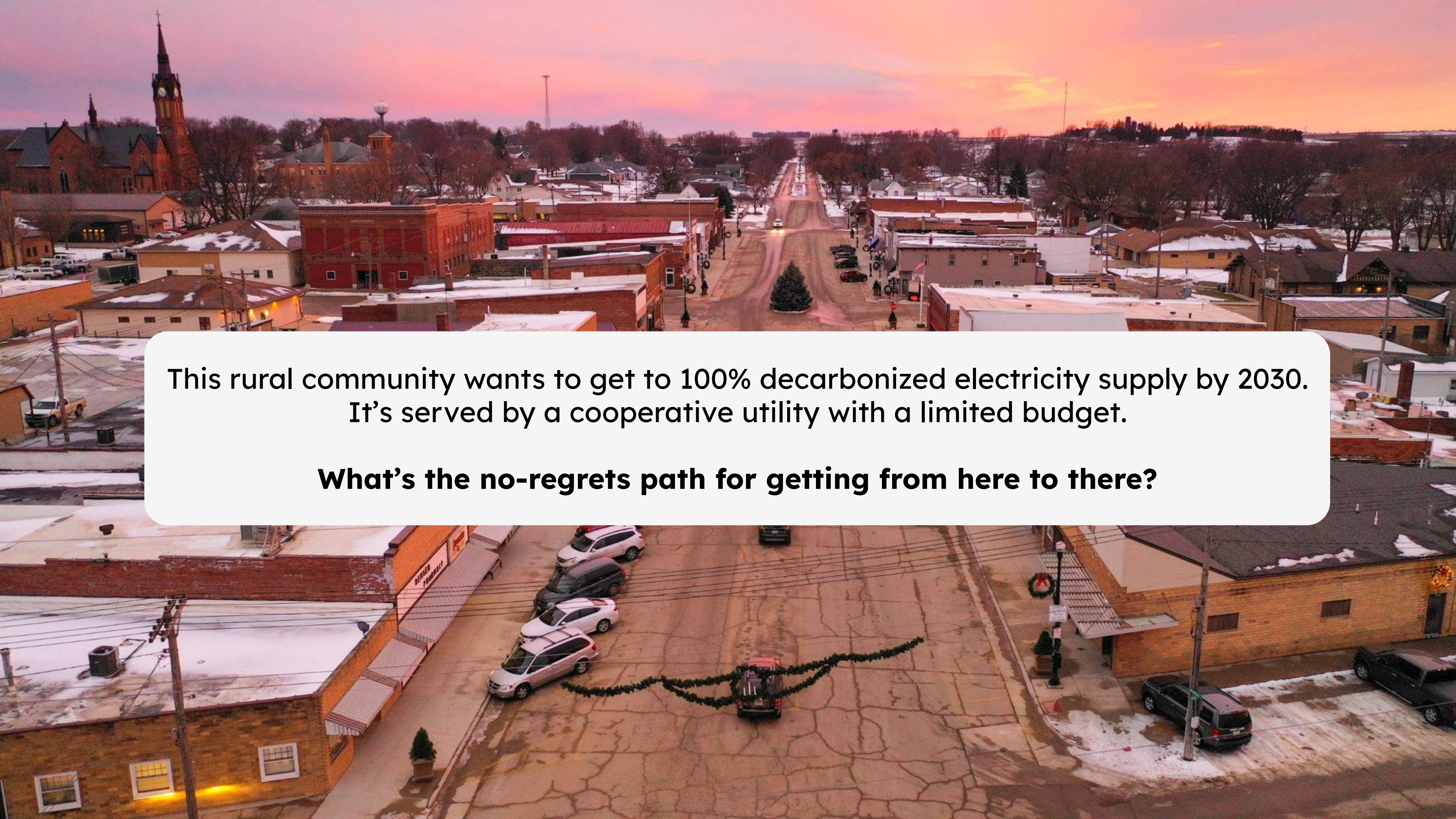
CAMUS

ESIG WORKSHOP

Real-time data and distribution system operations

APRIL 2022



This rural community wants to get to 100% decarbonized electricity supply by 2030.
It’s served by a cooperative utility with a limited budget.

What’s the no-regrets path for getting from here to there?

This suburban community wants to encourage electrification, buy cleaner energy, and keep their customers happy.

How can their grid support new loads and become a source of flexibility?

Managing the future grid: who's in charge?

THE FUTURE WORLDS (OPEN NETWORKS)

WORLD A — DSO Coordinates

WORLD B — Coordinated Procurement & Dispatch

WORLD C — Price-Driven Flexibility

WORLD D — TSO Coordinates

WORLD E — Flexibility Coordinators

We'll probably see each of these models play out…

Source: Open Networks Future Worlds

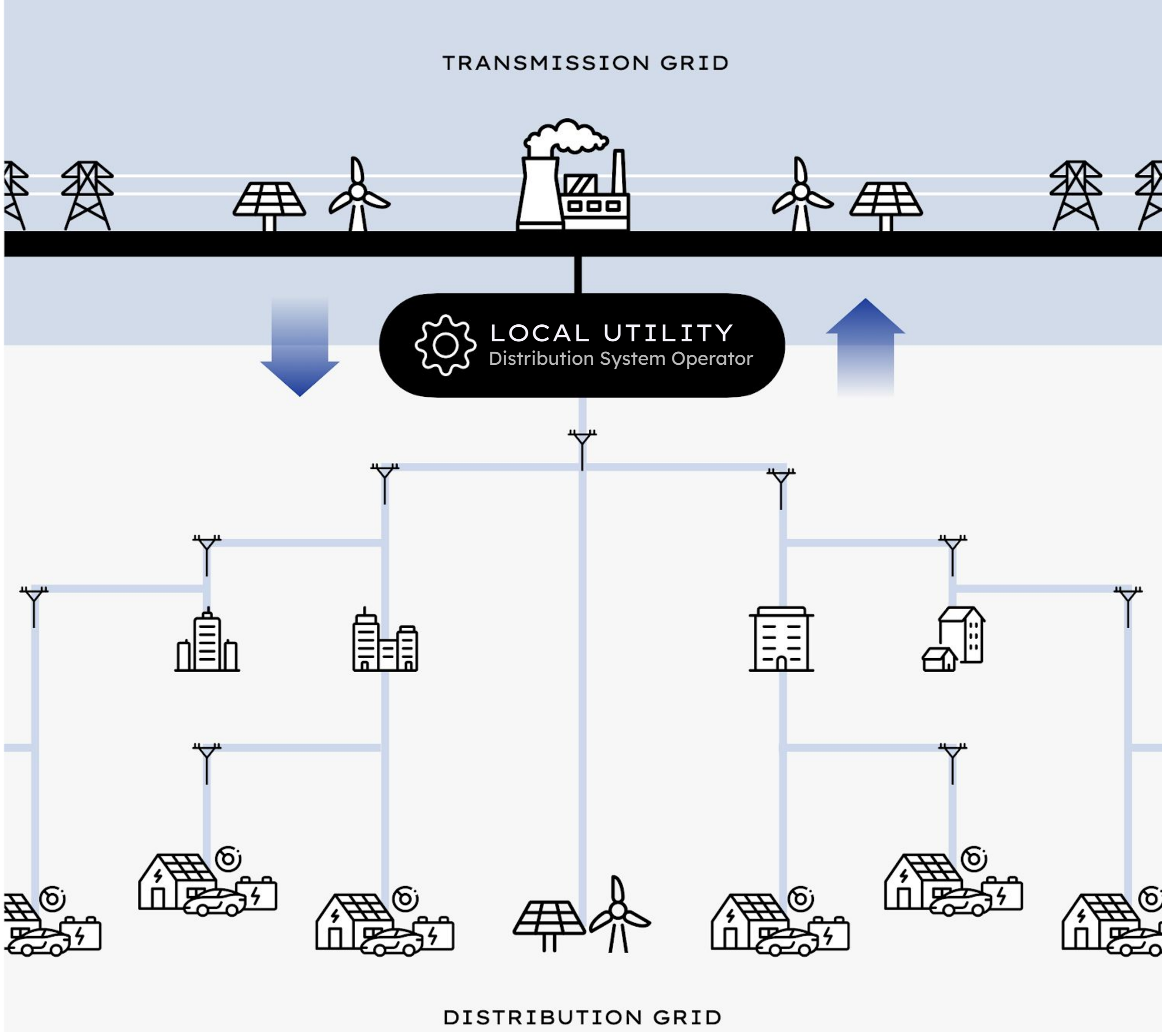
DSO MODELS

In every model, new capabilities will be needed

Safe and reliable operation of the grid will require more local insight and control by (some form of) Distribution System Operator.

DSO responsibilities:

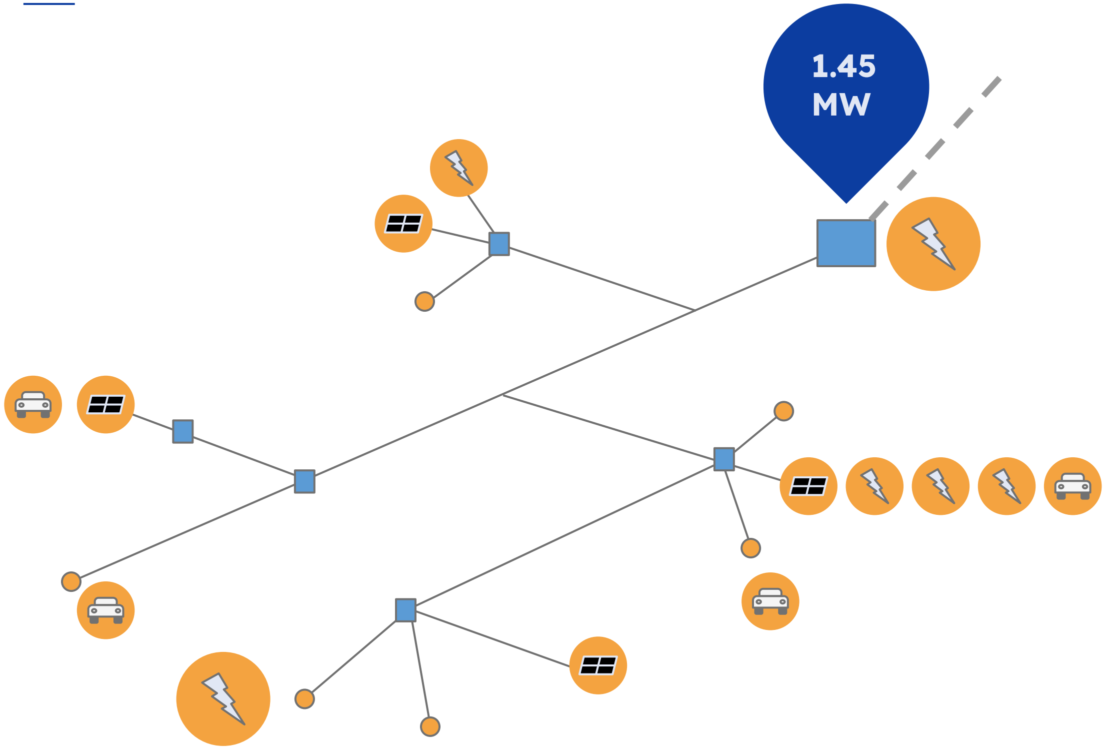
- Real-time operations and optimization of a two-way grid
- Forecasting, procurement, and scheduling of local resources
- DER integration into bulk markets and management of local markets



WHAT WE NEED

The ideal data landscape for the intelligent, 2-way grid

- Energy supply
- Carbon intensity



Feeder level: <1sec

- net + actual demand
- generation
- available flexibility
- voltage

Transformer & midline: <15min

- load at constraint points
- switching state
- voltage

Meter level: <15min

- demand
- voltage

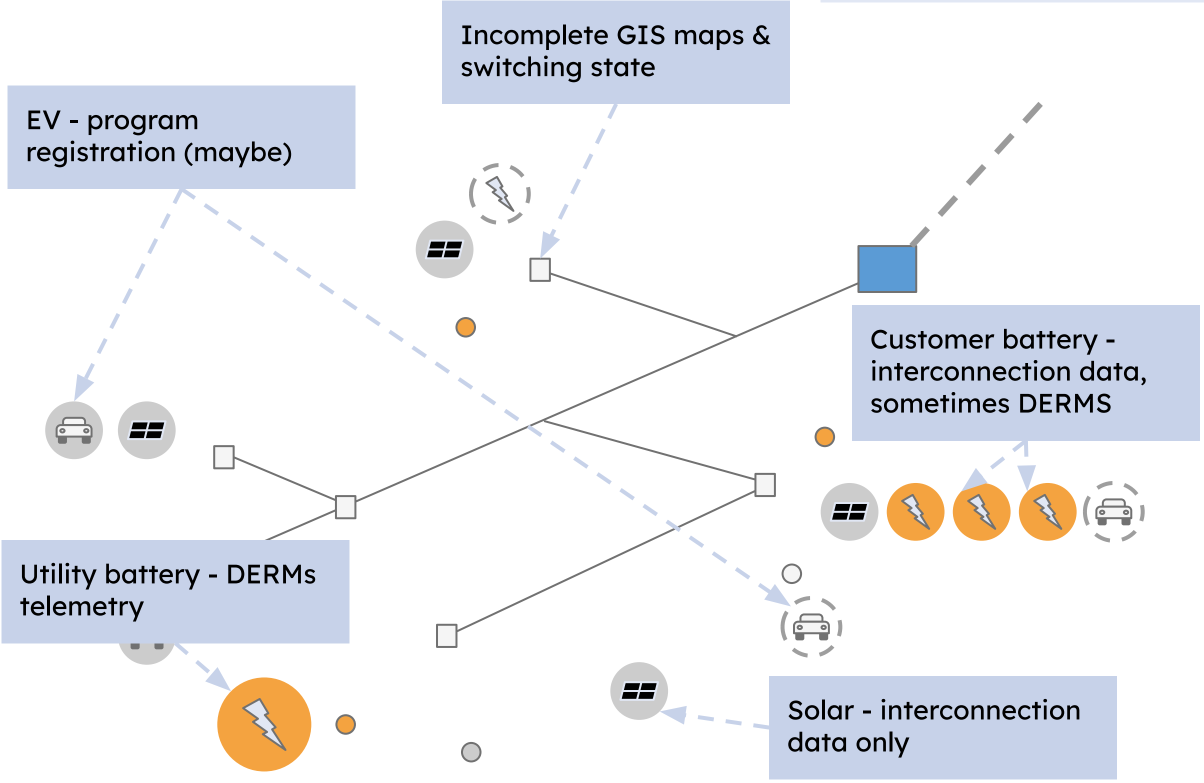
Device: ~1min

- Location, type
- Activity
- Available flexibility

WHERE WE ARE

The typical data landscape today

- Energy supply
- Carbon intensity



Feeder level: **<1-5min**

- net + actual demand
- generation
- available flexibility
- voltage

Transformer & midline: **periodic**

- Periodic engineering studies
- MDM based analysis tools
- Better with hardware

Meter level: **15min - 60min**

- Some/most meters
- Hours-days collection delay
- Secondaries often not in GIS

Device: some, with DERMs

- Multiple dashboards
- Many sources missing

HOW WE GET THERE

Three ways to bridge the data gaps

Get more value out of existing data

- Put together multiple operational sources (e.g. GIS, SCADA, AMI)
- Clean up data & make it easier to answer ?s
- Improve data access for common workflows

Gather data from more sources

- Invest in hardware instrumentation & comms infrastructure
- Integrate public data
- Leverage direct telemetry from DERs

Use models to fill in the data gaps

- Physics-based analysis
- Historical data interpolation/correction
- “Nowcasting” for real-time visibility
- Forecasting load, generation, flexibility

MULTIPLE STRATEGIES FOR FILLING GAPS

Getting to real-time awareness requires both direct reads and interpolation

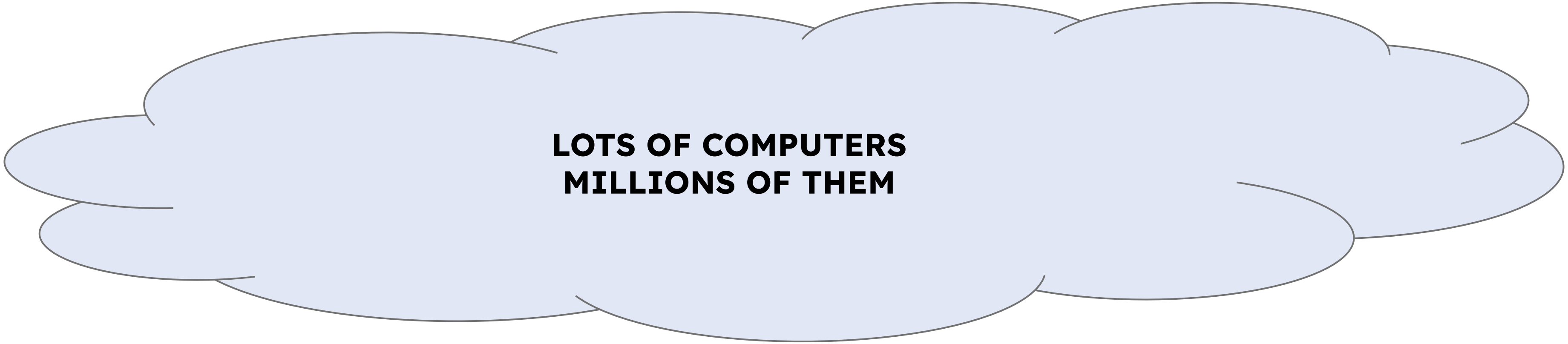
TD Substation	Real-time (~1sec)	DIRECT READ
Substation - near real-time	Near real-time (~1sec-5min)	
Midline	No	MODEL-BASED INTERPOLATION
Meter	~15minly, delayed 2-24 hours	
Rooftop solar	No	
Customer DERs	Someone else has it	DIRECT READ
Utility DERs	Real-time (~1sec)	

Cloud computing is essential for large-scale data management challenges

A scaling comparison:

- 1 million meters, 15minly reads: 96m reads / day
- Google's daily web searches (publicly reported) 5.6B queries / day
- Avg daily data points handled by internal monitoring 18T / day

180,000x scale!



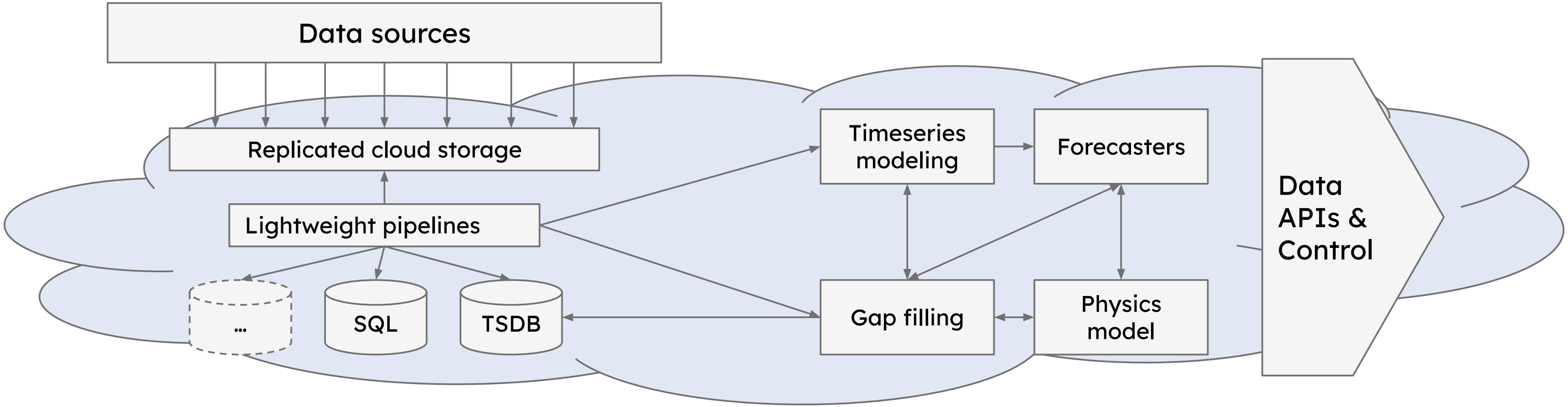
Cloud computing enables both high-scale collection and interpolation

Collection

- Collect & access all the data
- Provide multiple projections for different purposes
- Respect privacy and security
- Performant in real time

Interpolation

- Use the data we have to fill in gaps (past and future)
- Record source and precision
- Performant in *near* real time, but not for all use cases

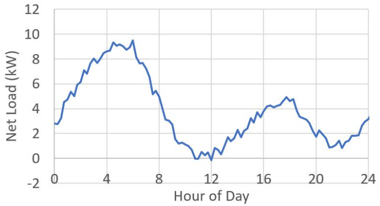


GETTING SPECIFIC: UTILITY DATA GAPS

Real-world data is not real-time. How do we bridge the gaps?

CHALLENGE

Aggregated metering of PV generation and load



CHALLENGE

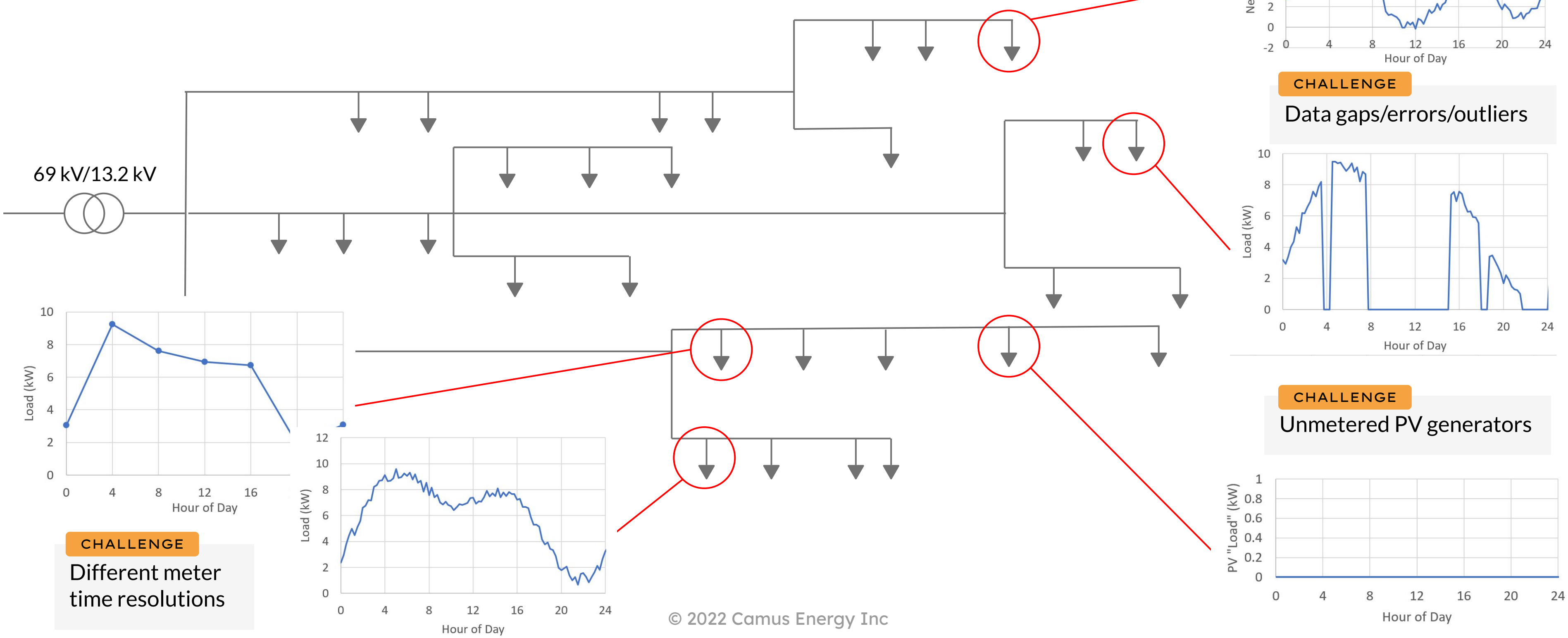
Data gaps/errors/outliers

CHALLENGE

Unmetered PV generators

CHALLENGE

Different meter time resolutions



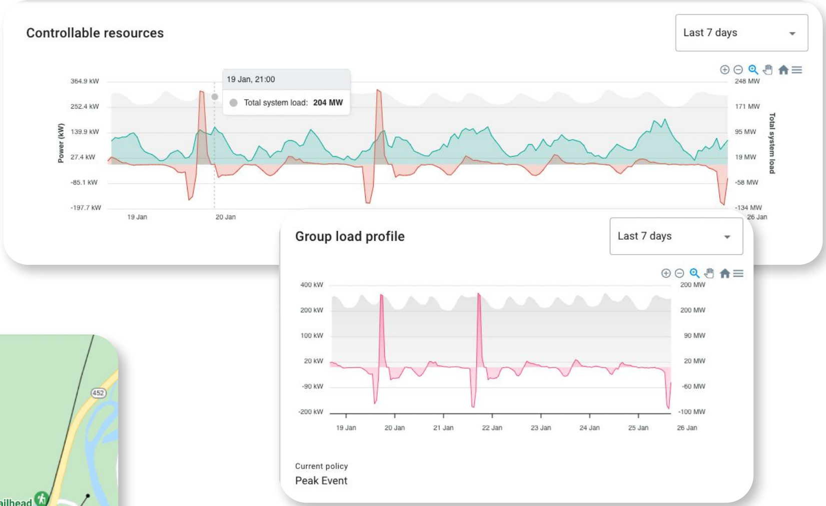
HOW WE FILL GAPS

Let’s look at how exactly we fill each of these gaps

	TD Substation	Real-time (~1sec)	DIRECT READ
	Substation - near real-time	Near real-time (~1sec-5min)	DIRECT READ
C	Midline	No	MODEL-BASED INTERPOLATION
B	Meter	~15minly, delayed 2-24 hours	MODEL-BASED INTERPOLATION
B	Rooftop solar	No	MODEL-BASED INTERPOLATION
A	Customer DERs	Someone else has it	DIRECT READ
	Utility DERs	Real-time (~1sec)	DIRECT READ

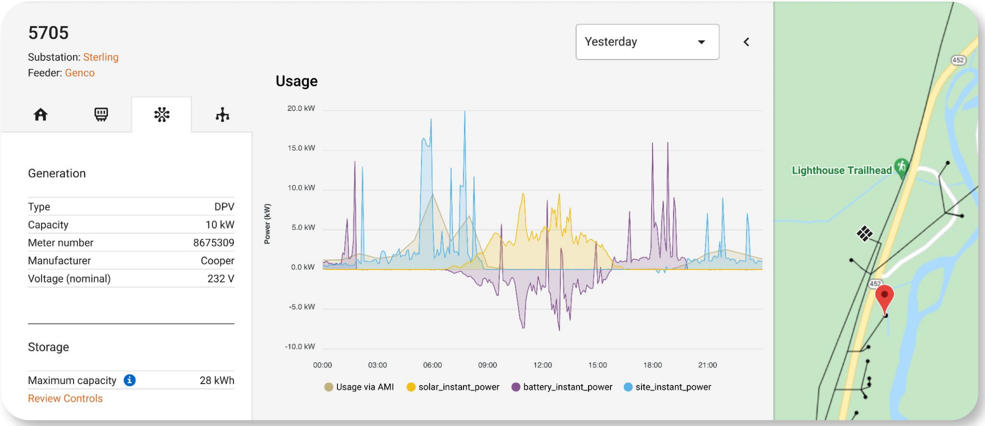
CUSTOMER RESOURCES / OTHER DERS

DERs: Someone else has the data



Data approaches:

- Direct telemetry - sourcing from the vendor or device*
- Measurement & verification with AMI
- Model based detection & forecasting



Combining DER data with AMI provides a **richer, more real-time view** & can complement M&V approaches.

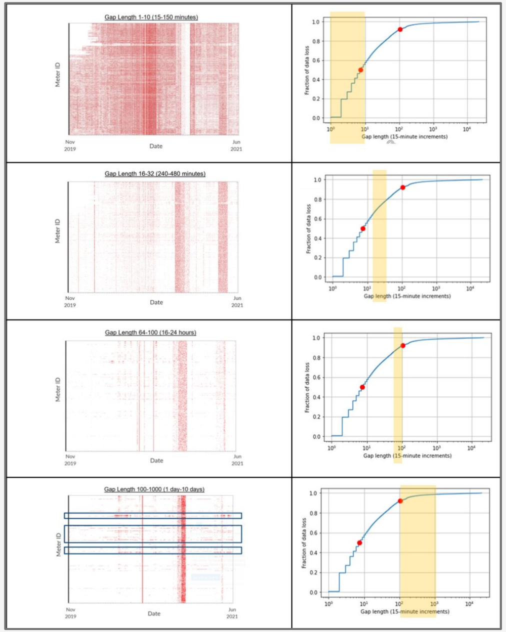
Note: *For cybersecurity, do not put consumer devices inside the utility security boundary

Funded by: SOLAR ENERGY TECHNOLOGIES OFFICE U.S. Department Of Energy

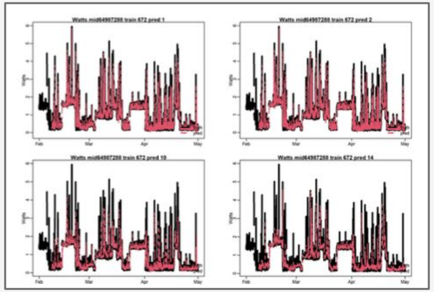
METERS, ENDPOINTS, & ROOFTOP SOLAR

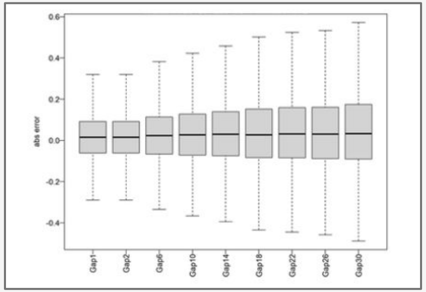
Machine learning approaches can enable model-based interpolation (via PNNL)

1. Data gap field analysis

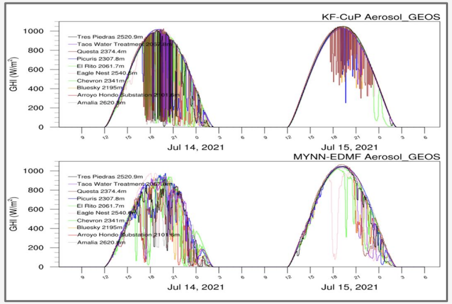


2. Modeling endpoints for gap filling and forecasting





3. Model-based forecasting for unmetered PV

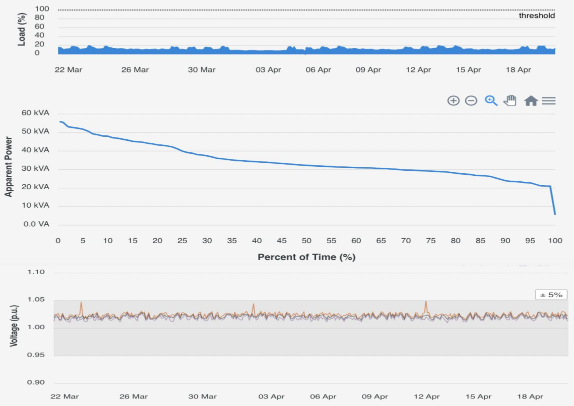


MID-LINE ANALYSIS & GIS

Filling the mid-line and GIS gaps relies on leveraging existing data

- With complete endpoint data, **we can draw conclusions about the state** of the unmetered parts of the network
- We can also **run the physics simulation in the simpler context** of a single feeder or substation, to help fill in the gaps

TRANSFORMER EXAMPLE



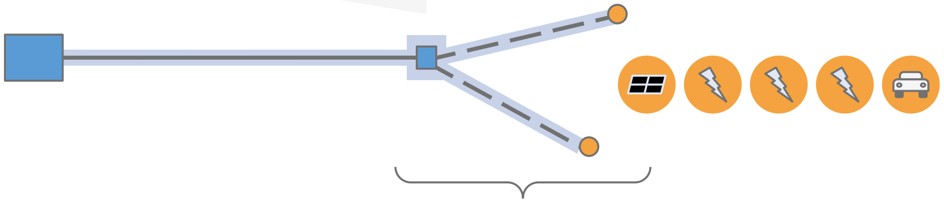
Transformer load

Load factor

Voltage

HOW IT WORKS

1. Transformer and line loading = adding up AMI + GIS relationships + cross-checking the SCADA
2. Voltage & other network conditions = physics model



We can estimate some of the common GIS gaps, but more work is needed

What data is actually necessary for coordinated control?

Baseline requirement:

- AMI at <60min intervals and <24hr collection delay
- SCADA instrumentation at every sub & feeder
- Digitized GIS maps

Aspirational requirements:

- <15min AMI data available instantaneously
- <1min SCADA collection
- Accurate GIS including connectivity and secondaries
- Midline device telemetry
- Active switching state

What about better comms?

- **Network infrastructure?**

  Helpful, if we're replacing RF mesh with something faster, eg direct broadband to every meter.

  Not required for consumer DER comms - use the internet.

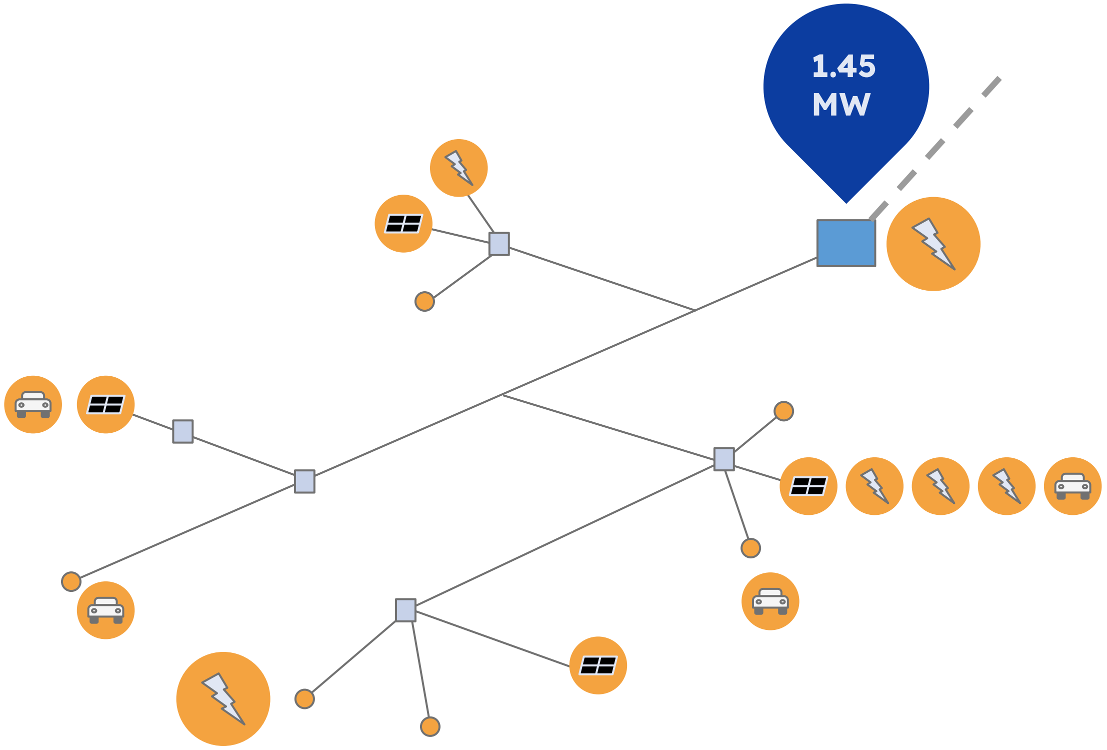
- **New network protocols?**

  No. Just stop.

How does real time data inform distribution operations?

USING DATA TO TAKE ACTION

What is the role of better data?



Grid level actions

- Optimize cost (& carbon)

Feeder level actions

- Prevent backfeed
- Manage feeders as resilience "microgrids"

Transformer & midline actions

- Keep load within constraints
- Manage voltage levels

Meter & device level actions

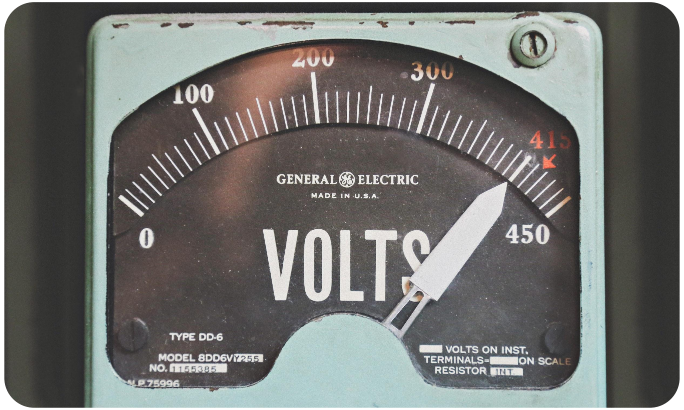
- Manage flexibility and generation for grid benefit & economic value
- Manage resilience
- (optional) Optimize carbon footprint

Managing Grid Conditions

What operational conditions do we actually care about?

- Voltage (maintain ±5% nominal)
- Impact on midline components (eg transformer load)
- Preventing backfeed at the feeder/substation
- Shutdown/tagout of local resources
- Integration with FLISR, OMS, etc

Grid management is traditionally done in interconnection & planning - but more resources create more complex interactions.



EXAMPLE

Backfeed Prevention

Measure and forecast feeder-level demand and local generation to avoid backfeed through curtailment.

If batteries are available:

- Charge & discharge batteries for load shifting, consistent with ITC requirements & backfeed constraints

Observations:

- Whose job is it to manage this?
- Planning time measures (protection design, volt/var requirements) still apply

FROM DATA TO OPERATIONS

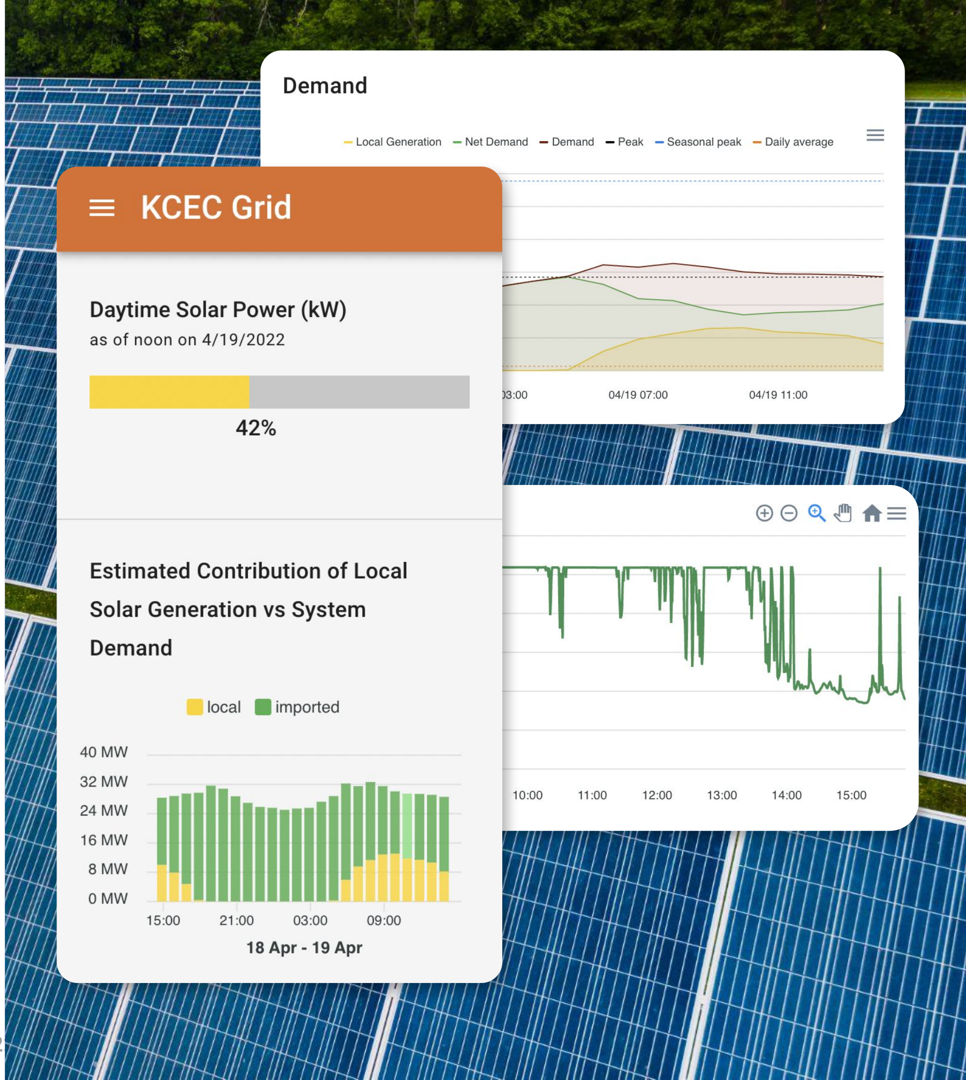
Managing supply and demand

What would need to be true to make use of dispatchable local resources on a daily basis?

- Real-time data about local resources
- Local resources integrated into power procurement workflows
- Operational/scheduling control of local flexibility
- Appropriate contract/market structures

Also enables:

- **Real-time carbon reporting**



EXAMPLE

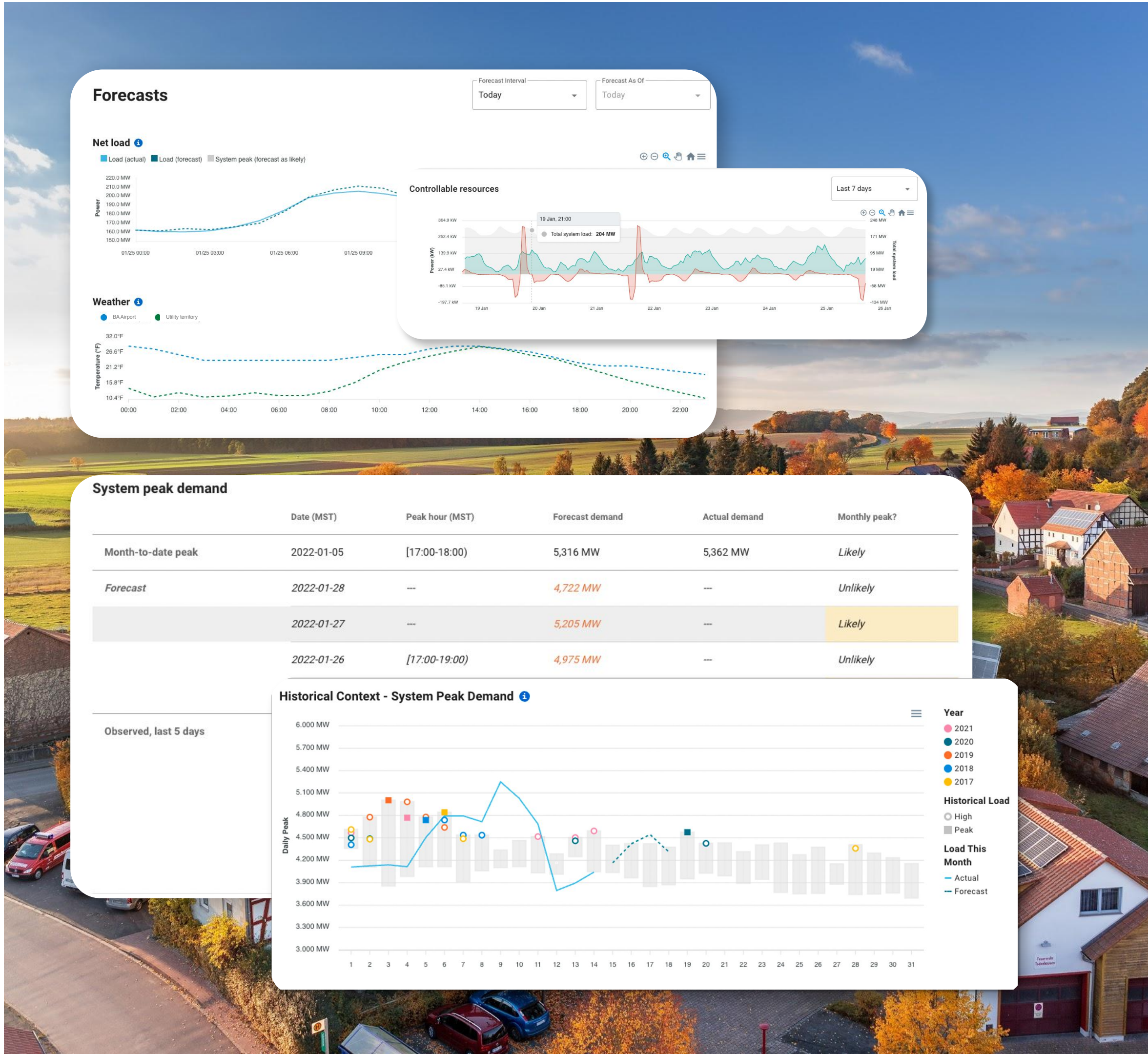
Peak Shaving

Tapping local resource flexibility to reduce peak demand (and system costs) relies on using high-fidelity data to:

- Measure & forecast net demand, and likely timing of peaks
- Dispatch all controllable resources according to abilities & device + grid constraints
- **Monitor the performance of DERs in real-time and over time**

Observations:

- Real-time data expands use cases, more frequent and more critical
- Utilities struggle with multiple control interfaces for different programs and DER types



Market and pricing integration of local resources

LOCAL RESOURCE USE CASES

- Grid efficiency
- Cost optimization
- Carbon optimization

WHOLESALE MARKETS AND FERC 2222

- Ancillary services
- Energy & capacity
- DR & load shifting

EXAMPLE: ORCHESTRATION IN PRACTICE

Procuring grid support from local DERs

Local grid insights & actions

Feeder ABCD 5 identified as within 5% of a transformer limit

Behind the feeder, 157 customers own EV chargers and 32 have PV/storage systems

Curtailing load at 8pm will lower risk at ABCD 5 and provide lowest-cost flexibility

43 DER owners are paid $0.35/kWh for curtailed or discharged electricity

Feeder model ingests local demand forecasts

Connectivity/GIS model identifies local DERs

Dynamic pricing model establishes value of load shifting over time

Market orchestration clears; utility dispatches select EVs and batteries based on market signals

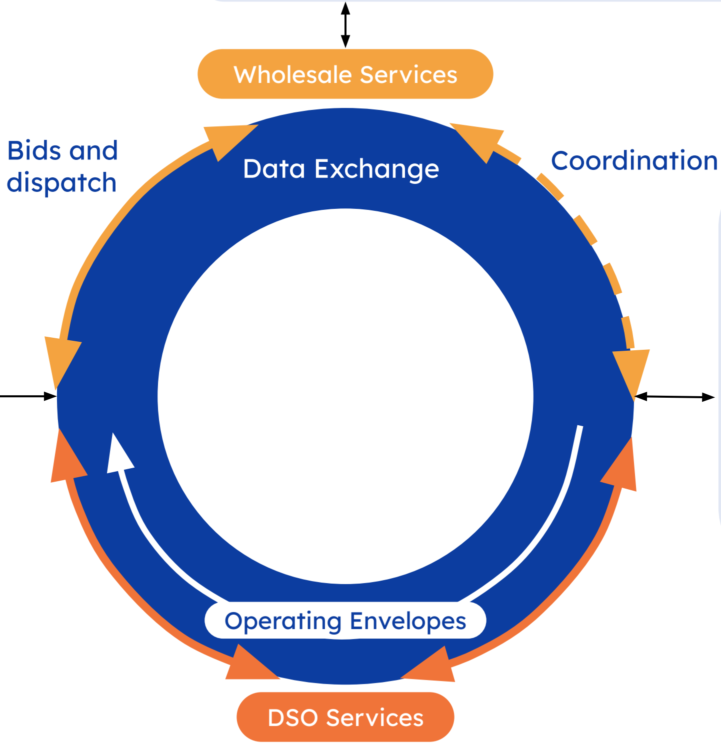
Utility workflow

PUTTING THE PIECES TOGETHER

Data Exchange (FERC 2222)

ISO / RTO

- Market data and forecasts
- Dispatch orders



Aggregator

- Registry of participants
- Real-time device activity data
- Forecasts
- Bid info

DSO

- Grid operating limits (dynamic envelopes)
- TD level forecasts (demand/gen/flex)
- Dispatch or approval (possible)

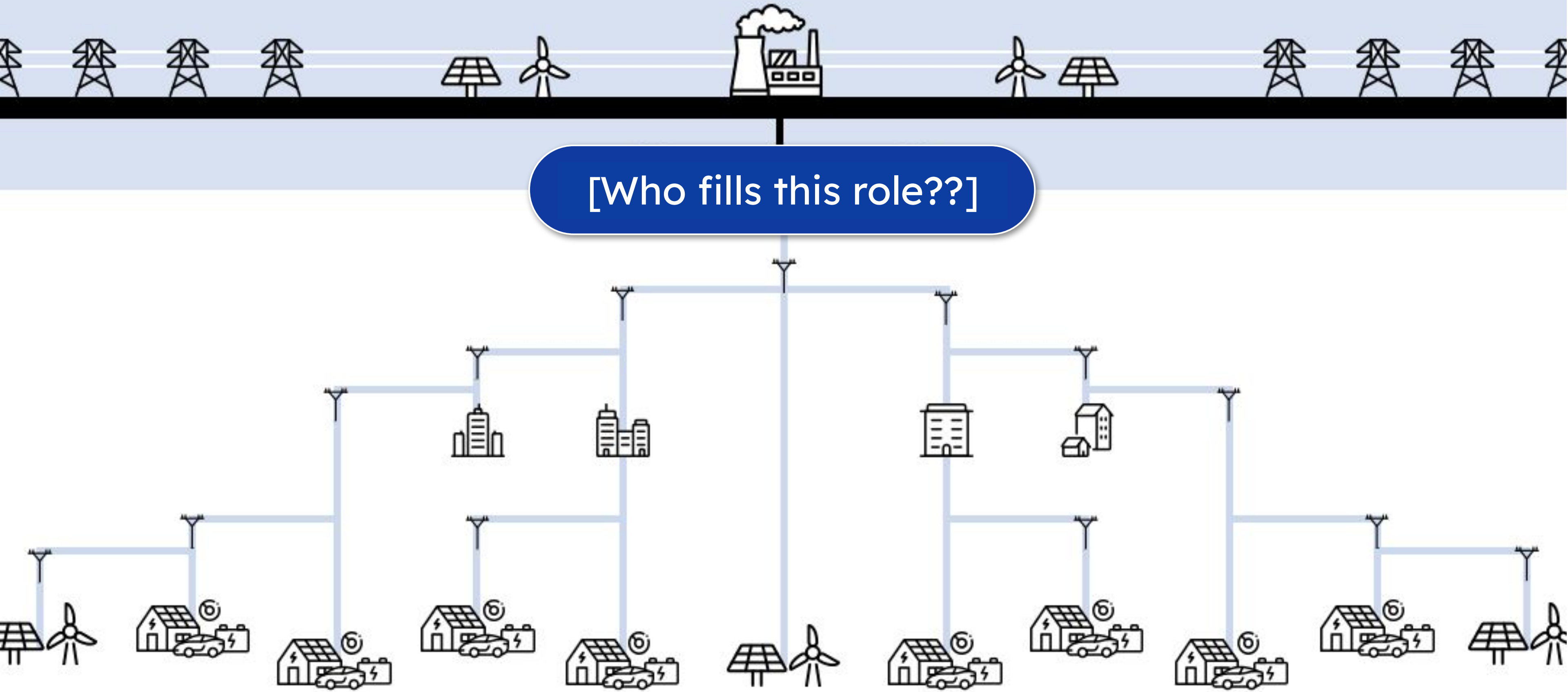
Source: AEMO's Project EDGE

RECAP

Four points to remember

1. In every version of the future grid, **safe and reliable operation will require more local insight and control** → enabled by real-time data
2. The real-world utility data landscape is far from ideal, but **there are ways to fill the gaps** that don't rely on massive communications investments
   - Accessing DER data directly from third parties
   - Applying machine-learning to forecast and interpolate
   - Using measured data to simplify the context for physics-based simulations
3. **Accessing real-time data helps utilities take actions at all levels of the grid**, from managing operational conditions to leveraging local resources for grid support
4. Real-time data also **opens the opportunity for local resources to play a big role** in management of the broader grid, enabling the shift to a DSO model

THE DSO FUTURE



Thank you!

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