Transactive Energy

The Elements of TE

Mark Knight
CGI Director, Consulting
Chairman Emeritus & Member GridWise Architecture Council (GWAC)

CGI

Experience the commitment®

Definition of Transactive Energy

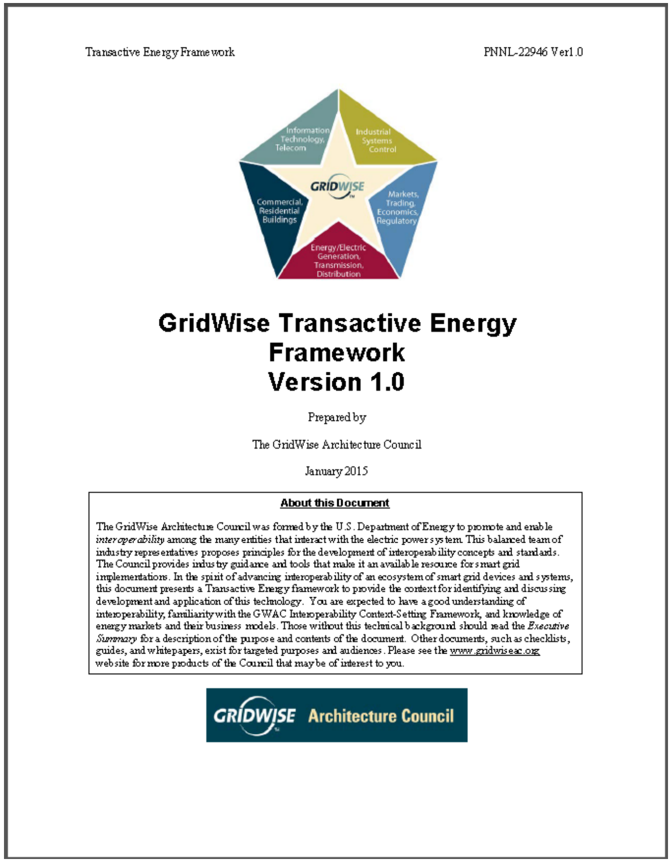
From GridWise® Architecture Council's Transactive Energy Framework*

- "A system of economic and control mechanisms that allows the dynamic balance of supply and demand across the entire electrical infrastructure using value as a key operational parameter"

Paraphrased to fit a tweet:

- "a set of techniques that encompass both economic and control mechanisms together to balance an electric power system using distributed agent based collaboration"

*http://www.gridwiseac.org/pdfs/te_framework_report_pnnl-22946.pdf



Transactive Energy Framework PNNL-22946 Ver1.0

GridWise Transactive Energy Framework Version 1.0

Prepared by

The GridWise Architecture Council

January 2015

About this Document

The GridWise Architecture Council was formed by the U.S. Department of Energy to promote and enable *interoperability* among the many entities that interact with the electric power system. This balanced team of industry representatives proposes principles for the development of interoperability concepts and standards. The Council provides industry guidance and tools that make it an available resource for smart grid implementations. In the spirit of advancing interoperability of an ecosystem of smart grid devices and systems, this document presents a Transactive Energy framework to provide the context for identifying and discussing development and application of this technology. You are expected to have a good understanding of interoperability, familiarity with the GWAC Interoperability Context-Setting Framework, and knowledge of energy markets and their business models. Those without this technical background should read the *Executive Summary* for a description of the purpose and contents of the document. Other documents, such as checklists, guides, and whitepapers, exist for targeted purposes and audiences. Please see the www.gridwiseac.org website for more products of the Council that may be of interest to you.

GRIDWISE Architecture Council

CGI

TE Definition(s)

- A system of economic and control mechanisms that allows the dynamic balance of supply and demand across the entire electrical infrastructure using value as a key operational parameter.
- TE utilizes economic & operational mechanisms to optimize an electric power system using distributed agent collaboration #Grid3pt0

Operational
and economic value
optimize power

俳

Electricity –
markets, control, and value
transactive future

(haiku:俳 pai2)

GridWise Architecture Council

A group formed by the U.S. Department of Energy

GWAC members are recognized and respected practitioners and leaders with broad-based knowledge and expertise

GWAC has broad, balanced representation among its 13 members selected to represent the full spectrum of industry and academia.

Neither a design team, nor a standards making body.

We help identify areas for standardization that allow significant levels of interoperation between system components.

We are helping to outline a philosophy of inter-system operation that preserves the freedom to innovate, design, implement and maintain each organization's portion of the electrical system.

http://www.gridwiseac.org/

https://gridwiseacdev.pnl.gov/call_for_candidates.aspx

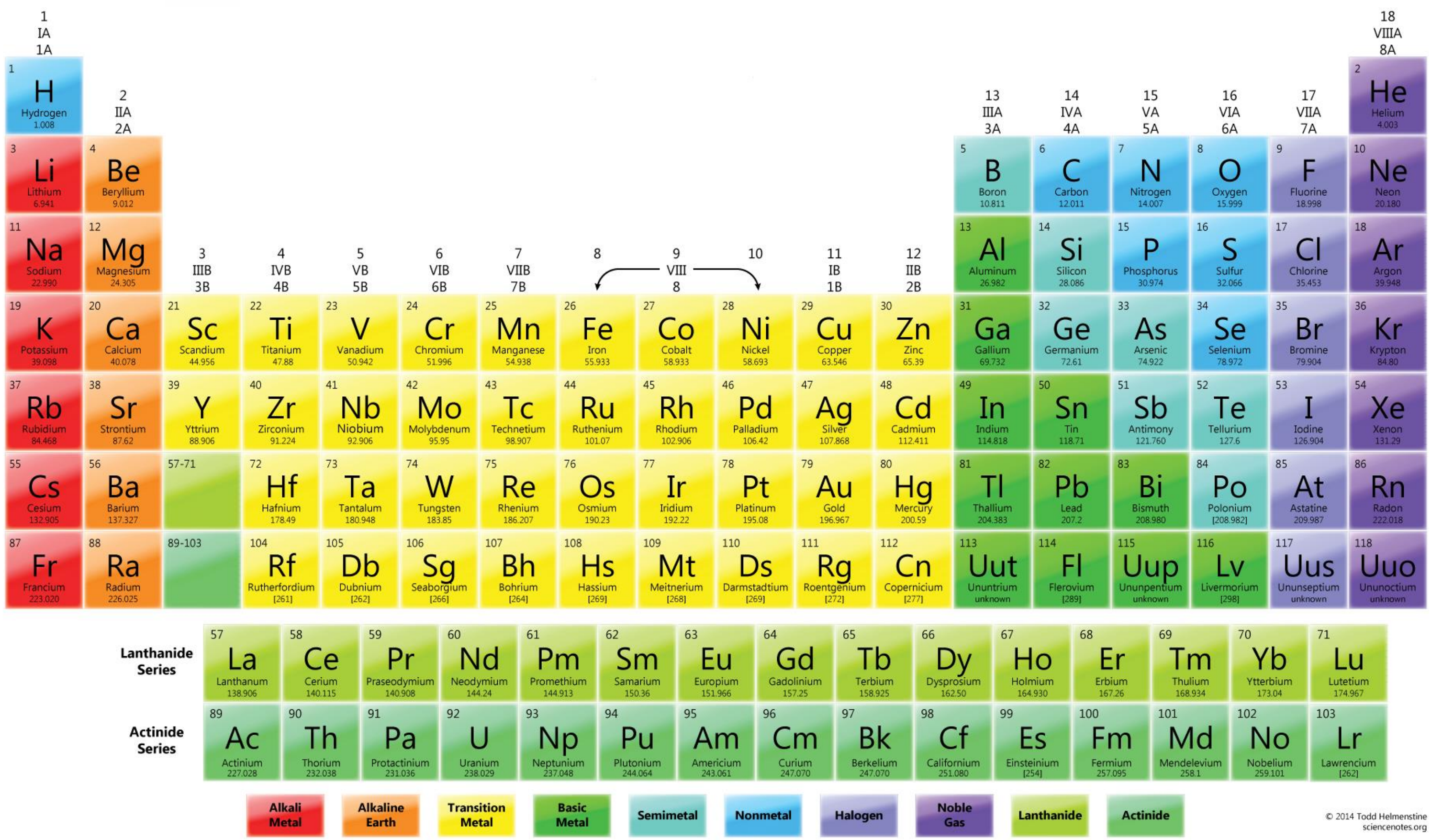
GRIDWISE® Architecture Council

CGI

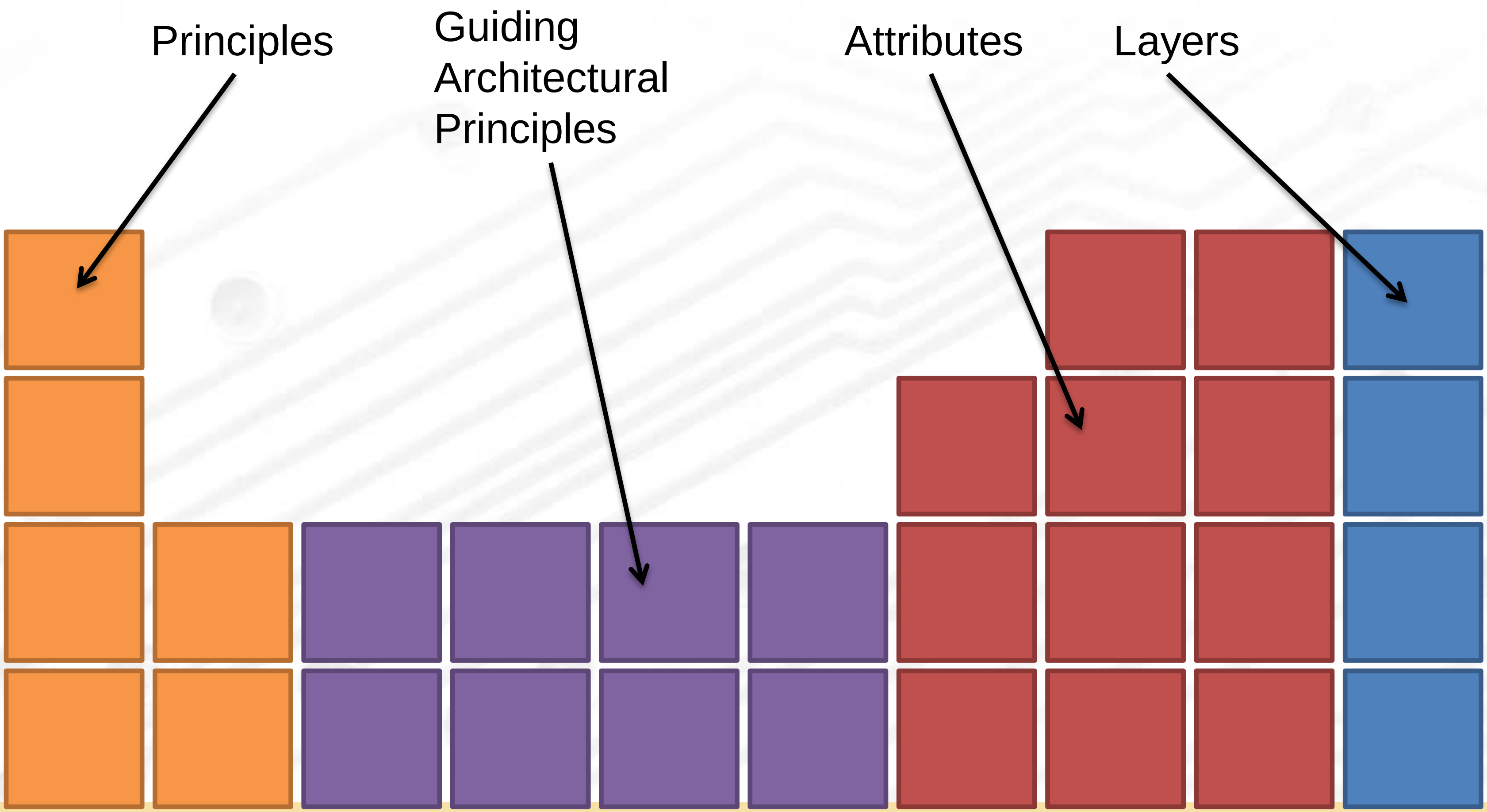
Global Strength, Local Presence

- We design and deliver solutions that integrate smart distribution network technologies with existing business systems.
- Major presence across the Americas, Europe and Australia
- 6,000+ professionals dedicated to the industry
- 68,000 staff globally
- 250+ clients worldwide
- 8 of the 10 largest utilities in both Europe and North America
- Design and build partner for 11 of the 17 central market energy systems in the world today
- Provider of asset, resource and workforce management systems to 60 of the top 100 utilities in North America

Elements of Transactive Energy



The Periodic Table of TE



Principles of TE

6 Principles

Transactive energy systems implement some form of highly coordinated self-optimization

TE systems should maintain system reliability and control while enabling optimal integration of renewable and distributed energy resources

Transactive energy systems should provide for non-discriminatory participation by qualified participants

Transactive energy systems should be observable and auditable at interfaces

Transactive energy systems should be scalable, adaptable, and extensible across a number of devices, participants, and geographic extent

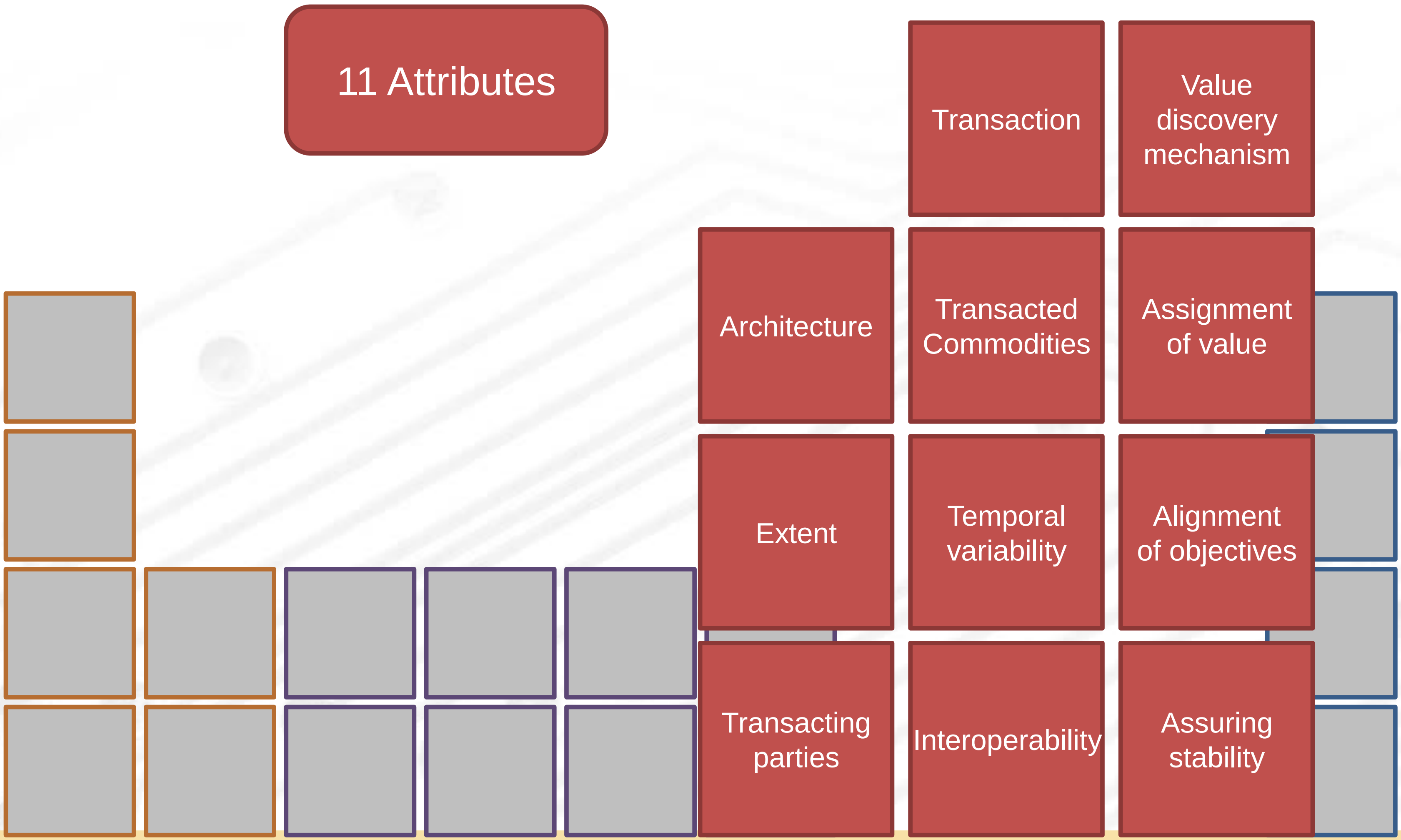
Transacting parties are accountable for standards of performance

Guiding Architectural Principles of TE

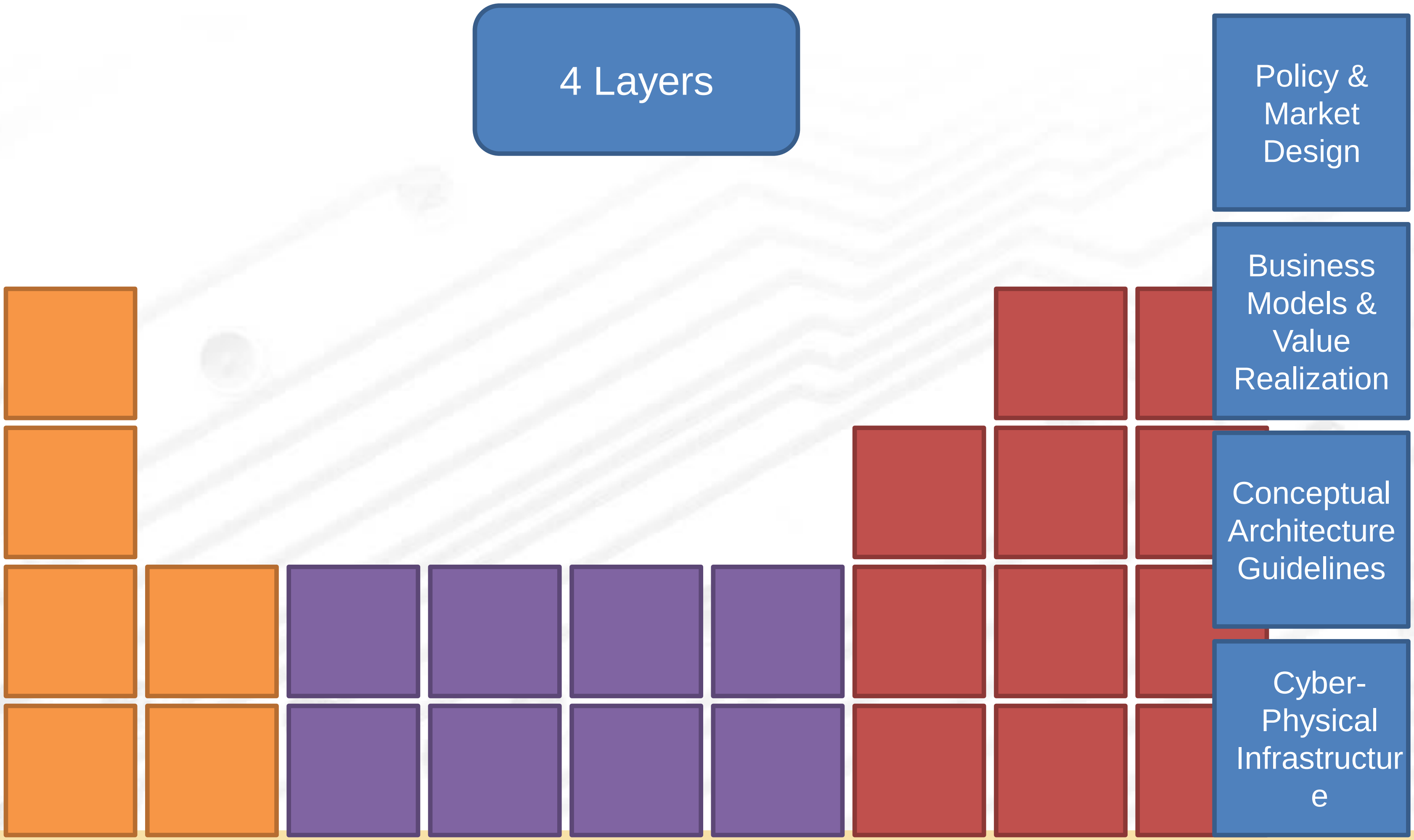
8 Guiding Architectural Principles

Strong consideration should be given to the inherent structure of the energy systems under consideration	Self-similarity or an approximation may be evident in the relevant structures and should be considered as a means to obtain scalability and organizational regularity	Layering for optimization decomposition may be considered as a mathematical foundation for structure of the control and coordination portions of the architecture	The architecture should be agnostic to the general physical layer: specific sensors and controls, energy types, etc., should not be specified nor eliminated by the architecture
The ability of the transactive energy system to operate should not be limited to any specific type of communications network or specific technology	The architecture should accommodate open int'l standards, and must not restrict implementations to proprietary interfaces, algorithms, communication protocols, or application message formats	To the extent possible, the architecture should be adaptable to changes in underlying energy systems, in terms of structure, capabilities, business models, and innovation in value creation and realization	The architecture should include plans for convergence of network types over time: physical networks, information and communication networks, financial networks, and social networks

Attributes of TE



Layers of TE


4 Layers
Policy & Market Design
Business Models & Value Realization
Conceptual Architecture Guidelines
Cyber-Physical Infrastructure

The Elements of Transactive Energy

- Principles
- Guiding Architectural Principles
- Attributes
- Layers

Principles

- During the February 2014 GWAC workshop held at PJM in Philadelphia, the participants agreed on the need for a set of high-level principles that apply to TE systems.
- Such principles are, in effect, statements of high-level requirements for such systems.

GRIDWISE

Guiding Architectural Principles

- GWAC recommends that a Transactive Energy Conceptual Architecture, like any architecture, be based on rigorous foundational principles wherever possible.
- To that end, the Guiding Architectural Principles are suggested as starting points for the architectural foundation.

Attributes

- Attributes represent qualities or characteristics that describe significant dimensions of TE.
- To assist the reader in understanding the boundaries of TE systems and supplement the definition

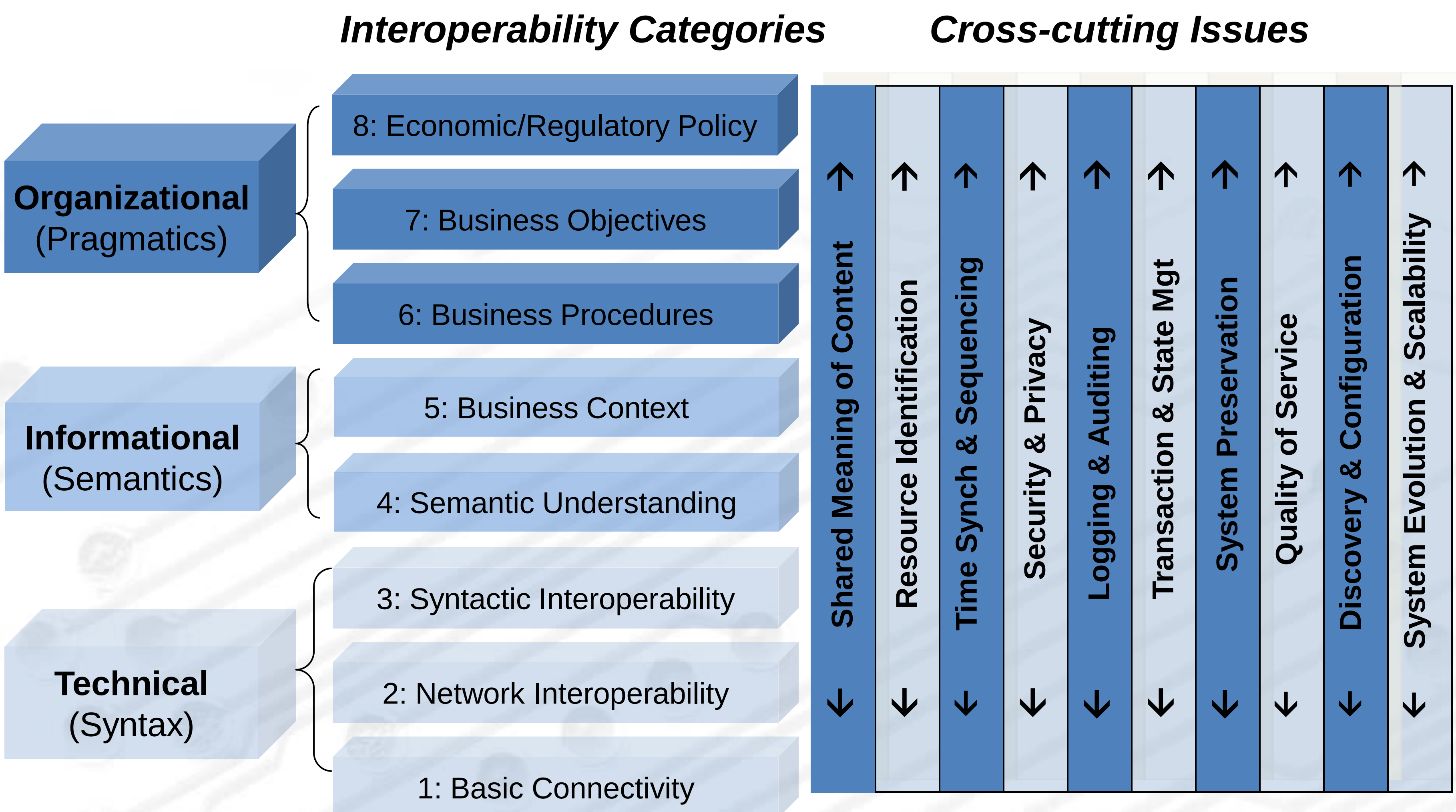
Layers

- The GWAC interoperability context-setting framework ("GWAC Stack") identifies eight interoperability categories relevant to the mission of systems integration and interoperation for electrical end-use, generation, transmission, and distribution.
- The organizational categories (technical, informational, organizational) emphasize the pragmatic aspects of interoperation.
- *Concerns, motivators, challenges*.

Layers

- Layers apply the set of principles described in the “Interoperability Context-setting Framework” (GWAC Stack) to Transactive Energy as a smart grid application taking advantage of the deployment of two-way communications capabilities and intelligent, communicating sensors and devices.

GWAC Stack and X-Cutting Issues



GWAC Stack and X-Cutting Issues

	Interoperability Categories	*Transactive Energy*
Organizational (Pragmatics)	8: Economic/Regulatory Policy	**Policy & Market Designs**
	7: Business Objectives	**Business Models & Value Realization**
	6: Business Procedures	
Informational (Semantics)	5: Business Context	
	4: Semantic Understanding	**Conceptual Architecture**
Technical (Syntax)	3: Syntactic Interoperability	
	2: Network Interoperability	**Cyber-Physical Architecture**
	1: Basic Connectivity	

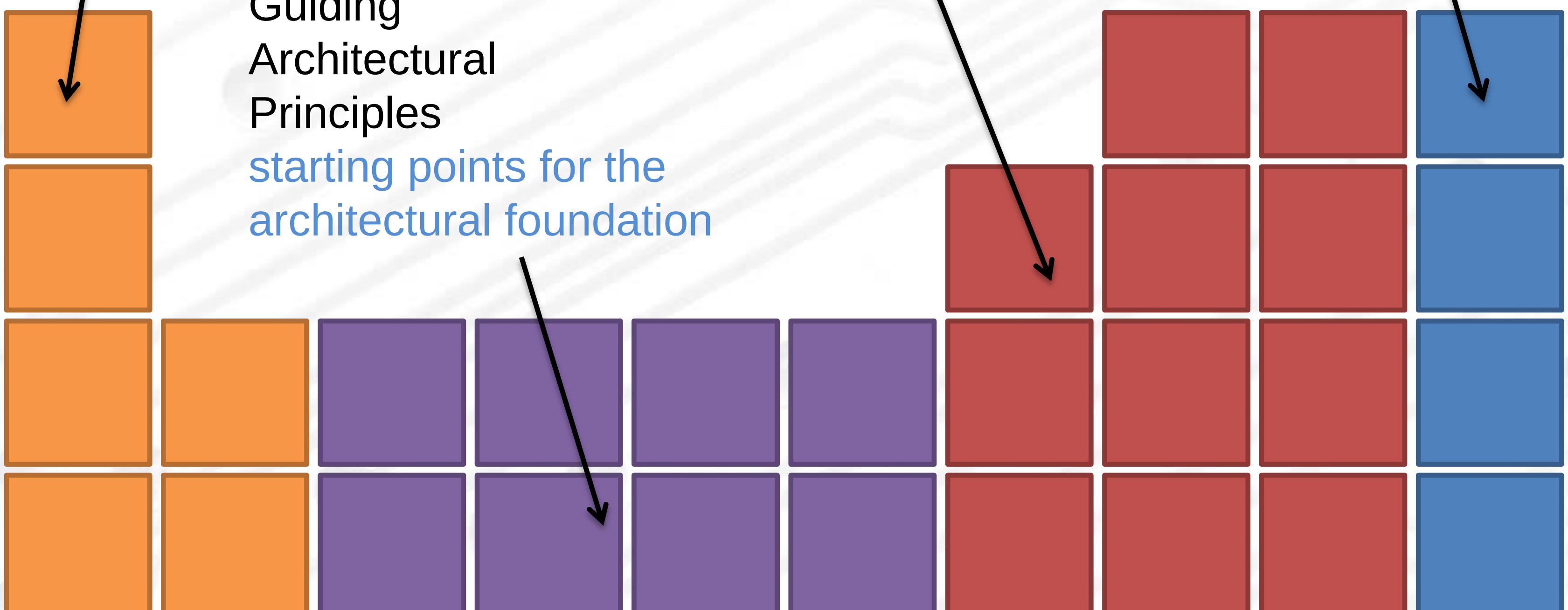
The Periodic Table of TE

Principles
statements of high level requirements

Attributes
qualities or characteristics to help understand the boundaries

Layers
emphasize the pragmatic aspects of interoperation

Guiding Architectural Principles
starting points for the architectural foundation



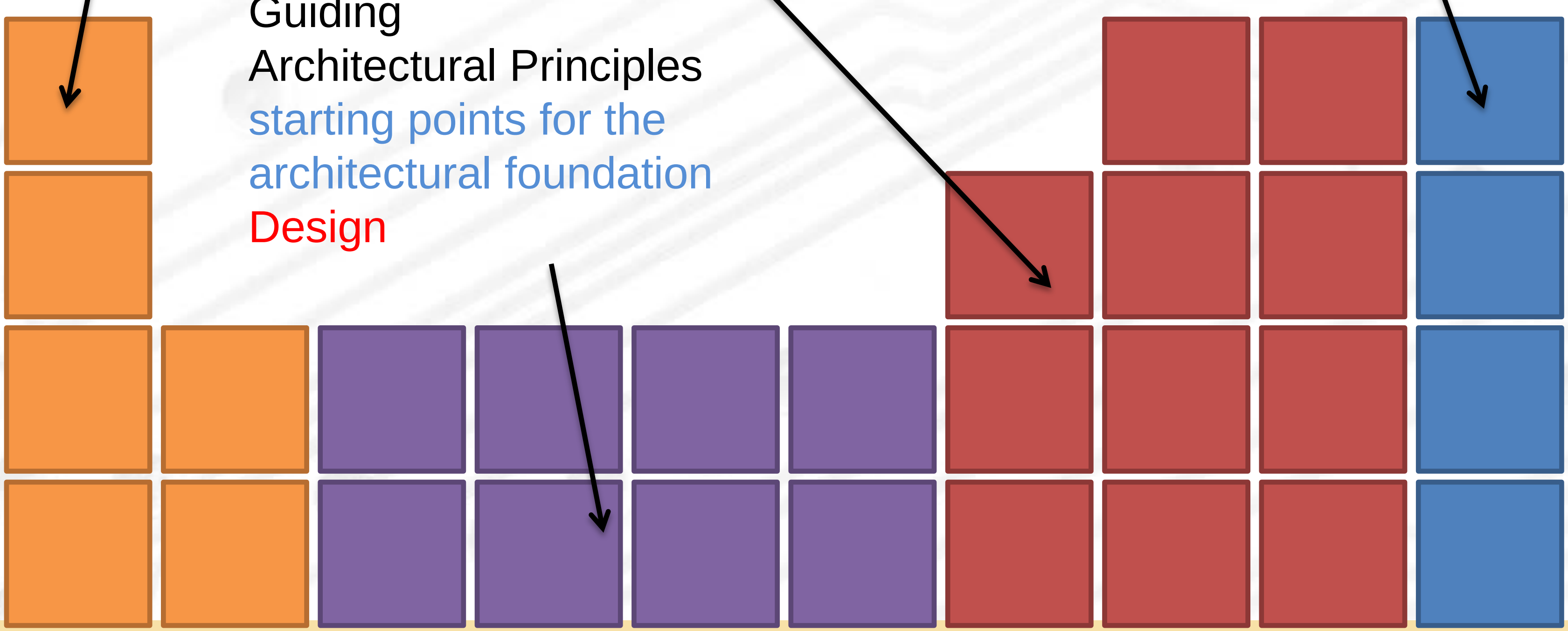
The Periodic Table of TE

Principles
statements of high level requirements
High Level Design

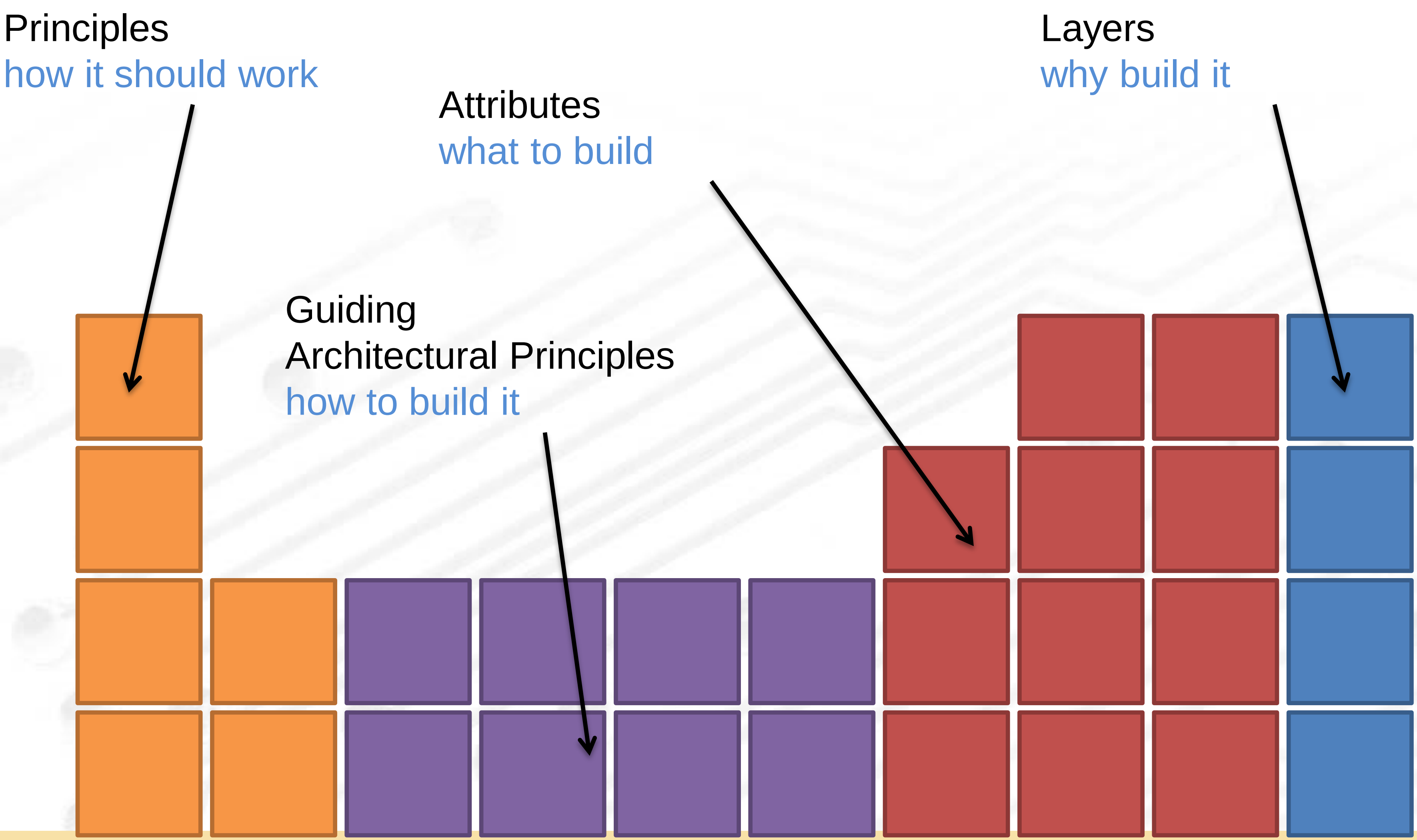
Attributes
qualities or characteristics to help understand the boundaries
Policy / Design

Layers
emphasize the pragmatic aspects of interoperation
Policy

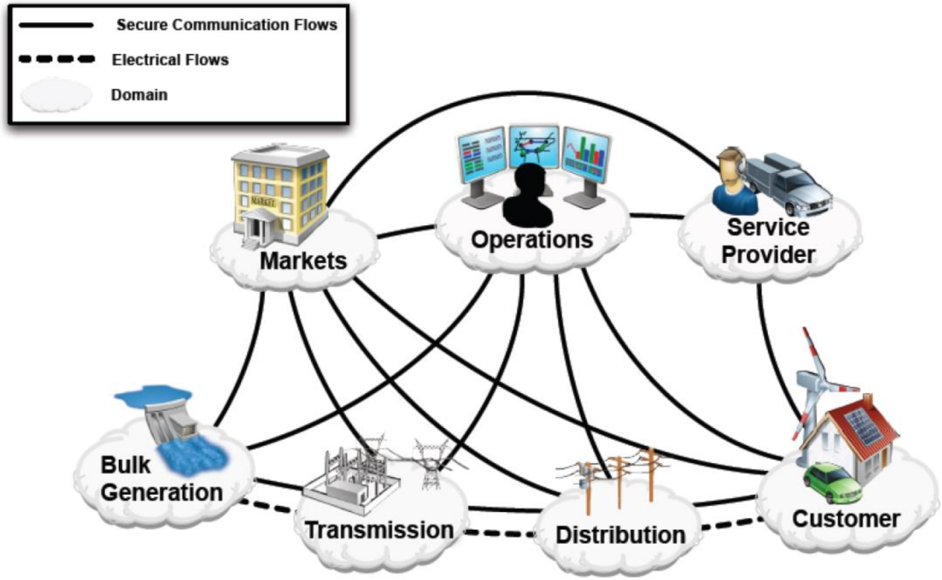
Guiding Architectural Principles
starting points for the architectural foundation
Design



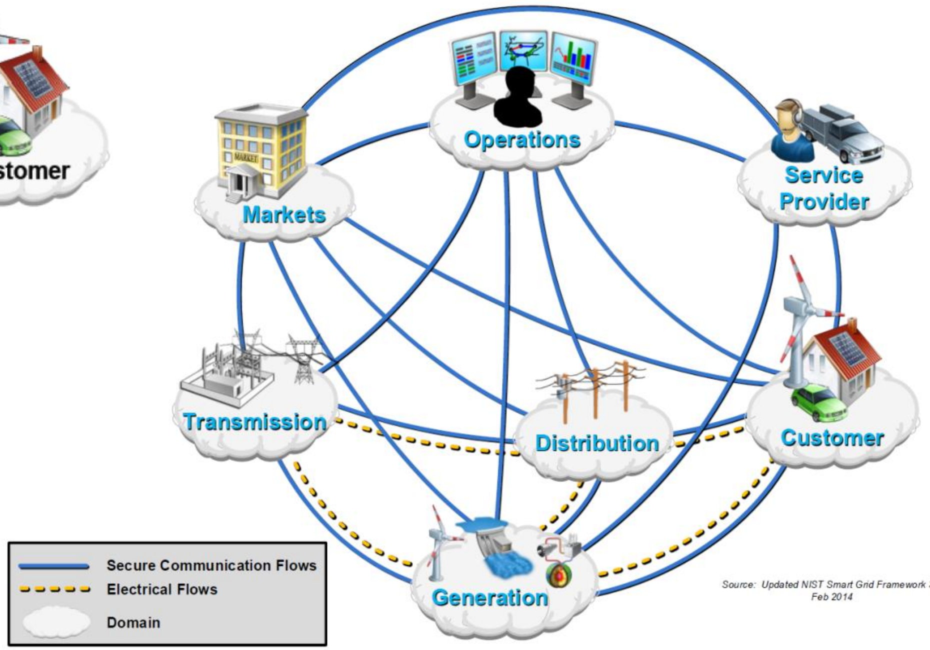
The Periodic Table of TE



The Future is Uncertain



NIST Smart Grid Framework



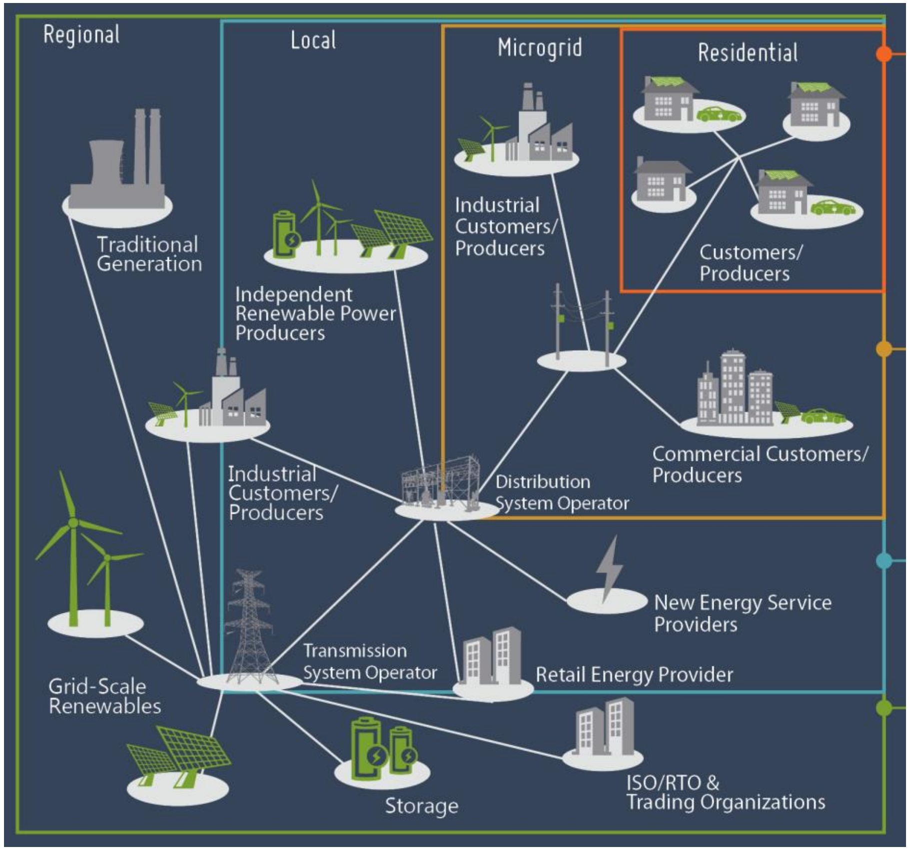
Source: Updated NIST Smart Grid Framework 3.0 Feb 2014

Motivation for Transactive Energy Systems

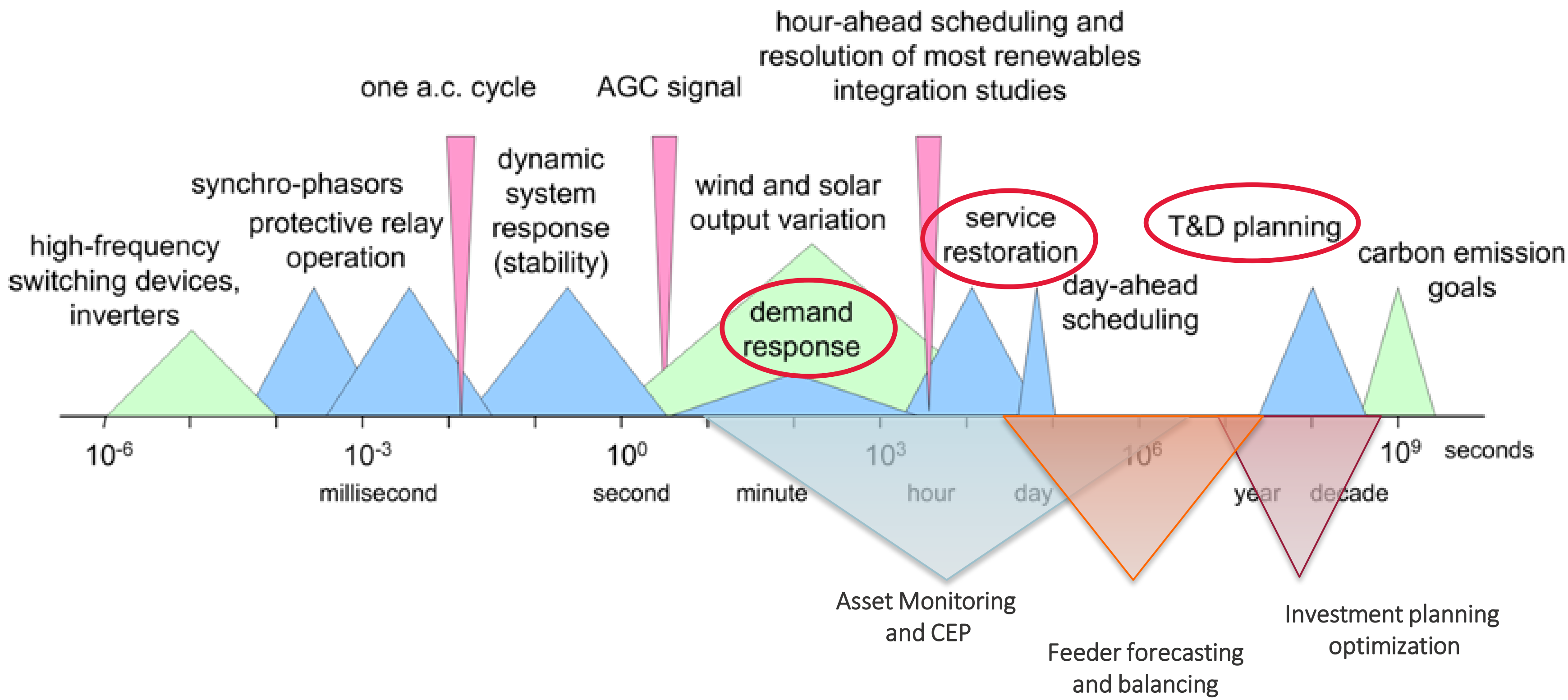
The changing nature of the electric power system:

- Increased penetration of distributed energy resources – Increased variability
- Intelligent devices / internet of things becoming our reality – increased flexibility

TE responds to the need to coordinate variability and flexibility



Time Scales in Electric Grid Operation



Adapted from and reproduced with permission from Dr. Alexandra von Meier, Grid Integration Challenges for Renewable Generation

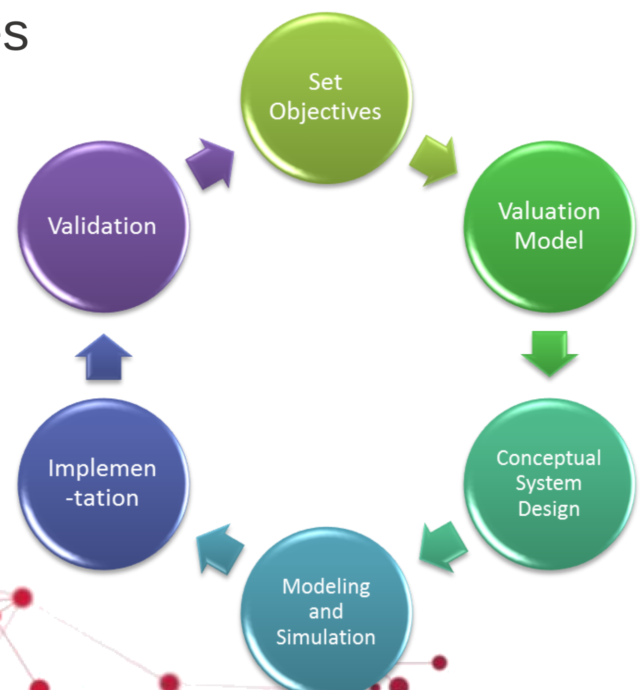
ciee California Institute for Energy and Environment

CGI

TE Decision Maker’s Checklist

A tool to help decision-makers evaluate options such as capital asset investments or new information technology opportunities

A tool that will help reflect and assess the best long-term value for all parties



Addressed to the following key decision makers:

- Regulators that are working on policy decisions
- Utilities that work with customers, ISOs, and partners to develop a value based approach to energy supply
- Service providers that work with customers to provide a consistent value proposition

2016 Transactive Energy Systems Conference (and TE Challenge Summit meeting)

- Portland, Oregon, on **May 17 – 19, 2016** at the World Trade Center.
- The theme for this year's conference will be "Transactive Energy Systems: Harnessing Flexibility in an Evolving Electric Power System"
- Abstracts for papers are being sought to address transactive energy methods and systems in the electric grid, buildings and facilities, and grid integration.

We plan to organize the presentations into three tracks:

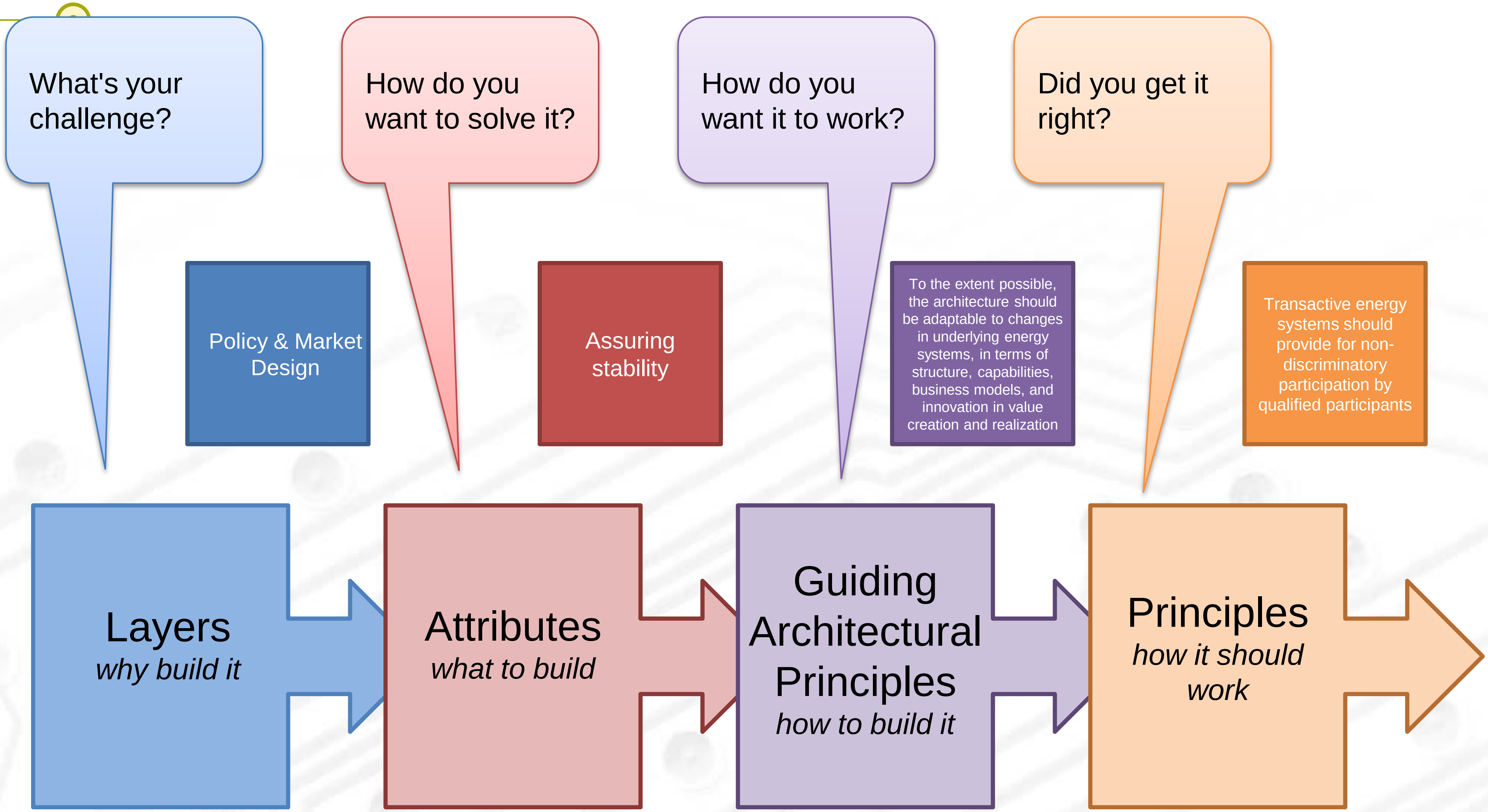
- Regulatory/Environmental/ Governmental
- Utility Perspectives
- Technology

The panel sessions will be followed by facilitated workshop sessions for in-depth discussion of the panel topic and presentations.

There will also be sessions focused on the NIST TE Challenge

http://events.gridwiseac.org/2016/tes/#cfp

CGI


What's your challenge?
How do you want to solve it?
How do you want it to work?
Did you get it right?
Policy & Market Design
Assuring stability
To the extent possible, the architecture should be adaptable to changes in underlying energy systems, in terms of structure, capabilities, business models, and innovation in value creation and realization
Transactive energy systems should provide for non-discriminatory participation by qualified participants
Layers
why build it
Attributes
what to build
Guiding Architectural Principles
how to build it
Principles
how it should work

What is Electricity? – Dave Barry

- Today's scientific question is: ***What in the world is electricity and where does it go after it leaves the toaster?***
- After Franklin came a herd of Electrical Pioneers whose names have become part of our electrical terminology: Myron Volt, Mary Louise Amp, James Watt, Bob Transformer, etc
- The greatest Electrical Pioneer of them all was Thomas Edison, who was a brilliant inventor despite the fact that he had little formal education and lived in New Jersey. Edison's first major invention in 1877 was the phonograph, which could soon be found in thousands of American homes, where it basically sat until 1923, when the record was invented.
- But Edison's greatest achievement came in 1879 when he invented the electric company. Edison's design was a brilliant adaptation of the simple electrical circuit: the electric company sends electricity through a wire to a customer, then immediately gets the electricity back through another wire, then (this is the brilliant part) sends it right back to the customer again.
- This means that an electric company can sell a customer the same batch of electricity thousands of times a day and never get caught, since very few customers take the time to examine their electricity closely. In fact, the last year any new electricity was generated was 1937.