Flexible Connections Definition:

A Flexible Connection is when an asset is provided a Flexible Capacity Allocation. The asset will be able to connect where existing grid infrastructure can accommodate said capacity without the need for additional system modifications to the common distribution system. Additional capacity can be made available based on real time monitoring of grid conditions and available capacity. Flexible Connections use time-based dynamic controls to adjust generation output to grid conditions in real time.

As a SubGroup, our primary aim is to define and review Flexible Connections across industry. The goal being to enable DER projects in appropriate areas to interconnect to avoid significant distribution system upgrades, while reducing costs and timeframes associated with the standard interconnection process. This includes defining policy on how curtailment will work for DERs. Success may allow for faster and cheaper integration of DERs by increasing the hosting capacity of existing grid infrastructure and/or increased penetration of DERs to the grid.

There are 2 overarching "practices", or "schools of thought" being discussed.

- **Utility Controlled, Flexible Connections**
- **Dynamic "Local" Control, "Enabling inverter functionality"**

We as a subgroup are breaking down these 2 practices into Phase 1a and Phase 1b, to be discussed and delivered on as a group.

Phase 1a: Utility Controlled, Flexible Connections (*Primary Focus of this SubGroup*)

Defining Flexible Interconnections:

i. Not only interconnection, but also ongoing controls and management
ii. Use Cases
iii. Issuing direction vs control

Basic Use cases:

i. PV, ESS, & EV
   a. Not just connection - also handles and deals with controls & management.
   b. Active Resource Integration as a Flexible Interconnection – current NG program offering
   c. Other programs? How are we looking at future programs and use cases?
      - Looking for other stakeholder input for ongoing programs, trends, etc.

Flexible interconnections extend beyond initial DER integration to encompass ongoing control, management, and communication strategies, enabling dynamic use cases—such as PV, ESS, and EV— through stakeholder-informed program development, and a balance between issuing operational direction and direct control.

Thermal Constraints:

i. Optimizing the system around thermal constraints
    i. Using technology to optimize system dispatch in a way that allows more MWs on the system in a dynamic nature

ii. Number of constraints
    i. Need to start with one constraint but have the ability to look at multiple constraints
    ii. Curtailment at the feeder level, thermal constraints

An asset will be able to connect where existing grid infrastructure can accommodate said capacity without the need for additional system modifications to the common distribution system. To enhance system efficiency and reliability, and further test out these foundational technologies, energy systems will first be optimized around thermal constraints by leveraging dynamic dispatch technologies, beginning with single-constraint models and evolving to accommodate multiple constraints such as feeder-level curtailments.

Foundational Technologies

i. Using technology to optimize system dispatch in a way that allows more MWs on the system in a dynamic nature

ii. What system is needed?
   a. 3rd party Enterprise energy software company enabling the connection and real-time monitoring and control of DERs (National Grid path)

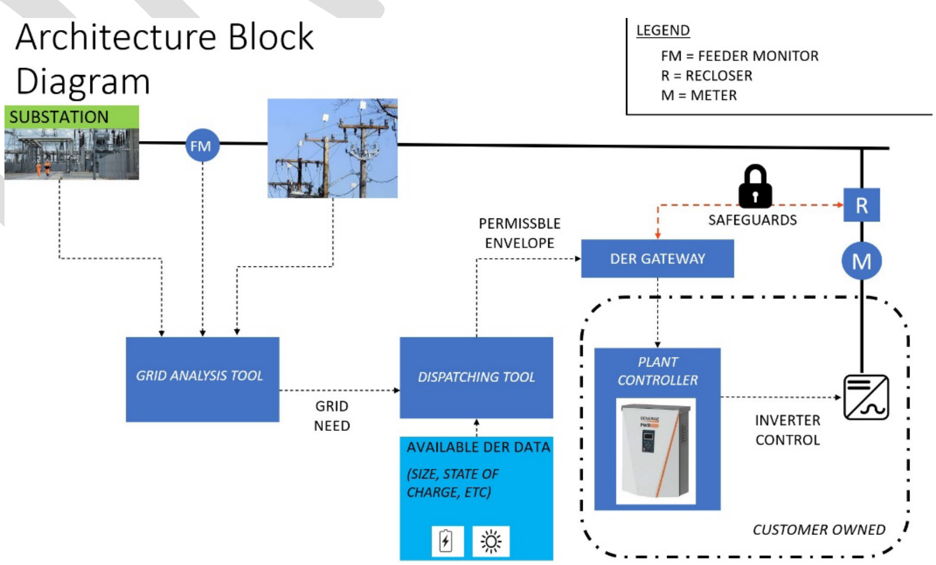
iii. What hardware/equipment is needed?
   a. Utility
      i. DER or "RTAC" Gateway
         - RTAC
         - Firewall
         - Cell Radio

   b. Customer-owned
      i. Local Power Controller or Power Control System

   c. Power Plant controllers
      i. Need for equipment protocols (look to add language here during circulation)
      ii. These protocols are/may be needed elsewhere outside of just equipment
      iii. Looking into PCS - not a lot of information on these
         - UL 1741 CRD is what we (National Grid) are basing it off of for now

iv. Communications Protocols
   a. Cyber Security

   b. Implementation of Flex Connections
      i. Concept of implementation – communications with RTAC/RTU, additional equipment
      ii. Scaling & ensuring availability
      iii. Costs



Flexible Connections requires integrating advanced enterprise software and interoperable hardware—including RTAC or DER gateways, local power controllers, and power plant communication protocols—to enable real-time monitoring, dynamic dispatch, and flexible DER connections, all underpinned by cybersecurity and standardized implementation frameworks.

Communication Protocols:

- **DNP3 (equivalent is IEEE 1815.2), 2030.5, SunSpec Modbus**
- **2030.5 is undergoing testing and Flex Connect in California at the moment**
- **1815.2 – DNP3 1815.2 Vote completed on September 03, 2024. The committee needs to address comments, and an updated draft should get approved by the committee and will go to the IEEE SA committee for approval.**

DER SCADA Monitoring and Control Requirements:

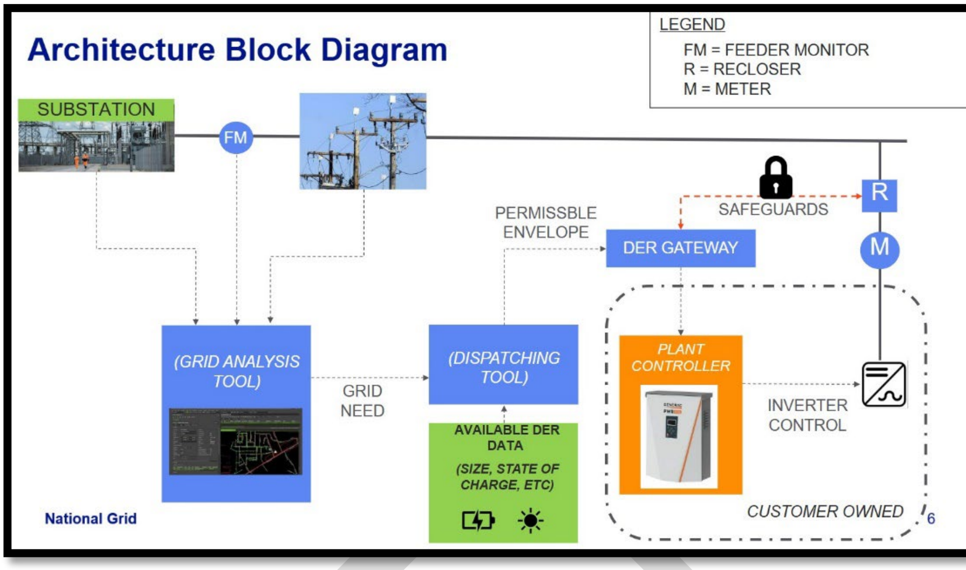
- **For a DER facility >= 500kW (Eversource) >= 1MW (National Grid) the standard is we will install and operate the utility side POI Recloser and DER Gateway using DNP3 protocol on the EDC comms network.**

- **We also require the customer to install a Power Plant Controller (PPC) to provide SCADA monitoring and control to the DER Gateway**
  - **Fiber cable connection between the DER Gateway and PPC using DNP3 protocol**
  - **RTAC can be used for a PPC**

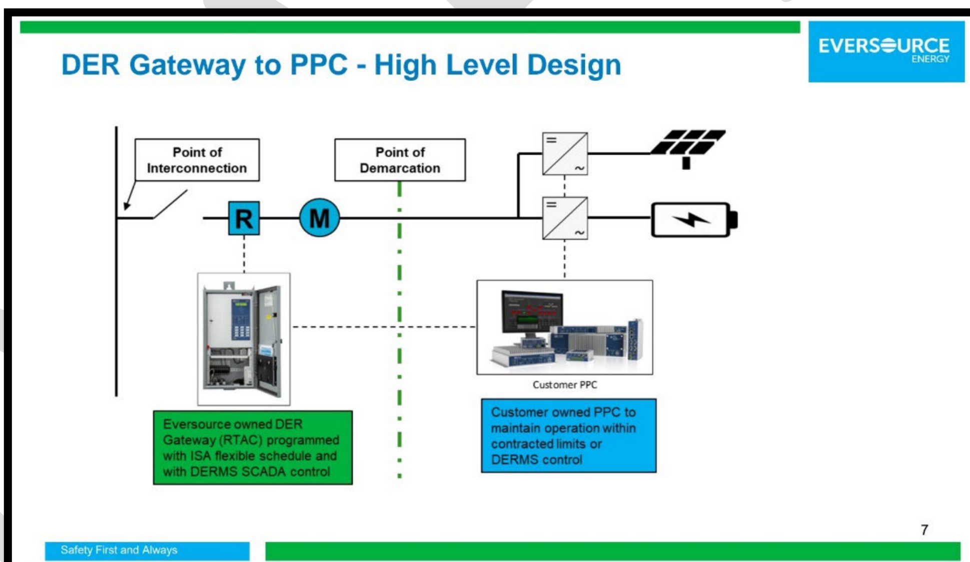
- **This will also require the customer to provide an interface between their PPC and the inverter control system to provide for monitoring and P/Q (real & reactive) control**

- **For flexible DER interconnections we are requiring DER Gateway to use an SEL RTAC programmed with the P/Q operating limits and/or Operating Schedule to directly control the customer PPC or inverter control system locally**

National Grid:



Eversource:



Scheduling:

i. Moving away from the term "schedule"
    a. Schedule is more so referencing on the customer-end, where they can expect to de-rail/curtail based on historical readings
    b. Replace with envelope or boundary

ii. Static schedule vs. Dynamic real-time control
    a. National Grid has been doing static schedules for a few years
        i. Dynamic is rolling out now with ARI
            1. Same concept as the schedule but real-time

iii. Battery Charge/ Discharge Schedules

As energy systems evolve, the shift from static customer-side schedules to dynamic, real-time control frameworks—framed as operational envelopes or boundaries—enables more responsive and efficient DER integration, particularly in managing battery charge and discharge behaviors.

Economics and Program Tie-in

i. Pro-rata vs Li-Fo
ii. Curtailment agreements and subsequent projects – minimize curtailment
iii. Energy market/incentive programs, & revenue value stacks for reducing barriers to flexibility participation.
    I. ConnectedSolutions
    II. CleanPeak Standard
    III. SMART

Being discussed in other working groups.

Curtailment:

i. Can we define "Curtailment"?
   a. Curtailment –

ii. Curtailment vs. Trip
   a. Shutting down sites - more detail/discussion to follow

iii. Monitoring & Configuration of DER Curtailment Limits

iv. Driving/defining policy on how curtailment will work for DERs.
   a. Industry thoughts on ways of curtailing

v. Feasibility analysis and curtailment studies – adding definition of a process*
   a. ISA's and whether projects qualify for flexible interconnections
   b. Curtailment studies as a next step

vi. How to size a potential cohort – collaborative discussion between Utility and Developers **
   a. Looking at the different percentages of a cohort – deeper percentage of curtailment the riskier it becomes
   b. And look at the potential of tiered cohort/group
   c. First project to be curtailed… what does this mean for subsequent applications/projects

vii. Compensation mechanisms for missing curtailment percentages?
   a. Look to "Add List of potential **avoided** upgrades and conditions that caused the curtailment" so that developers can "build to the standard."

Curtailment, in the context of distributed energy resources (DERs), refers to the intentional restriction of electricity import or export at the point of common coupling (PCC) to maintain grid stability during curtailment events. Unlike a full system trip, curtailment is a controlled, often dynamic action that can scale from partial to full reduction without disconnecting the DER from the grid. For example, a solar photovoltaic (PV) system may be curtailed during midday when generation exceeds local demand and feeder capacity, or a battery energy storage system (ESS) may be limited from charging during peak grid congestion. Similarly, electric vehicle (EV) charging stations may receive curtailment signals during high-load periods to reduce strain on the distribution network. These events are typically triggered by real-time grid conditions, such as thermal overloads, voltage violations, or system contingencies.

This distinction is critical as utilities move toward real-time curtailment signals and flexible interconnection models. These models require communication protocols and hardware integration to manage curtailment across front-of-the-meter (FTM) and behind-the-meter (BTM) assets.

This includes estimating curtailment impacts by substation or feeder, defining cohort-based curtailment strategies, and exploring tiered interconnection models that blend firm and flexible capacity. Emerging discussions around hosting capacity fees and compensation for missed curtailment targets further highlight the need for standardized definitions, technical language, and collaborative planning between utilities and developers.

Studies:

- 8760 Impact studies
  - Steady State Models
    - Software
      - Excel
      - CYME (Ngrid)
      - Synergi (Eversource)
      - Windmill (Unitil)
      - PSSE (Unitil)
    - Unitil does not currently use 8760 models.
    - Eversource does not currently use 8760 models
    - Limiting elements (thermal, voltage)
      - Between POI-Substation
        - Offer flex solution
        - Upgrade asset
  - 8760 Load Data
    - Net load
      - Raw data from PI
      - Includes:
        - DER penetration
        - Switching events
      - Uncleaned net load is not favorable to use for analysis since it could lead to heavy curtailment.
    - Gross Load
      - Challenges:
        - Need advanced scrubbing or algorithms to clean data
      - GLC Application (Eversource)
    - Forecasted Load
      - Using historical data to predict future load growth is challenging. Could cause varying amount of curtailment per years.
    - Level of info to provide customer?
      - Assumptions for study?
      - Specific feeder data?
      - Load profile?
  - DER Types and profiles
    - PV
      - Easiest to study
      - Weather data is fairly accurate
    - PV + BESS
      - Charging constraints with ESS systems during peak times may lead to inability to discharge next day or during events
    - BESS only
      - Charging constraints with ESS systems during peak times may lead to inability to discharge next day or during events
    - Hydro, wind, sync

- ISO and Incentive Based Markets
  - Demand Response
  - Clean Peak
  - SMART
- Study Methods
  - DPU has ruled that each EDC planning process is up to the individual EDC.
  - Focusing on feeder level and substation level constraints
    - Find constraints in CYME, use excel to curtail (NGRID)
  - LIFO
    - Assigning DER priorities on which to curtail first
  - Pro-rata
- DER Schedules and Use cases
  - Limited schedules now, perform upgrades, increased output later
    - Is it flex as a temp solution to enable the connection before upgrades are built? Or flex as the ongoing design/operation in lieu of upgrades?
  - 5% curtailment annual energy
  - Firm and flex combination
  - When in the process to offer flex?
  - When do customers have to commit to firm?
  - Is there an opportunity to go back to firm in some cases? When does that happen?
- Customer Study Deliverables - Operational Impact
  - Screening
    - Group Study Areas (Further discussion required)
    - Pre existing list of potentially good substations/feeders for flex connect?
      - High cost items are better for flex connect solutions
        - Substation
        - Feeder
    - Provide high level estimated flex connect schedule
      - Thermal Constraints Initial
        - Substation
        - Feeder
      - Voltage Constraints later identified during SIS
  - Impact Estimation (Based on schedule):
    - Perform 8760 analysis
      - Solar, 8760 profile based on irradiance
      - Solar + ESS,
        - Discharge at solar peak to EPS
        - Charging from PV
      - ESS
        - Clean Peak
        - Charge and discharge once per day
        - Limitations in inability to reach full charge/discharge
    - Provide Flex Connection impacts to site operation
  - Customer Choice:
    - Allows customer to make informed decision on economic viability of the project
    - Enable interconnection that may be otherwise non-viable under conventional planning

        - Maintain Safety/Reliability:
            - Customer operates as they see fit, within permissive “guardrails” from Flex Connection
        - Dynamic real time control

Scaling Flexibility:

i. Once you have multiple Flex projects on a feeder, how do you approach who gets curtailed
    - Contingencies in the Distribution level

ii. Developer perspective
    a. Does not ***require*** saturation but more so high interconnection costs and equipment upgrade costs
    b. Economic alternative given the probability of curtailment with said interconnection
        i. How much, when, where, how frequently is curtailment taking place
    c. Conditions & Reports are provided via ISA’s to developers in advance & throughout project go-live

iii. Reporting Requirements
    a. Flexibility SubGroup - Reporting Questions List.docx

Phase 1b: Dynamic “Local” Control, “Enabling inverter functionality”

Flexible capacity of the asset, Volt/Var curve as part of ISA. – “Enabling inverter functionality”

i. Moving beyond thermal and into voltage, power quality

Smart Inverter control(s) and Power Control system(s)

ii. Looking into PCS - not a lot of information on these
    - UL 1741 CRD is what we are basing it off of for now

New way of managing assets. i.e. Grid Services

iii. Demand Response programs

Piloting advanced inverters – updates from Utilities in the form of how this has gone to date

i. Learnings and tested to-date

Outside of Current Scope:

i. Generation/Demand balancing

a. PV, ESS

ii. Future Planning

iii. DERMS Integration

iv. Data Sharing

v. Performance Tracking

vi. Localized edge intelligence (exploring approaches that are not DERMS related)