Welcome to the webinar.

We will begin at the top of the hour.

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

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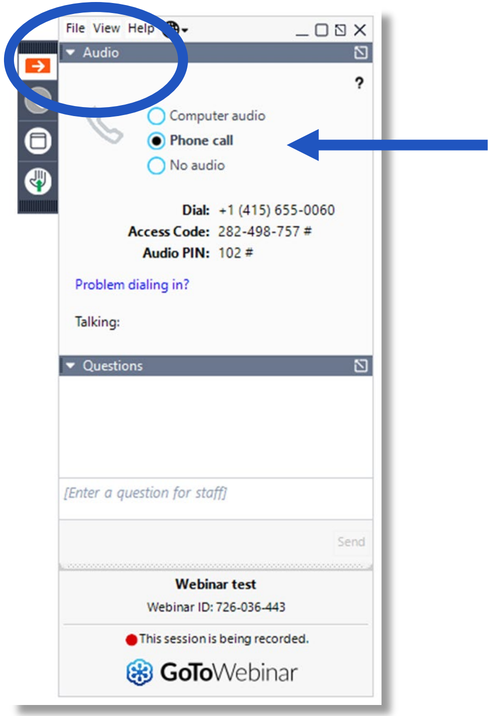

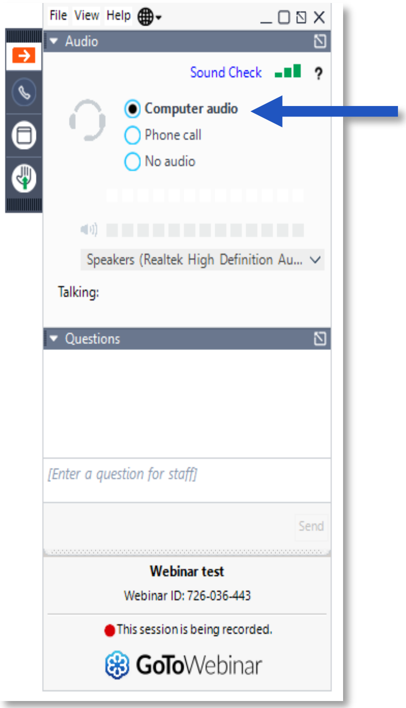

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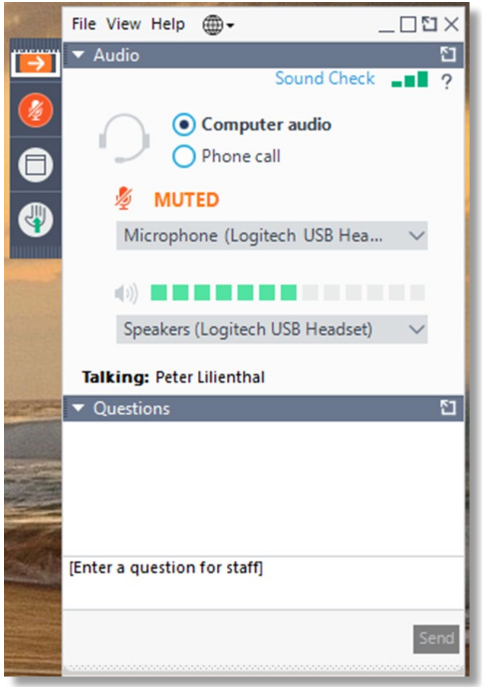
Your questions are welcome



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

Presented by

Martin Yan, Ph.D.

Hybrid value engineering leader
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Peter Lilienthal, Ph.D.

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Complexities of modeling storage

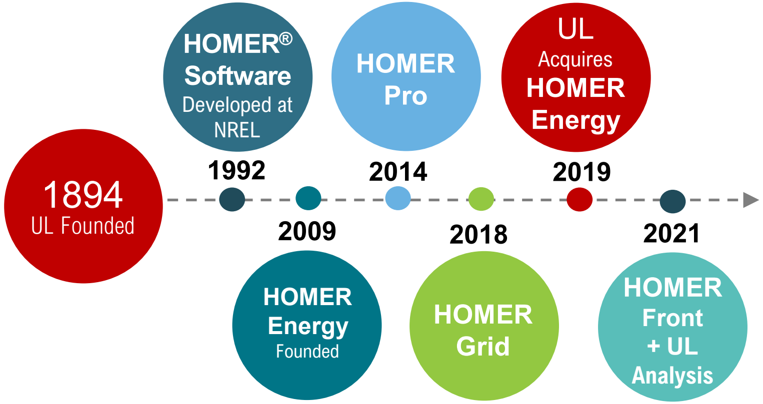
Peter Lilienthal, Ph.D.
Global microgrid lead, UL
Founder, HOMER Energy by UL

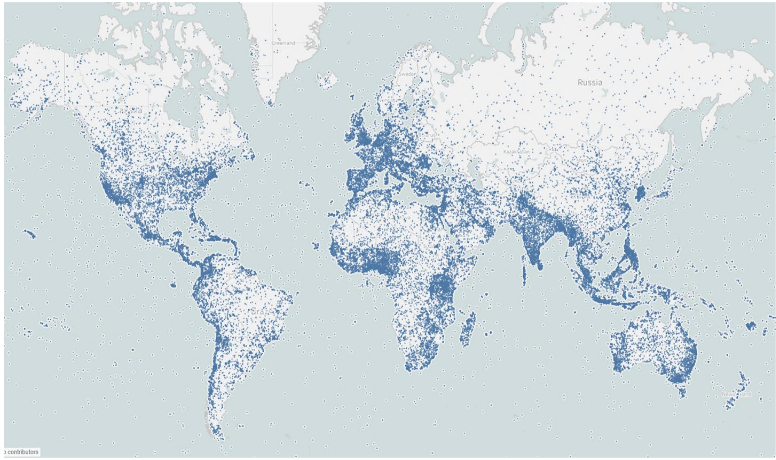
September 2021

"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?

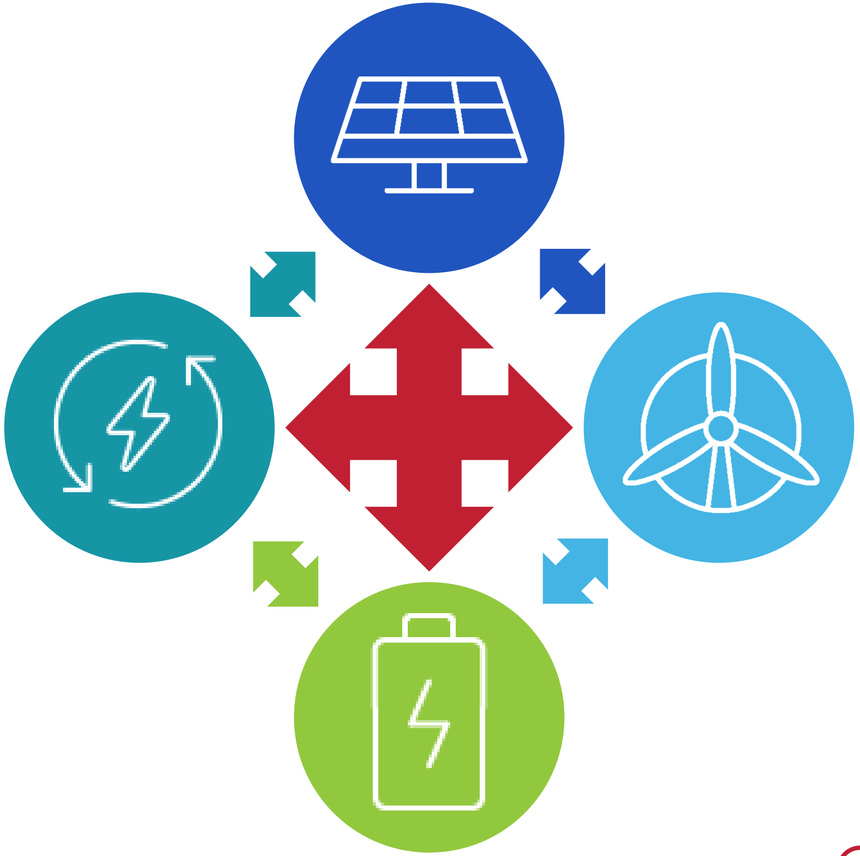
- Storage is crucial for future projects
- Hybrid projects have become much larger
- Finance for commercial projects is more demanding
- The modeling challenge is intensified
  - Models must simulate real-time storage decision
- Spreadsheets are inadequate

Complexities

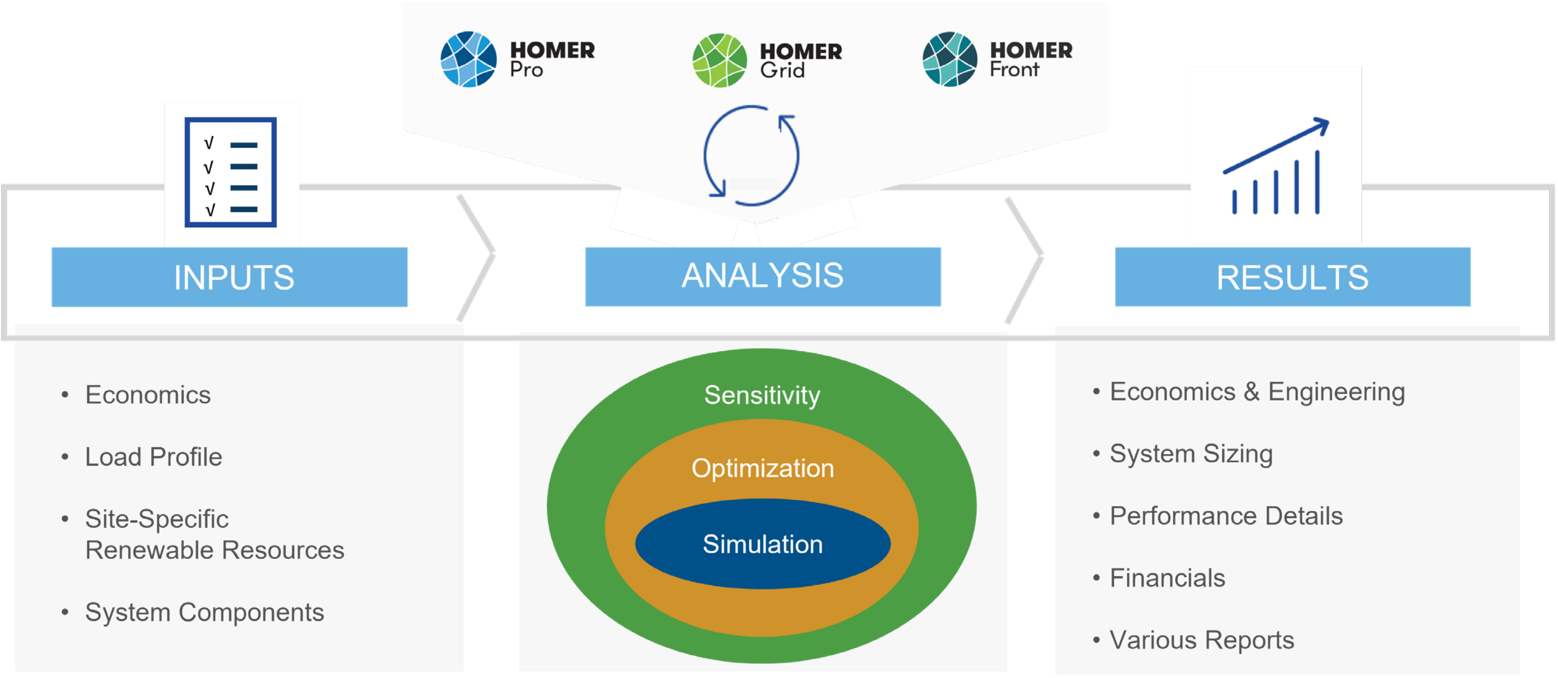
Hybrid systems are more complicated than single technology projects

- 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?”



Microgrid/DER optimization and design in HOMER®



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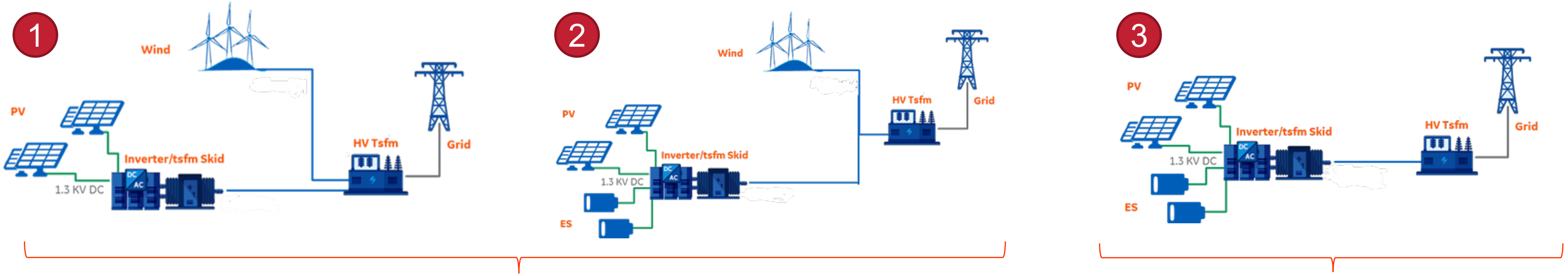
Wind + solar + storage model verification

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



Wind/PV resource for hypothetical project: Dalhart, TX

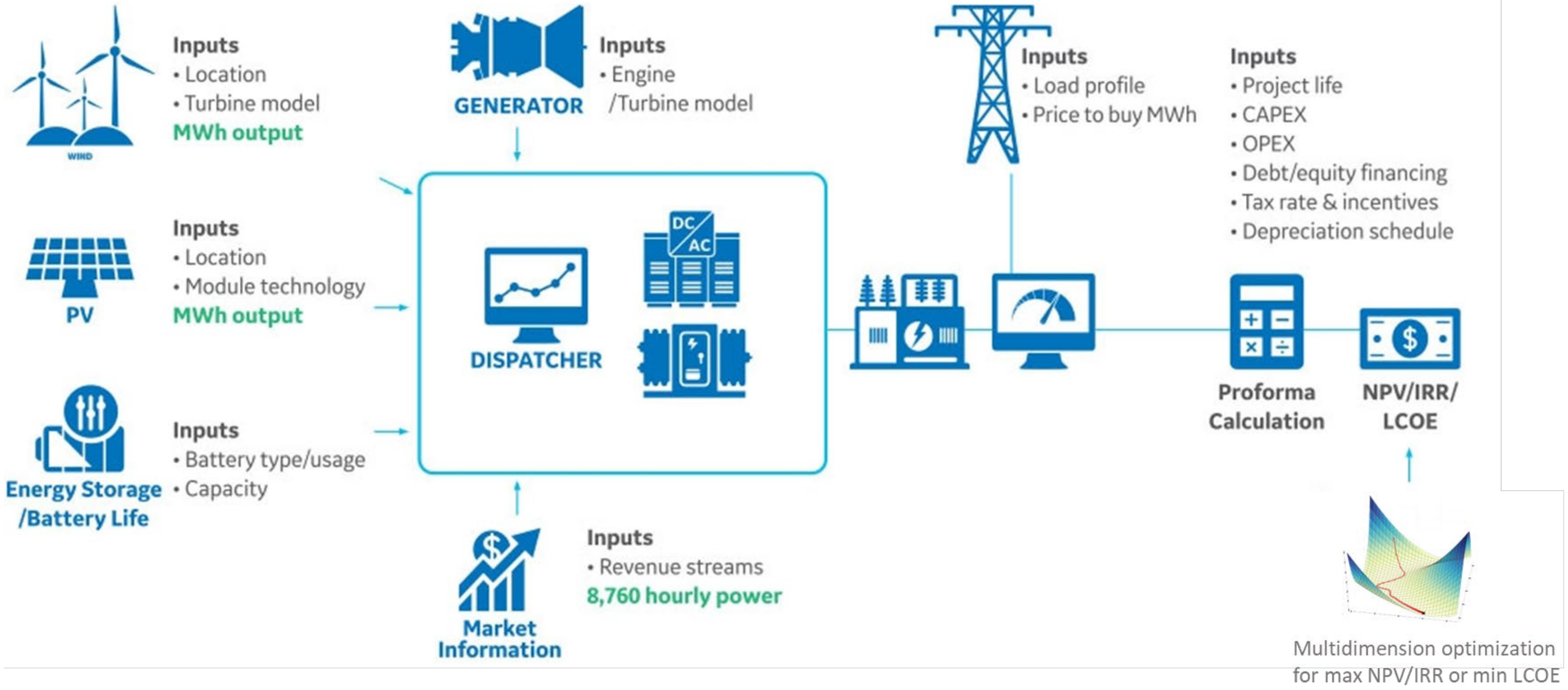
PV resource for hypothetical project: Bakersfield, CA

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

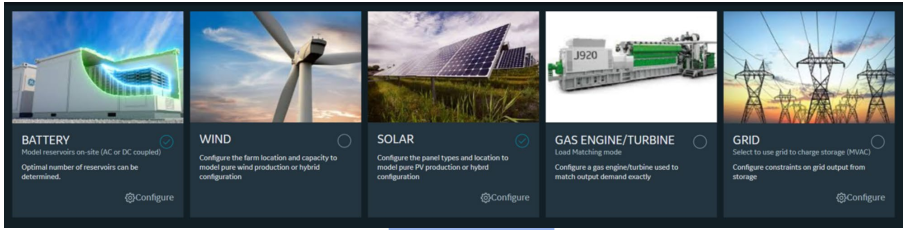
Battery Wind PV Grid Gas

Applications/ Use Cases:

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

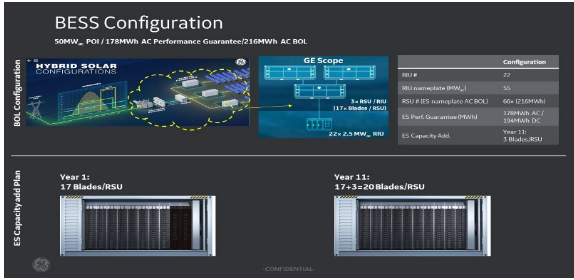
User Input:

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



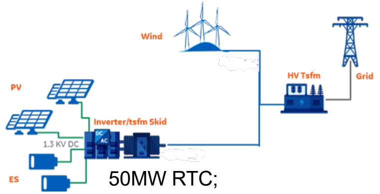
Output:

- *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.

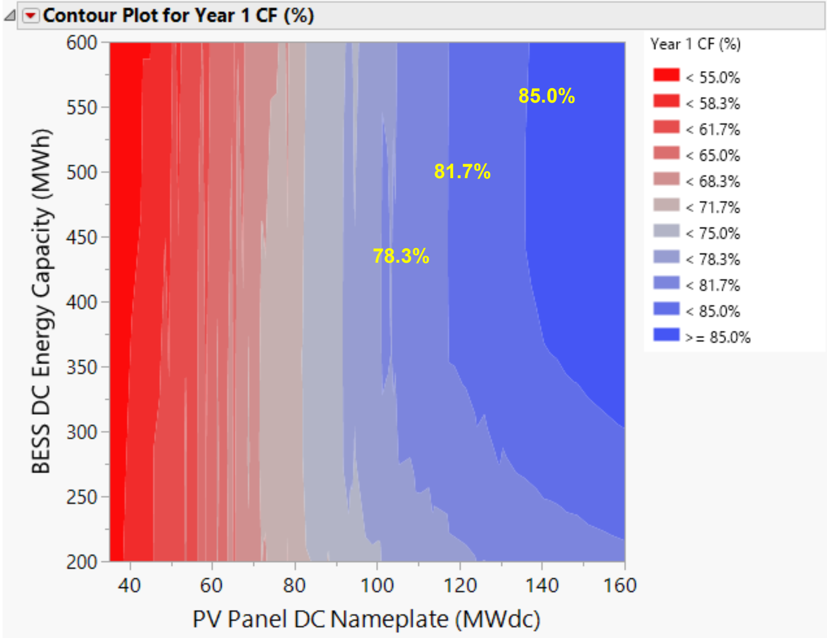
Case 2: Wind + PV + BESS



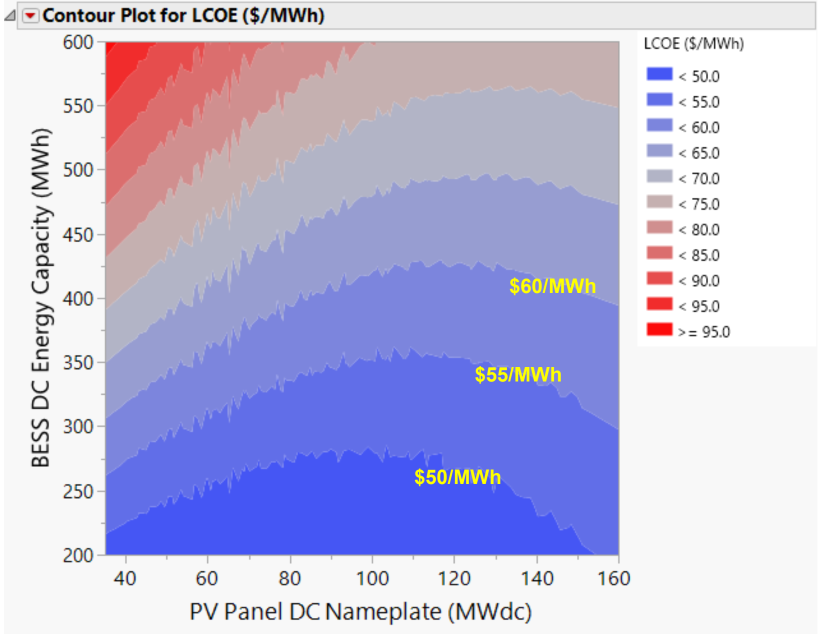
Configuration parameters:

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}



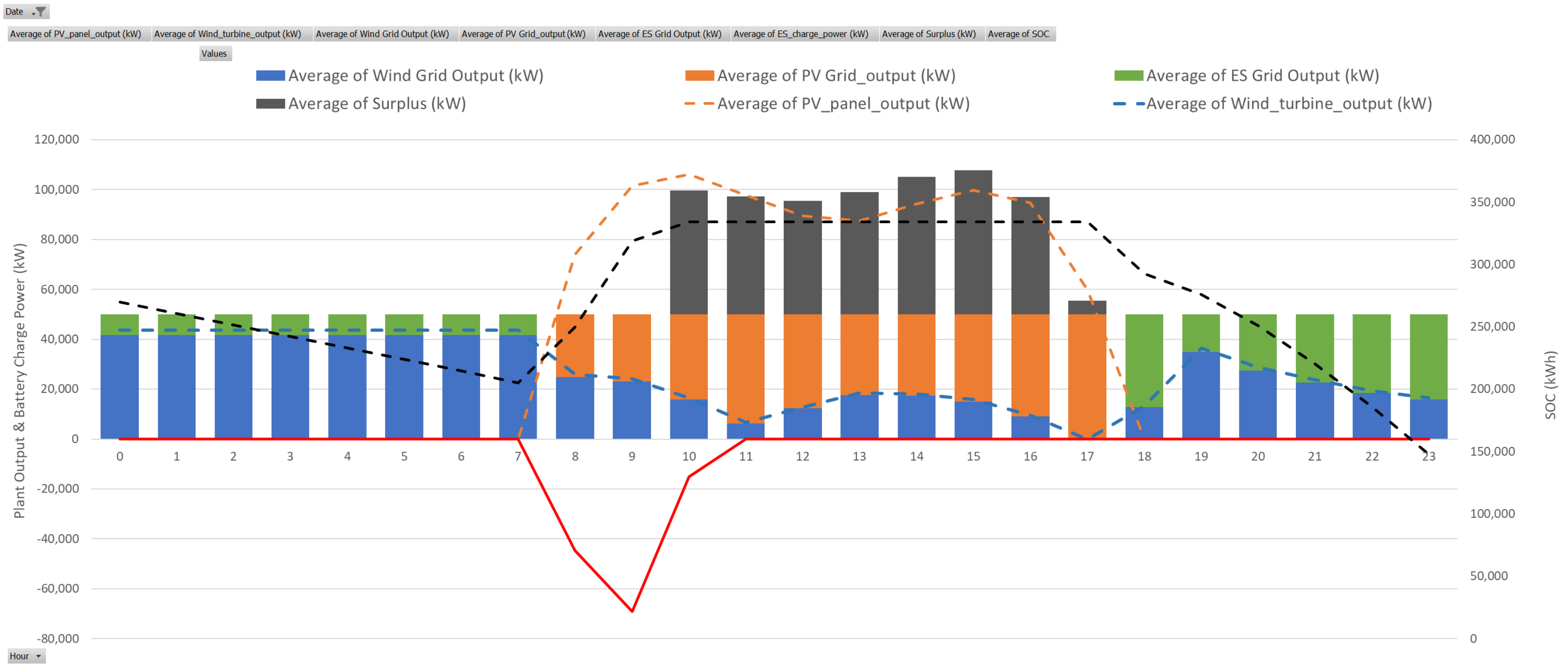
Project LCOE w/ Wind Turbine @ 50MW_{ac} & PV Inverter @ 50MW_{ac}



- 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 ≥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

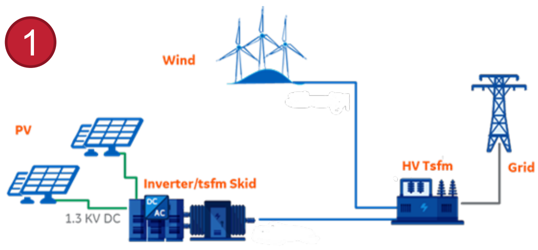
Simulated plant hourly operation through a day.



- 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

1



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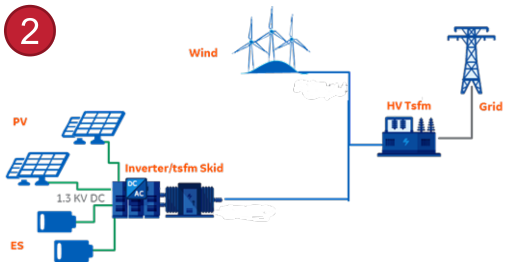

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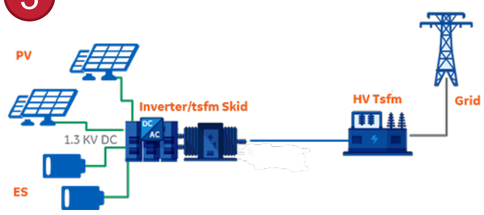

Case 1	GE	UL
PV	22.5MW_{ac}/ 31.5MW_{dc}	
Wind	50MW_{ac}	
PV Yr1 AEP (GWh)	57.0	56.9
Wind Yr1 AEP (GWh)	171.3	173.1
Yr1 Capacity Factor (%)	52.1%	52.5%
Yr1 curtailment (%)	3.6%	3.8%

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 values well within an expected and normal range of comparison, which are accurate to HOMER's third-party simulation."

Need help with your project?

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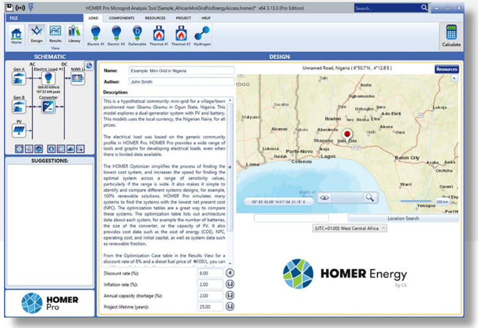
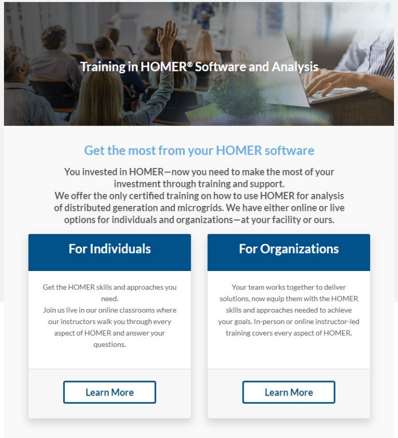


Training and Engineering Hours

Support@HOMERenergy.com



Project Advisory Services

RenewableEnergyServices@ul.com

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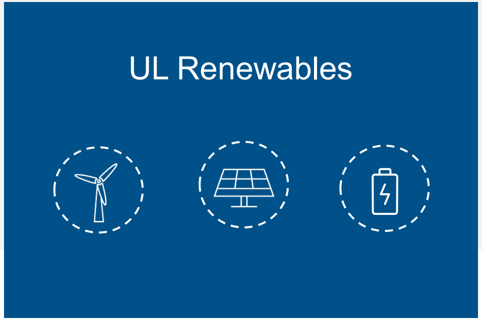
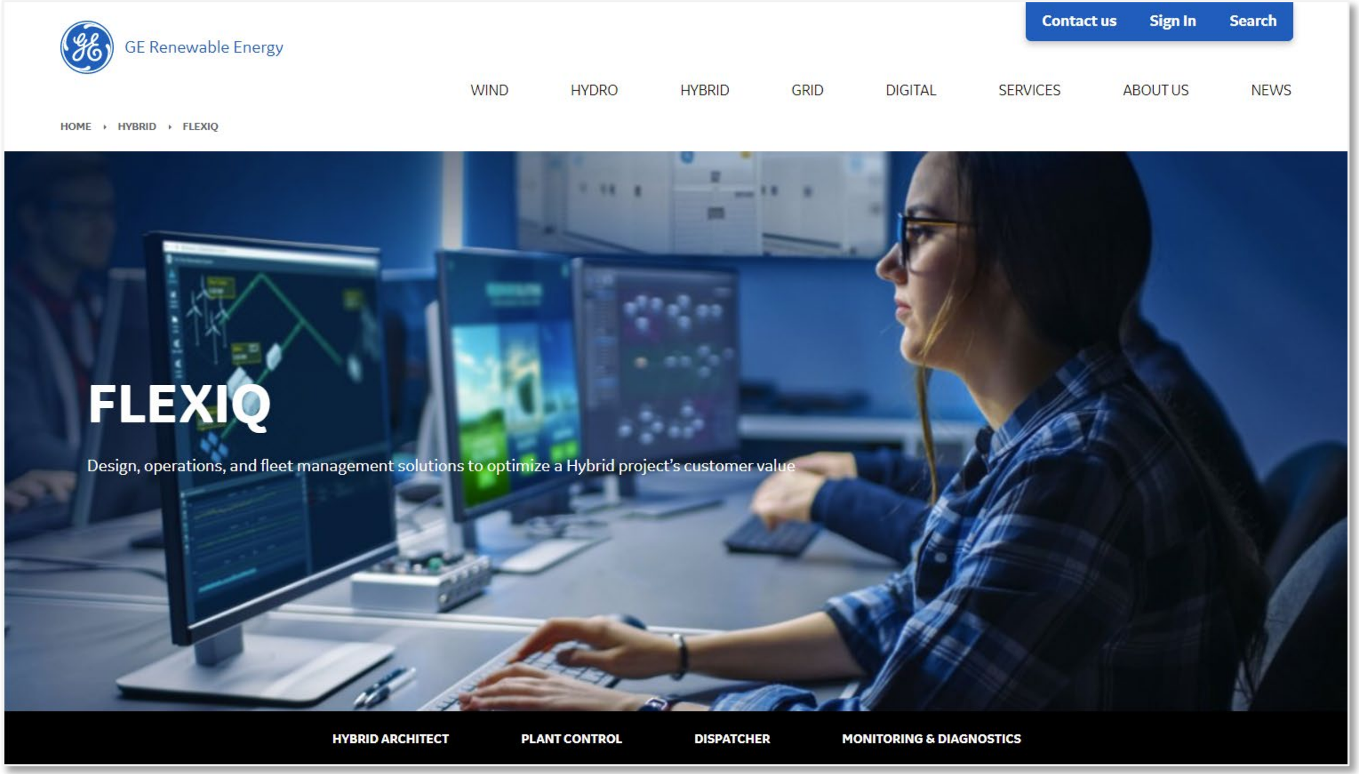


Learn more about GE Hybrid Architect

ge.com/renewableenergy/hybrid/flexiq



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

Resources

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