Grid Architecture Work Products
Purposes of the Work Products

• The architecture development process generates a variety of work product documents
  ▪ Some are documentation of inputs (requirements, constraints)
  ▪ Some are internal intermediate works (analyses, simulations)
  ▪ Some are deliverables for use by stakeholders

• The primary tangible outputs are structures and component classes with support detail

• The ultimate purpose is to enable a shared stakeholder vision of the grid, so many architectural views may be generated to aid in managing complexity
Grid Architecture Development Process

- Work products document both inputs and outputs of the process
- Various analyses are created as intermediate products
Work Products

- **Inputs**
  - User Requirements and Public Policies
  - Emerging Trends and Constraints Lists
  - Reference Models and Systemic Issues Lists
  - Use Case Documents
  - Architectural Bases and Principles List
  - Architecture and Industry Technical Glossary

- **Outputs**
  - System Qualities, Properties, and Elements Mappings
  - Component class models and external properties
  - Structures and external properties
  - Validation Studies and Analyses
  - Reports and Presentations

The Core Architect Team determines the exact list of work products to be created for any specific architecture project.
INPUTS
User Requirements and Public Policies

- Word document listing and describing the requirements gathered from stakeholders and the set of relevant public policies used as inputs to the architecture process
- Reference materials as appropriate
  - Policy documents
  - Requirements studies
  - User surveys and reports
  - Related industry white papers
- Compilations of stakeholder interview/focus group discussions comments
Emerging Trends & Constraints

• Two lists, one for trends, one for constraints

• Emerging Trends
  ▪ Typically a spreadsheet or slide deck
  ▪ Trend name, detailed description, comments on significance/impact
  ▪ As many as needed, but typically 10-20

• Constraints

• Also a spreadsheet or slide deck
  ▪ Name, description, comments, and references if needed
  ▪ As many as are relevant
Reference Models, Systemic Issues, As-Is Depictions

- Reference models are depictions of a problem domain from a particular point of view
  - Diagrams
  - Text to explain PoV (context) and diagram contents
  - As many as needed; architect team decides

- List of Systemic (Cross-Cutting) Issues
  - Derive from reference models and knowledge of constraints, relevant technologies, and
  - Typically a spreadsheet or slide deck
  - Issue name, detailed description, comments on significance/impact
  - As many as needed, but typically 30-50

- As-Is Grid Depictions
  - Architectural representations (structure/components and detail) for existing aspects of the grid where needed
Use Cases

• Unlike design processes, in architecture development, use cases are primarily for conceptual testing of proposed architectures

• Typical use case format

• As such, the detail level and granularity of these use cases is less than for typical design processes

• It is often useful to create use case *scenarios* involving multiple activities in order to help capture couplings and interactions – this makes them inherently less granular than typical design use cases
Architectural Bases and Principles

• List and description of formal bases and underlying principles used in the development of the architecture
• Provides part of the foundation for conceptual integrity
• Word doc plus reference materials
Technical Glossary

• List of architectural terms and industry technical terms with definitions
• Use to establish a common language for stakeholders to discuss grid architecture
• Word doc
OUTPUTS
System Qualities, System Properties and Architectural Elements Mappings

- Mapping diagrams with drilldown details
  - Three layer (tri-partite graph) map
  - Define each box (quality or property) and each mapping line (with numerical attribute)

- Properties-Qualities mapping is done early in the project; components and structures are mapped later

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Key Components and Structures
  Synchronized distribution sensing
  AC/DC power flow controllers/converters
  Bilaterally fast storage
  Integrated planning and operations
  Synchronized markets
  Advanced multi-mode optimizing controls
  X2grid interface/integration
  Transactive buildings
  Meta-data management incl.
  network model mgmt.
  Distribution System Operators
  Variable mesh electric circuits
  Microgrids
  Laminar coordination framework
  Central/distributed energy resources
  Central/distributed control
  Business/value streams
  Regulatory (DSO/coor)
  Industry (DSO) model

Key Properties
  Observability: wide and deep situational awareness
  Controllability and dynamic stability
  Smoothly adjustable N-way power flow
  Tolerance of generation/load stochasticity
  Converged T&D, gas, prosumer
  Scalability
  Distributed reliability management
  Whole (extended) grid coordination
  Attack resistance/fault tolerance/self healing
  Data/device/system interoperation
  Boundary defense/local optimization
  Control federation/disaggregation

System Qualities
  Security
  Safety
  Robustness
  Reliability
  Resilience
  Minimum environmental footprint
  Flexibility
  Extensibility
  Optionality
  Financeability
  Used and useful
  Rate-baseable
  Discrete
  Bankable
  Affordability
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Component Classes, External Properties

• Component class models are abstractions; externally visible properties matter; internal implementation must remain hidden
  ▪ Defined function, interfaces, and externally visible properties
  ▪ No representation of how the component works or is implemented
• Do not over-abstract; this conceals important information
  ▪ Demand Response is NOT a form of storage
• Formal text descriptions are fine; Word, Excel, or slides; some require diagrams and so Word or slides preferred
• ADL/SysML/UML not recommended (but prefer SysML to UML or ADL)
  ▪ Most Grid Architecture stakeholders cannot consume
  ▪ System (not IT) architects moving away from these anyway
Structures, External Properties

- Graphical depictions of structures with drilldown information
  - Power circuit bus and branch line diagrams
  - Industry structure diagrams
  - Regulatory scope diagrams
  - Application taxonomy and component models
  - Network connectivity diagrams
  - Measurement and control block/flow diagrams
  - Coordination skeleton diagrams
  - Value/intelligence/cash/energy flow diagrams
  - Network dependency/convergence diagrams
Validation Studies and Analyses

• Reports on technical support activities used to verify architectural concepts and approaches
  ▪ Analyses
    o Two down/one up feasibility analyses
    o Theoretical and analytical studies on components and structures
    o DSM analysis
    o Use case concept test results
  ▪ Simulations
    o Multi-structure co-simulations
  ▪ Stakeholder reviews
    o End user qualities-based reviews (problem domain)
    o Developer/operator properties-based reviews (solution domain)
Architectural Views

• A view is a set of diagrams and drilldown detail depicting some aspect of the architecture from a particular point of view
  ▪ Stakeholder interest
  ▪ Industry or regional segment
  ▪ Notional approach

• Views can depict alternate approaches but should have common conceptual integrity

• The entire set of views is the architecture.
Is There Just One Architecture for the Grid?

- There are an unlimited number of possible architectures; they are not all equally strong so part of the grid architecture process is to weed out the weak and identify the strong.

- In the US, the diversity of the utility industry makes it impossible to have a universal one-size-adapts-to-all architecture. In addition, there are diverse competing approaches to various grid problems.

We use multiple views to accommodate appropriate regional, industry segment, and notional variations while maintaining conceptual integrity across the set of views and so in that sense we construct a single (multi-view) architecture.
Reports and Presentations

- As needed to explain architecture or validation analyses to stakeholders
- No specific format
- Word
- PowerPoint