MODERN GRID STRATEGY

Viability and Business Case of Alternative Smart Grid Scenarios

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Agenda

- Modern Grid Strategy perspective
- Considerations for Scenario Valuation
- Key Observations
- Benefit Cost Framework
- Key Alternative Scenarios

MGS PERSPECTIVE

What is the role of the MGS?

- Define a vision for the Modern Grid
- Reach out to stakeholders for input
- Assist in the identification of benefits and barriers
- Facilitate resolution of issues
- Promote testing of integrated suites of technologies
- Communicate and educate stakeholders

MGS is an "Independent Broker" for the Smart Grid

The MGS Team

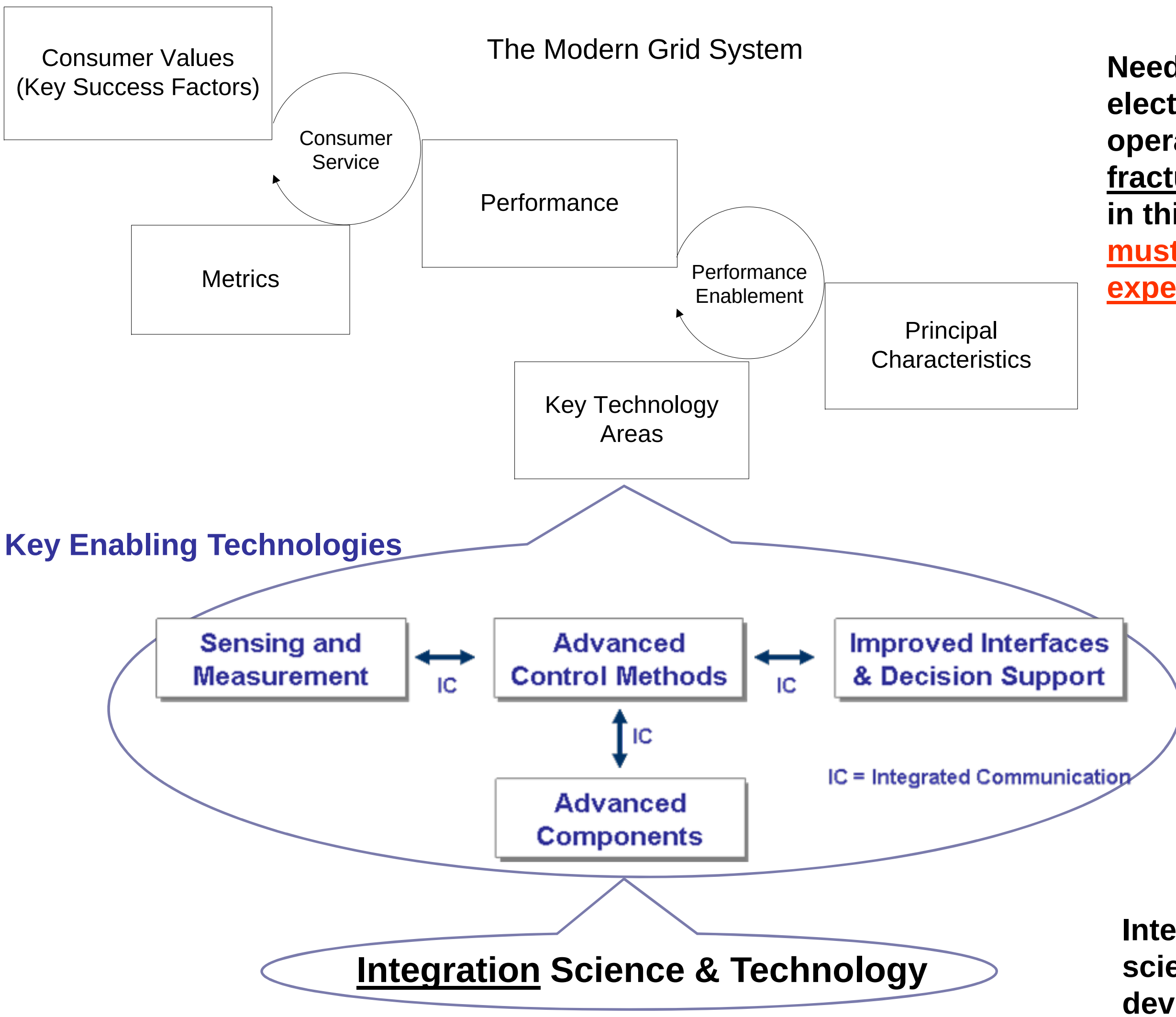
- 25 Industry Professionals with more than 500 yrs of energy experience (National Energy Technology Laboratory, Illinois Power, Progress Energy, AEP, Wisconsin Electric, PJM, Istanbul Electric, TVA, Air Force, DTE Energy, GPU, Duquesne Light, etc) - senior management, engineering, operations, T&D, generation, fuels, R&D, asset management, regulatory, etc.
- Recognized internationally – previous and current work in Asia, North America, Europe, and Middle East
- Active relationships in >100 utilities, 6 RTO/ISO’s, EEI, NARUC, 13 regulatory commissions, >25 industry (public and private) organizations, 10 energy investment organizations, >100 vendors, 6 consumer groups, and 39 “Smart Grid” groups

Principal Characteristics

The Smart Grid is "transactive" and will:

- *Enable* active participation by consumers
- *Accommodate* all generation and storage options
- *Enable* new products, services, and markets
- *Provide* power quality for the digital economy
- *Optimize* asset utilization and operate efficiently
- *Anticipate & respond* to system disturbances (self-heal)
- *Operate* resiliently against attack and natural disaster

The Systems View



Needed leadership in the electricity delivery vision and operating model; <u>industry too fractured</u> to form a consensus in this area; <u>Federal / States must take the lead – industry expects/needs this</u>

Tradition focus is in the technology development arena; this area is mature in assuring technologies streams

Integration – gap in today's science and technology development

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CONSIDERATIONS FOR SCENARIO VALUATION

Value Metrics – Work to date

Reliability

- Outage duration and frequency
- Momentary outages
- Power Quality

Security

- Ratio of distributed generation to total generation
- Consumers participating in energy markets

Economics

- Peak and average energy prices by region
- Transmission congestion costs
- Cost of interruptions and power quality disturbances
- Total cost of delivered energy

Value Metrics – Work to date

Efficient

- System electrical losses
- Peak-to-average load ratio
- Duration congested transmission lines loaded >90%

Environmentally Friendly

- Ratio of renewable generation to total generation
- Emissions per kilowatt-hour delivered

Safety

- Injuries and deaths to workers and public

Smart Grid Workshop in June – Developed “build metrics” for achieving the principal characteristics

Other considerations

- Jobs and the economic downturn
- U.S. dependence on foreign energy sources
- Climate change
- National security
- 50 coal plants canceled / delayed since January 2007
- Impact of electric vehicles

Smart Grid Milestones

Milestone	Description
Consumer Enablement	Empower the customer and enables grid interaction
Advanced Distribution Operations	ADO improves reliability and enables self healing
Advanced Transmission Operations	ATO addresses congestion and integrates with RTO's
Advanced Asset Management	AAM helps utilities reduce costs and operate more efficiently

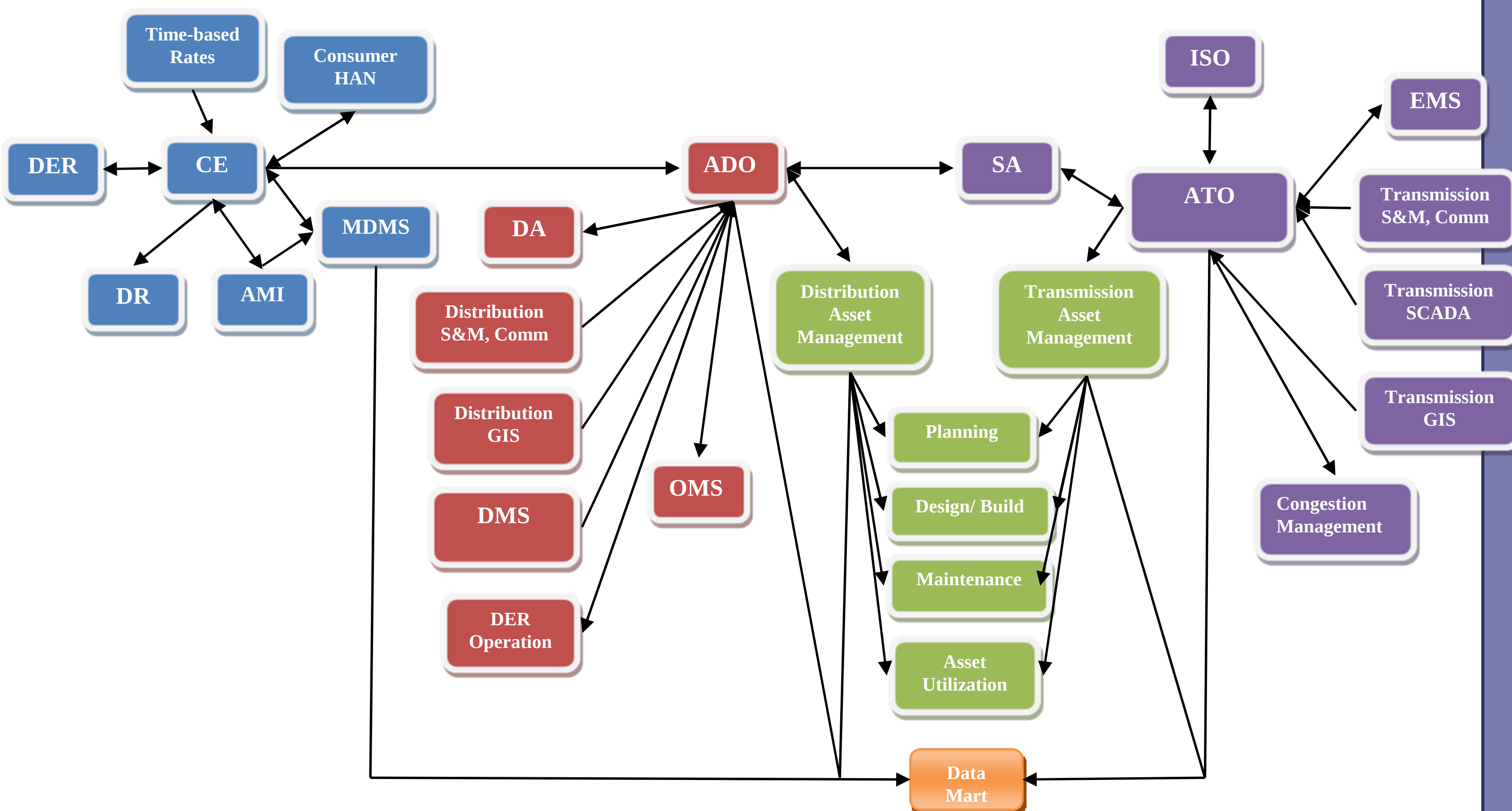
Each Milestone requires the deployment and integration of various technologies and applications

Characteristic – Milestone Map

Smart Grid Characteristic	*CE*	*ADO*	*ATO*	*AAM*
Enables Active Consumer Participation	✓	✓		
Accommodates All Generation & Storage Options	✓	✓	✓	
Enables New Products, Services, and Markets	✓	✓	✓	
Provides PQ for Digital Economy	✓	✓	✓	✓
Optimizes Assets & Operates Efficiently	✓	✓	✓	✓
Anticipates and Responds to System Disturbances	✓	✓	✓	✓
Operates Resiliently Against Attack and Natural Disaster	✓	✓	✓	

The "Big Picture"

MODERN GRID STRATEGY



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Lessons from 5 Smart Grid strategy projects

KEY OBSERVATIONS

Key Concepts for the Smart Grid

- Prepare controls, interfaces, and transactions to engage consumers
- Prepare distribution for two-way power flow
- Prepare transmission to see distribution as a generation and storage resource
- Prepare utilities for a different business model in the future
- Prepare the regulatory environment to incentivize transformation
- Take serious and immediate action to reduce the peak to average capacity ratio

Solutions / Applications

Applications	AMI	DR	DER	NMS	IT	Comm
Project			DG Storage	SA, DA, DMS, DA, SCADA	AAM, OMS, DS	
TVA	✓		✓	✓	✓	✓
SD SGS	✸	✸	✓	✓		✓
PSE	✸	✓	✓	✓		✓
SDG&E	✸	✸	✓	✓	✓	✸
West Virginia	✓	✓	✓	✓	✓	✓

✸ Assumed as a prerequisite because it already existed or was part of a previously funded program.

Denmark			✓	✓	✓	✓

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Penetration Variables

- Renewables park(s)
- Distributed renewables
- Distributed generation
- Communication
- Demand response
- Distribution automation
- Substation automation / SCADA
- Storage (utility-scale and distributed)

A Smart Grid ≠ 100% penetration of technologies

U.S. Renewables Potential

- **Today's grid-connected electric capacity is 960 GW**
- **Today's average daily capacity used is 440 GW**
- **If we include reserve margin, the U.S. needs a daily average of 530 GW**

- **NREL assessment of near-term practical potential by 2020 for electricity production:**
  - Biomass – 130 GW
  - Geothermal – 22 GW
  - Solar – 68 GW
  - Wind – 114 GW
- **Total = 334 GW**

Beneficiaries

- **Utility (Operational)**
  - Benefits of improved operational efficiencies
  - Often reflected back to the consumers through rate adjustments
- **Consumers**
  - Benefits directly felt by consumers
- **In-area Society**
  - Benefits felt by the local (utility area) society
- **Out-of-area Society (regional US)**
  - Benefits felt by the region outside of the local society

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Costs and Benefits per EPRI

Cost to Modernize

- **$165B over 20 years**
  - $127B for Distribution
  - $38B for Transmission
- **~$8.3B per year (incremental to business-as-usual)**
- **Current annual investment - $18B**

Benefit of Modernization

- **$638B - $802B over 20 years**
- **Overall benefit to cost ratio is 4:1 to 5:1**

(Source: EPRI, 2004)

Thus, based on the underlying assumptions, this comparison shows that the benefits of the envisioned Future Power Delivery System significantly outweigh the costs. (EPRI, 2004)

Business Case Results (Collective)

- **Database (range per M consumers; 20 yrs)**
  - CAPEX: $0.4 to $2B
  - Operational Benefits: $0.5B to $1B
  - Consumer Benefits: $0.5B to $5B
  - Societal Benefits: $0.5B to $2.3B
- **Extrapolating to the Nation (~ 110M consumers)**
  - CAPEX: $45B to $220B
  - Operational Benefits: $55B to $110B
  - Consumer Benefits: $55B to $550B
  - Societal Benefits: $55B to $253B
- **Compares favorably with EPRI 2004 estimates**

BENEFIT COST FRAMEWORK

Extended Gap Analysis Process

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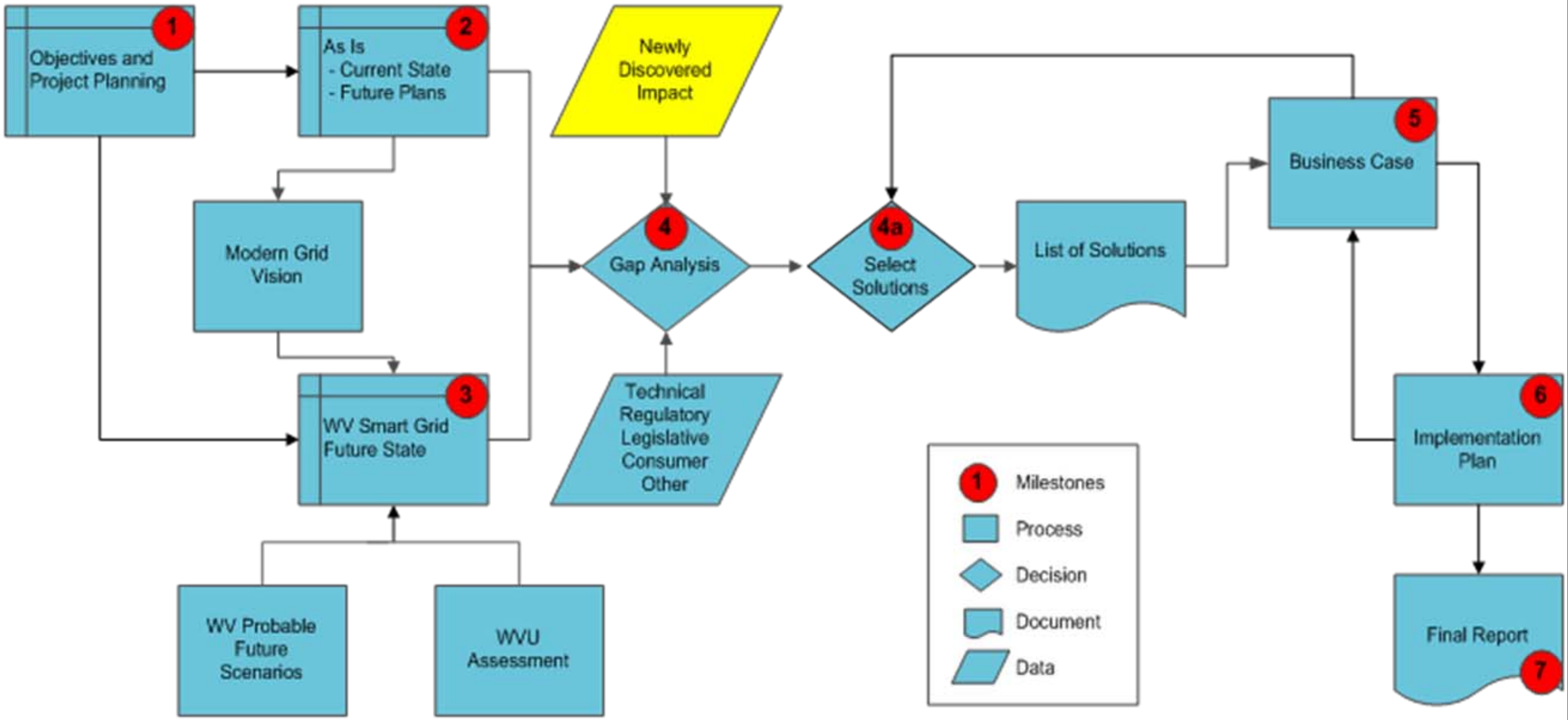

Generates a Smart Grid vision, high-level business case, and high-level implementation plan

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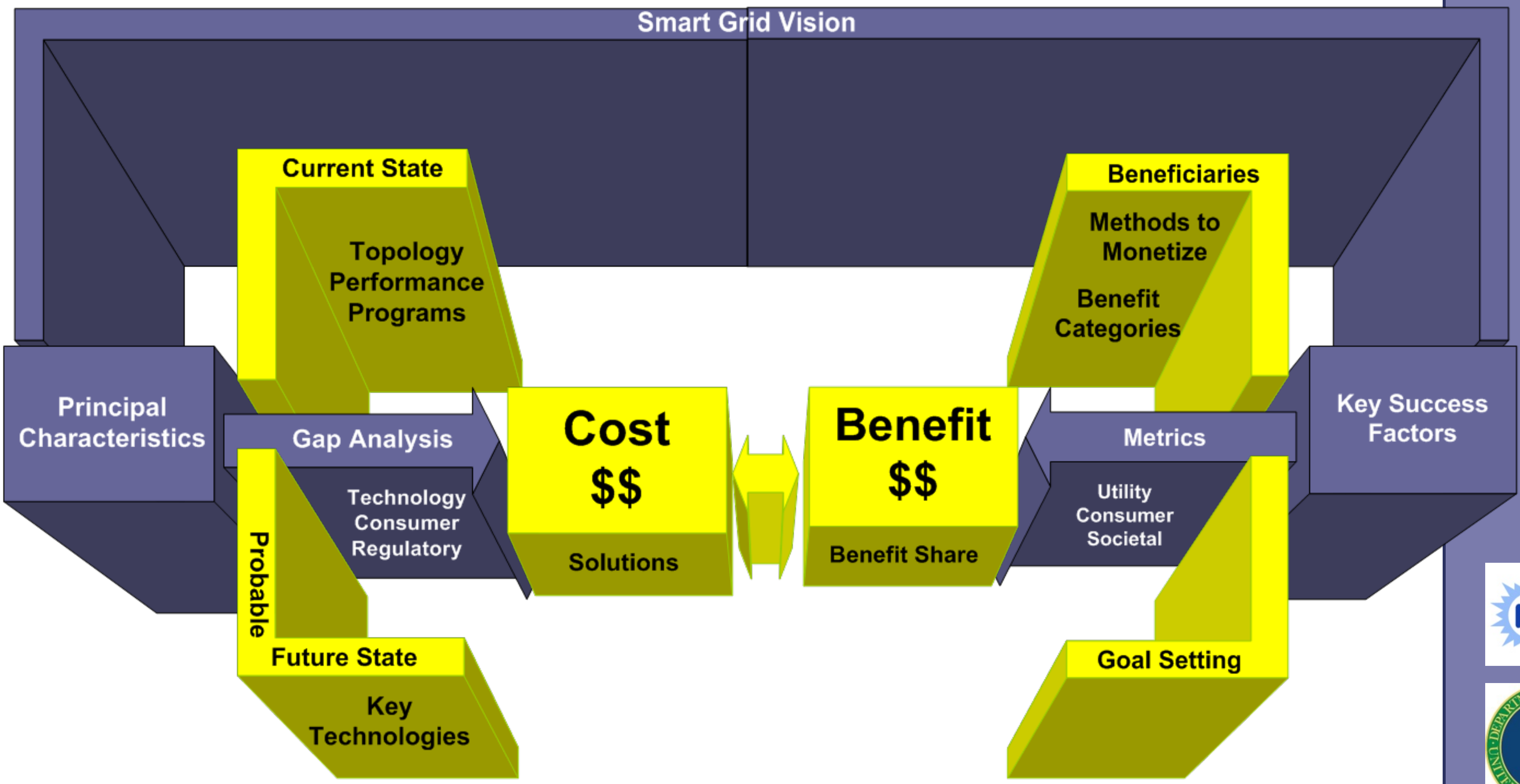
Business Case Framework



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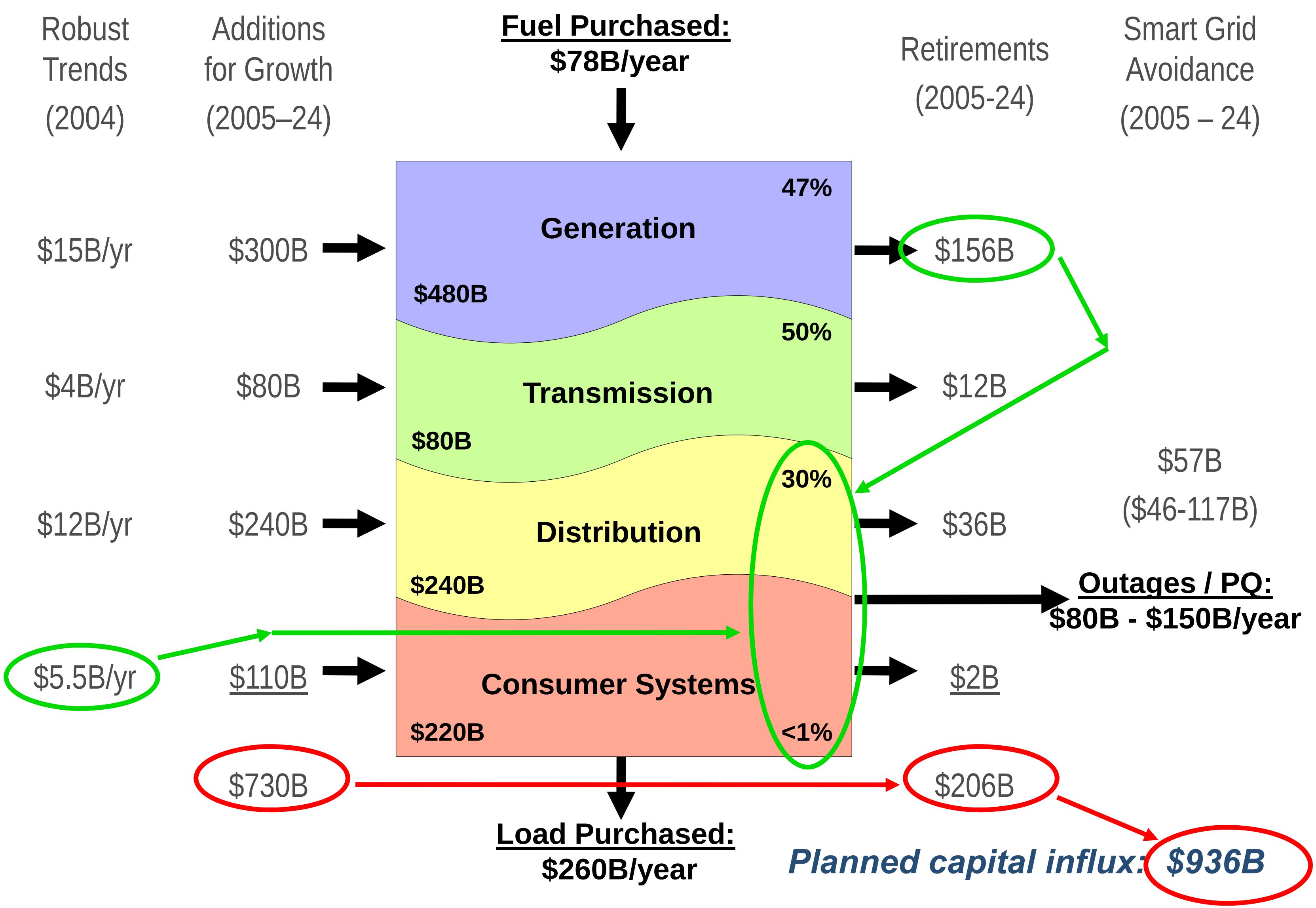
The Financial Electric System



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Over the next 20 years, if we just:

- **Use the $156B for planned retirements (because we have existing capacity) + the $5.5B/yr consumers will spend to invest in the Smart Grid, we can avoid the traditional ~$1 Trillion our industry already plans to spend**
- **Build the Smart Grid, we will raise distribution asset use above 40% and consumer system use above 10% offsetting the need to build new baseload generation and transmission for >20 yrs.**
- **Build the Smart Grid, we will enable renewables to reduce the U.S. carbon footprint by 20%.**

KEY ALTERNATIVE SCENARIOS

Scenarios – Reasons

- **Reliability driven**
  - SAIDI, SAIFI issues
  - +6% delta over Business As Usual capital plans
- **Renewables penetration driven**
  - State RPS
  - -20% delta below Business As Usual capital plans
- **Cost hedge for future (not yet)**
  - Denmark example

Contact Information

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For additional information, contact

Modern Grid Strategy Team

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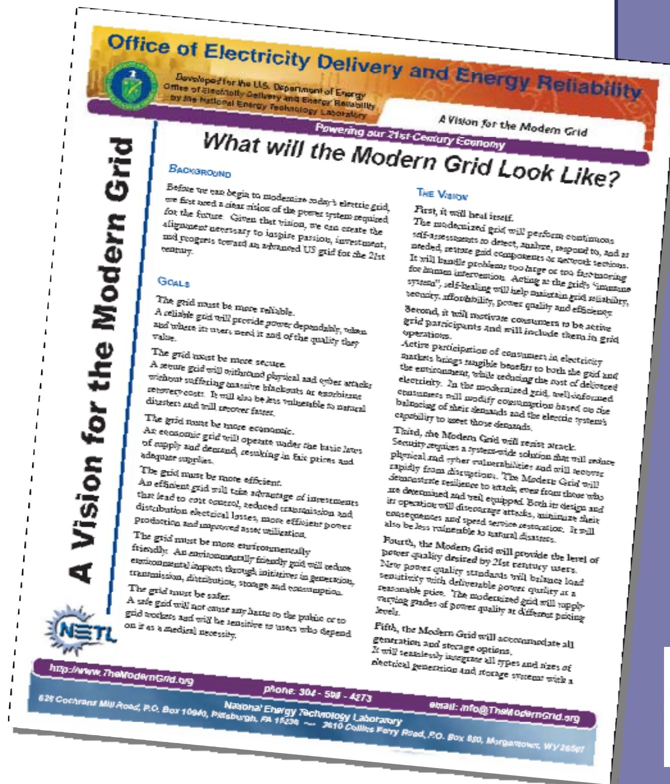

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A Vision for the Modern Grid

Powering our 21st-Century Economy

A Vision for the Modern Grid

What will the Modern Grid Look Like?

Background

Before we can begin to modernize today's electric grid, we first need a clear vision of the power system required for the future. Given that vision, we can create the alignment necessary to inspire passion, investment, and progress toward an advanced US grid for the 21st century.

Goals

The grid must be more reliable.
A reliable grid will provide power dependably, when and where its users need it and of the quality they value.

The grid must be more secure.
A secure grid will withstand physical and cyber attacks without suffering massive blackouts or exorbitant recovery costs. It will also be less vulnerable to natural disasters and will recover faster.

The grid must be more economic.
An economic grid will operate under the basic laws of supply and demand, resulting in fair prices and adequate supplies.

The grid must be more efficient.
An efficient grid will take advantage of investments that lead to cost control, reduced transmission and distribution electrical losses, more efficient power production and improved asset utilization.

The grid must be more environmentally friendly. An environmentally friendly grid will reduce environmental impacts through initiatives in generation, transmission, distribution, storage and consumption.

The grid must be safer.
A safe grid will not cause any harm to the public or to grid workers and will be sensitive to users who depend on it as a medical necessity.

The Vision

First, it will heal itself.
The modernized grid will perform continuous self-assessments to detect, analyze, respond to, and as needed, restore grid components or network sections. It will handle problems too large or too fast-moving for human intervention. Acting as the grid's "immune system", self-healing will help maintain grid reliability, security, affordability, power quality and efficiency.

Second, it will motivate consumers to be active grid participants and will include them in grid operations.
Active participation of consumers in electricity markets brings tangible benefits to both the grid and the environment, while reducing the cost of delivered electricity. In the modernized grid, well-informed consumers will modify consumption based on the balancing of their demands and the electric system's capability to meet those demands.

Third, the Modern Grid will resist attack.
Security requires a system-wide solution that will reduce physical and cyber vulnerabilities and will recover rapidly from disruptions. The Modern Grid will demonstrate resilience to attack, even from those who are determined and well equipped. Both its design and its operation will discourage attacks, minimize their consequences and speed service restoration. It will also be less vulnerable to natural disasters.

Fourth, the Modern Grid will provide the level of power quality desired by 21st century users.
New power quality standards will balance load sensitivity with deliverable power quality at a reasonable price. The modernized grid will supply varying grades of power quality at different pricing levels.

Fifth, the Modern Grid will accommodate all generation and storage options.
It will seamlessly integrate all types and sizes of electrical generation and storage systems with a

NETL

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