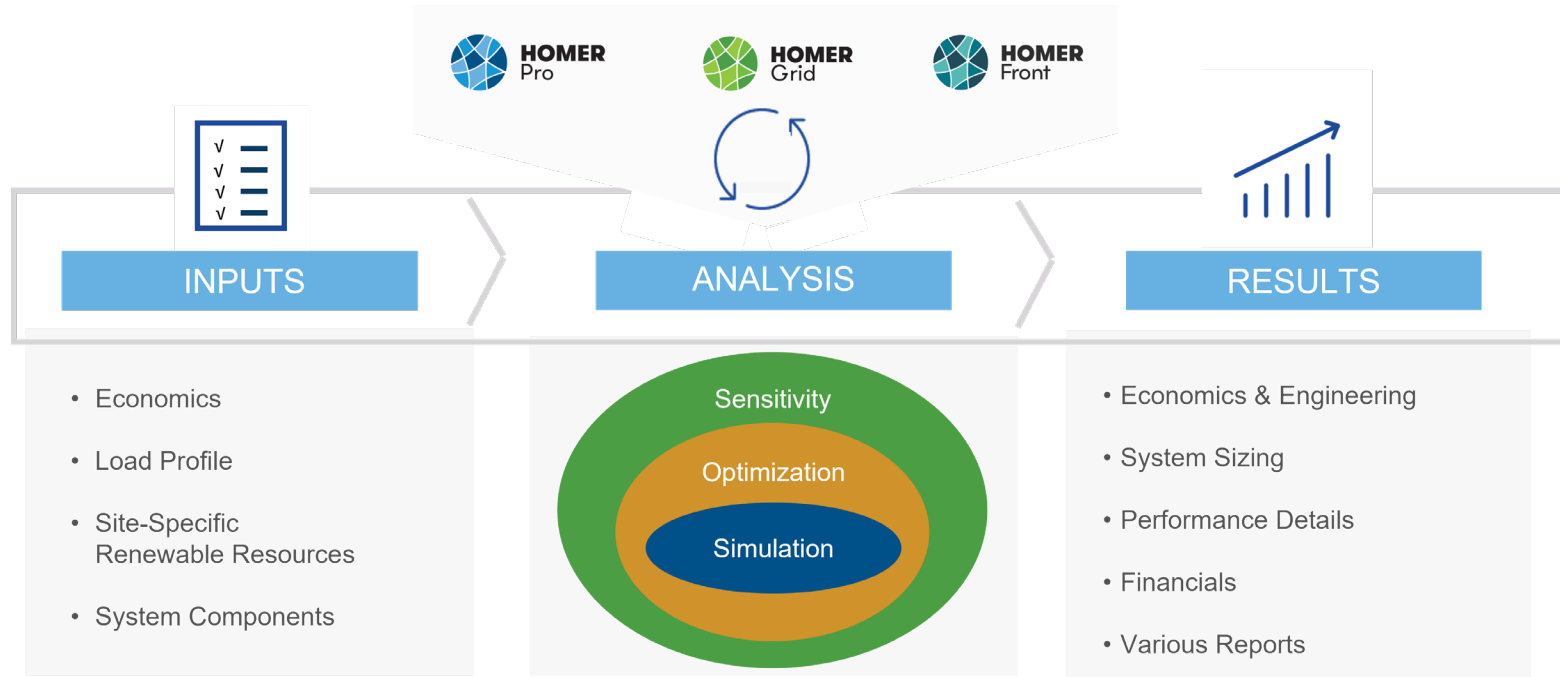
Hybrid systems are more complicated than single technology projects

- More components to model
- Interactions between the components
- Dispatch decisions
- Battery charge/discharge decisions
- Batteries are complex in and of themselves
 - Current limitation
 - Cycle life and degradation

“Who said it was going to be easy?”



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Wind + solar + storage model verification

Martin Yan, Ph.D.

Hybrid Value engineering leader

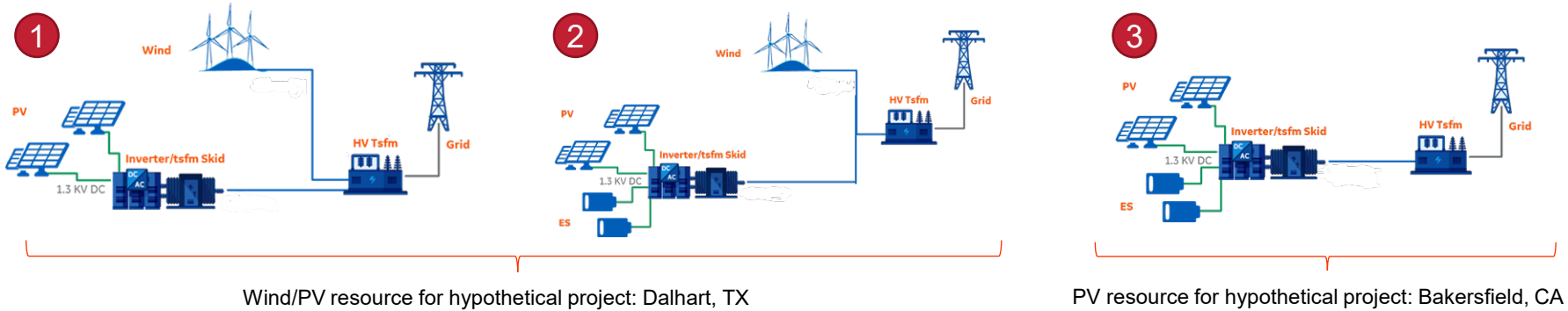
GE Renewable Energy



GE & HOMER Energy by UL Collaborated on Model Verification

HOMER is a general-purpose commercial tool; GE's Hybrid Architect is an internal GE tool

Mutual benchmarking project: Involved 3 hypothetical cases of increasing complexity



Case #	Plant Topology	Revenue Stream	Optimization Objective	Constrains***
1	Wind + PV	Flat rate PPA	Min LCOE	>50% CF* through project life; POI 50MW
2	Wind + PV + BESS	Flat rate PPA	Min LCOE	>80% CF through project life; POI 50MW
3	PV + BESS	Merchant + RA**	Max IRR	POI 50MW

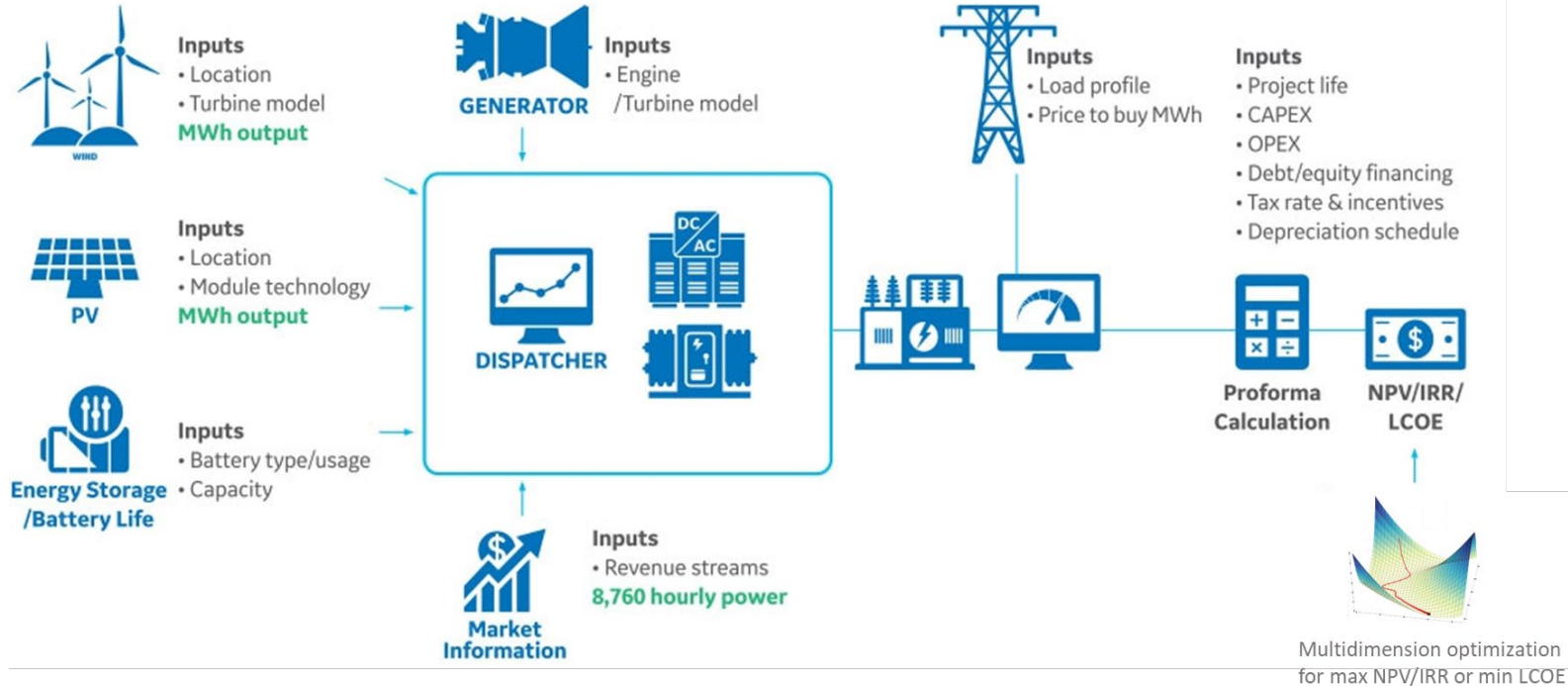
* CF: capacity factor (annual average)

** RA: resource adequacy (CAISO)

*** Individual asset's AC nameplate cannot exceed POI MW rating.

PTC is considered for Wind output; ITC is considered for PV/BESS.

GE Hybrid Architect



Value tool: specify system configurations → calculate NPV/IRR/LCOE;
Configurator: optimize system configurations → maximize NPV/IRR or minimize LCOE



Hybrid Architect



Battery



Wind



PV



Grid



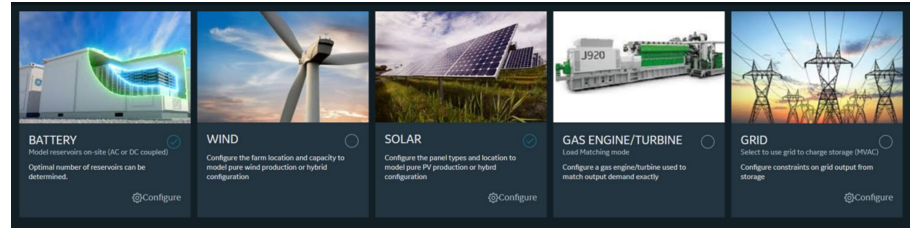
Gas

Applications/ Use Cases:

- Energy Shifting
 - Structured PPA
 - Merchant
- Load Following/ Firming
- Capacity Payments
- REC for Revenue
- Curtailment
- Ancillary Services

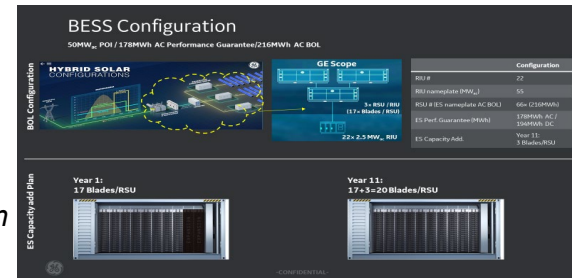
User Input:

- *Basic user: location, generation equipment, revenue & power output*
- *Expert level: allows adjustment of 70 variables finance, Capex, Opex, Equipment efficiency and degradation*



Output:

- *Enhanced hybrid system configuration.*
- *Multi-year proforma w/LCOE, NPV, IRR.*
- *Curtailment Analysis*
- *Battery Capacity Addition schedule/cost.*
- *Power point summary.*
- *Excel files for hourly and annual operation data.*

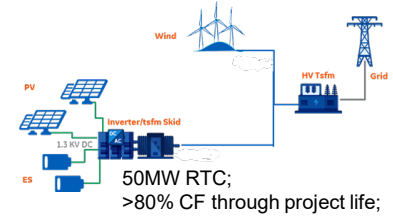


*Hourly operation simulation throughout the whole project life.
After tax proforma calculation for project economics.
Brute-force enhancement mapping out the whole hybrid system design space.*

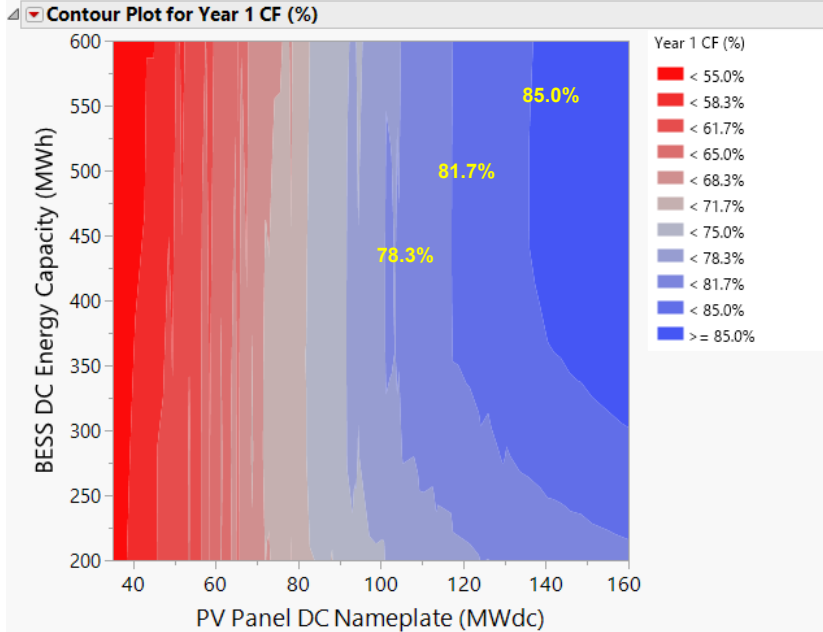
Case 2: Wind + PV + BESS

Configuration parameters:

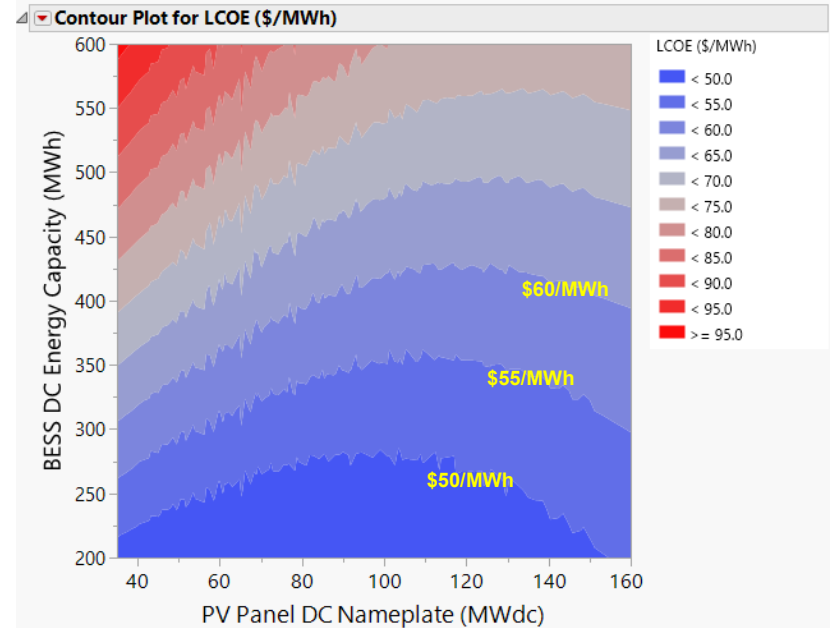
- 1) Wind turbine nameplate (MW_{ac})
- 2) PV inverter nameplate (MW_{ac})
- 3) PV panel DC nameplate (MW_{dc})
- 4) Battery DC energy capacity (MWh)



Year 1 Plant CF (%) w/ Wind Turbine @ $50MW_{ac}$ & PV Inverter @ $50MW_{ac}$



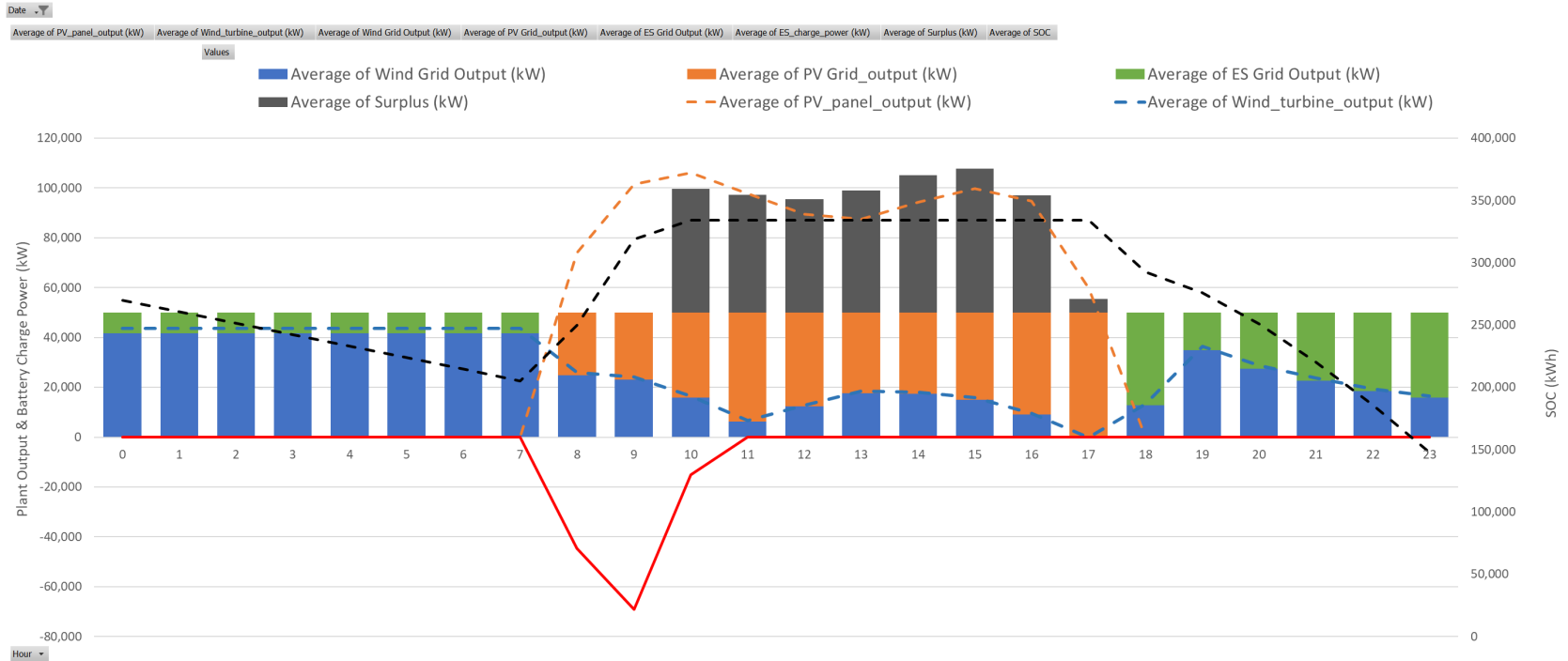
Project LCOE w/ Wind Turbine @ $50MW_{ac}$ & PV Inverter @ $50MW_{ac}$



- The round-the-clock nature of the project pushes for added wind turbine nameplate ($50MW_{ac}$) and added PV inverter nameplate ($50MW_{ac}$).
- To meet CF of 80% throughout 20 year project life, Year 1 CF needs to be $\geq 83\%$.
- To help to minimize LCOE, the optimal configuration is PV panel DC nameplate @ $145MW_{dc}$ & battery DC energy capacity @ $335MWh$.

Case 2: Wind + PV + BESS

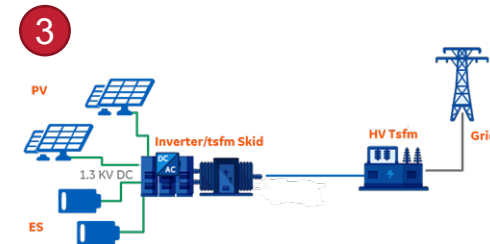
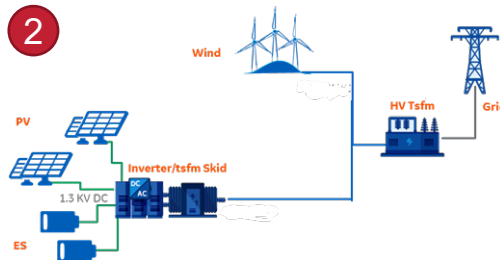
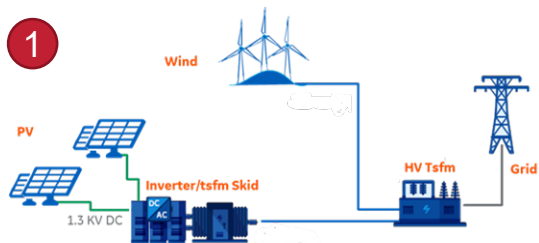
Simulated plant hourly operation through a day.



- Night time load is met by wind turbine output and firmed by BESS.
- Day time load is met by solar generation.

- Battery charges from extra solar output.
- Surplus energy from extra solar output could bring in addition revenue if addition offtaker can be secured.

GE & HOMER Energy by UL: Model Verification



Case 1	GE	UL
PV	22.5MW _{ac} / 31.5MW _{dc}	
Wind	50MW _{ac}	
PV Yr1 AEP (GWh)	57.0	56.9
Wind Yr1 AEP (GWh)	171.3	173.1
Yr1 Capacity Factor (%)	52.1%	52.5%
Yr1 curtailment (%)	3.6%	3.8%

AEP: annual energy production

Case 2	GE	UL
PV	50MW _{ac} / 145MW _{dc}	
Wind	50MW _{ac}	
BESS (DC BOL)	335.5 MWh	
PV Yr1 AEP (GWh)	113.4	120.3
Wind Yr1 AEP (GWh)	163.3	174.5
BESS Yr1 AEP (GWh)	86.0	84.1
Yr1 Capacity Factor (%)	82.8%	84.9%
Yr1 surplus/curtail (%)	20.0%	19.1%

BOL: beginning of life

Case 3	GE	UL
PV	50MW _{ac} / 85MW _{dc}	
BESS (DC BOL)	244 MWh	
PV Yr1 AEP (GWh)	107.0	120.7
BESS Yr1 AEP (GWh)	79.0	74.3
Yr1 Grid Export (GWh)	186	195

Conclusion from UL on GE Hybrid Architect:

“It was concluded that in all cases where differences exist, UL notes UL values well within an expected and normal range of comparison, which are accurate to HOMER’s third-party simulation.”

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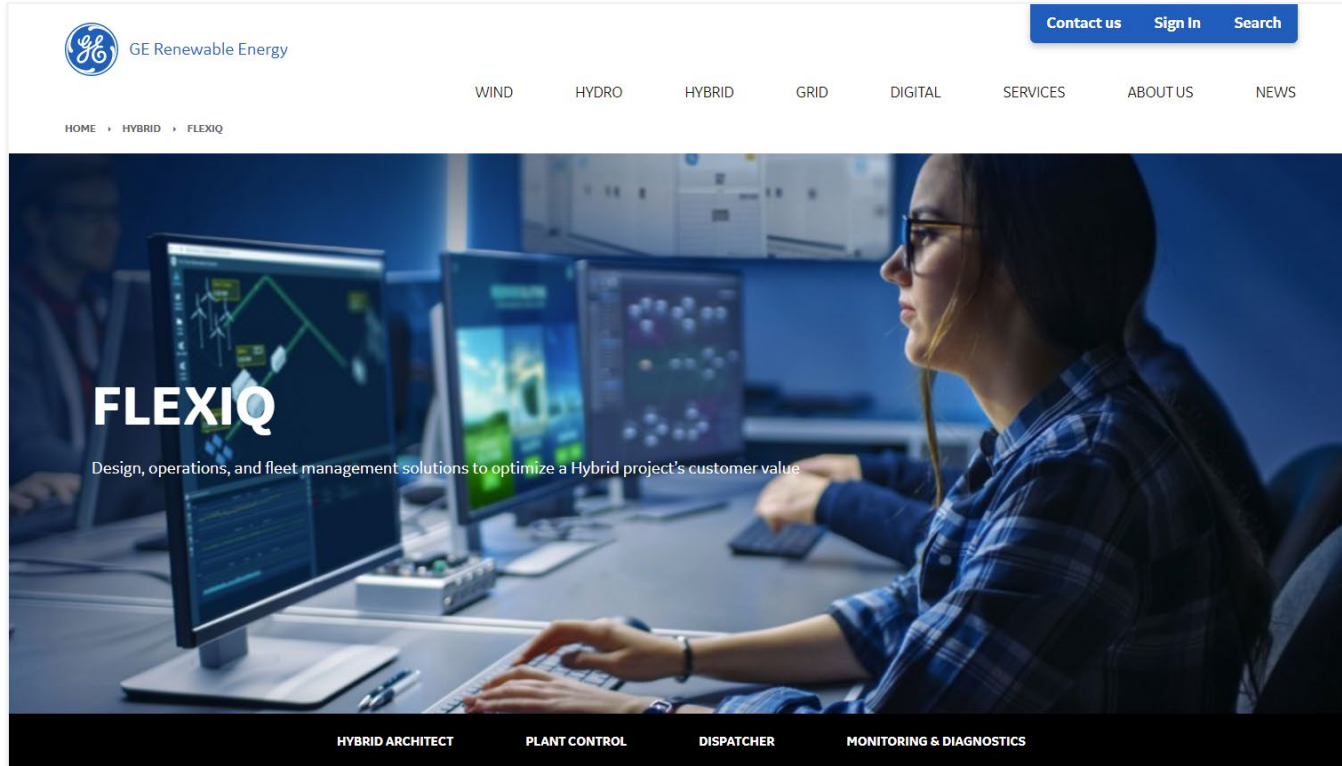
RenewableEnergyServices@ul.com

UL Renewables



Learn more about GE Hybrid Architect

ge.com/renewableenergy/hybrid/flexiq



The image is a screenshot of the GE Renewable Energy website. At the top left is the GE logo and the text "GE Renewable Energy". To the right of this are three buttons: "Contact us", "Sign In", and "Search". Below the logo is a navigation menu with the following items: WIND, HYDRO, HYBRID, GRID, DIGITAL, SERVICES, ABOUT US, and NEWS. Below the navigation menu is a breadcrumb trail: HOME > HYBRID > FLEXIQ. The main content area features a large image of a woman in a blue plaid shirt working at a computer workstation with multiple monitors displaying data. Overlaid on this image is the word "FLEXIQ" in large white letters, followed by the text "Design, operations, and fleet management solutions to optimize a Hybrid project's customer value." At the bottom of the page is a dark navigation bar with four white text links: "HYBRID ARCHITECT", "PLANT CONTROL", "DISPATCHER", and "MONITORING & DIAGNOSTICS".

Questions?



David Mintzer
Session moderator
Energy storage lead, UL



Martin Yan, Ph.D.
Value engineering leader,
GE Renewable Hybrids



Peter Lilienthal, Ph.D.
Global microgrid lead, UL
Founder, HOMER Energy by UL

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A promotional banner for the HOMER Microgrid and Hybrid Power International 9th Annual Virtual Event. The background features a sunset sky over a field of solar panels. A central graphic shows a lightbulb with a battery symbol inside, connected to six icons: solar panels, wind turbine, battery, forklift, A+ energy rating, and a power line tower. A red overlay on the right contains the event title, UL logo, dates, and a 'Register now' button.

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