Agenda for October 13, 2020
Session 1. Part 1. Energy Master Planning and Resilience Analysis

- Community Energy Plans as a Part of the Master Plans, Scope, and Boundaries of Energy Master Plan. Dr. Alexander Zhivov, ERDC CERL
- Establishing Energy Requirements, Goals, and Constraints - Mr. Terry Sharp, ORNL
- Panel Discussion: Mission Critical Facilities
- *Moderator:* Dr. Alexander Zhivov, Senior Research Engineer, ERDC CERL
    - *Threat and Hazard Analysis*: Dr. Arun Veeramany, PNNL
    - *Mission-Related Power Requirements*: Mr. Todd Traver, Uptime Institute
    - *Building-Level Power System Configurations:* Mr. Adam Ledwell, Schneider Electric
- Panel Discussion: Defining, Measuring, and Assigning Resilience Requirements
    - *Moderator:* Dr. Alexander Zhivov, ERDC CERL
    - Mr. Andrew Stringer, USACE Power Reliability Enhancement Program
    - Mr. John Benefiel, Chief - Protective Design–Mandatory Center of Expertise, USACE

ESTCP

EBC

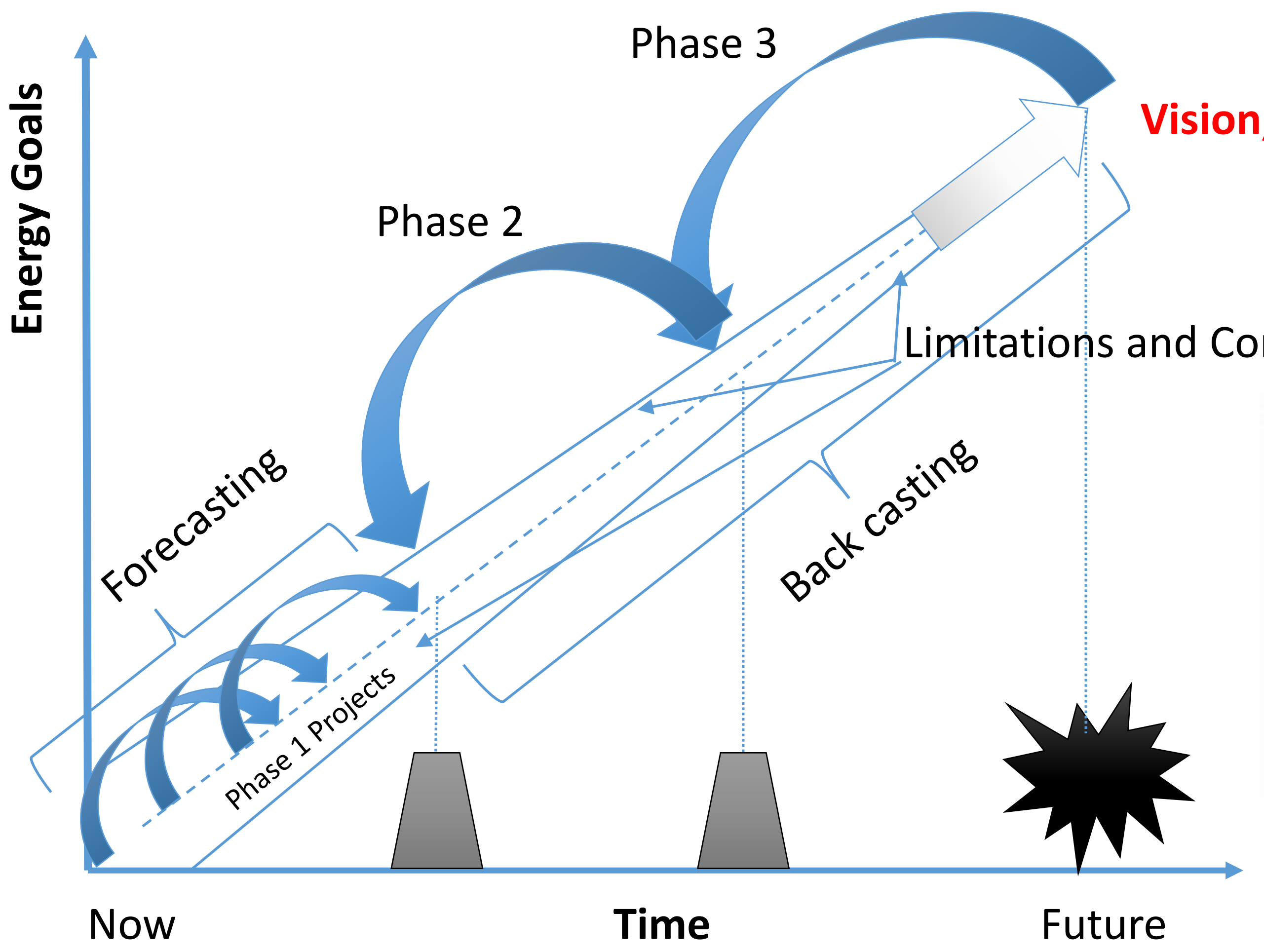
Energy in Buildings and Communities Programme

Community Energy Plans as a Part of the Master Plans, Scope, and Boundaries of Energy Master Plan

Virtual training workshop

October 13, 2020

Energy Master Planning = Establishing a Roadmap



From **A** to **B**

Concept

- The objective of the community/installation Energy Plan is to produce a **holistic roadmap** that enables to work constructively towards **various framing energy goals** within **defined community boundaries** and **specific constraints**
- Energy master planning is a complex process that includes cultural, organizational, technical, legal, and financial aspects. We will be focusing primarily on **technical and financial aspects** of this process.
- The process of building efficient, sustainable, and resilient communities requires careful coordination between several stakeholders, including **master planners**, **energy planners**, **building owners/tenants** and **building designers.**
- Three levels of stakeholders can readily be identified**.**
  - **Highest level**: master planners think in terms of long-term sustainability goals, including community layout, transportation, and street design. To address sustainability, master planners have to extend the length of their view to 25 or more years.
  - **Middle tier**: Energy managers focus may vary between longer-term energy infrastructure projects, such as district energy systems, to medium- or near-term projects, such as building retrofits designed to meet community energy goals.
  - **Detailed level**: The building (or infrastructure) designer must create designs for a specific project that can be shown to be effective, buildable, biddable, and cost effective.

Scope of Energy Master Plan

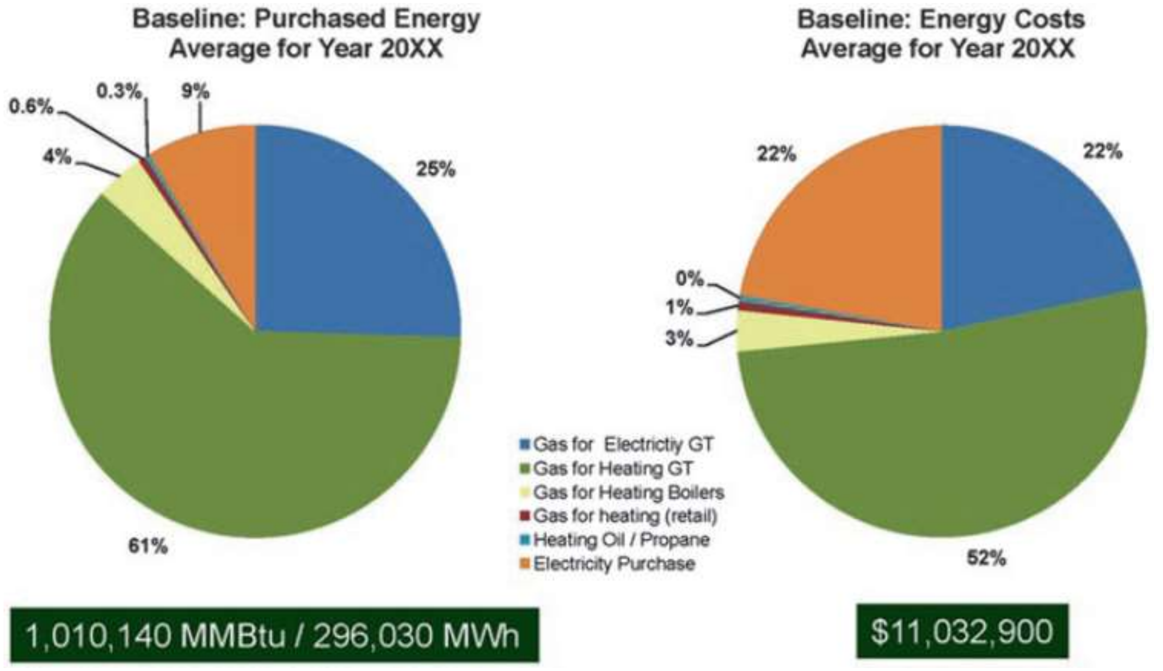
- The scope of energy master planning effort can include residential, commercial, and public buildings; community-based infrastructure; industrial energy users; community-owned and transit transportation and other energy-consuming users; or any combination of those. Also, it can be limited to include only mission-critical facilities. When defining the scope, it is important to understand the energy users that the community can control.
- A community can have fixed boundaries defined either by physical limitations (e.g., an island-based community) or political or administrative boundaries. For example, a military installation or university campus may be a contiguous area or may be comprised of separate areas

Selected Terminology

- Baseline
- Base Case
- Alternatives
- Resilience
- Blue-sky scenario
- Black-sky scenario

Baseline

The baseline is defined as the current energy consumption profile (site and source), energy cost profile and associated greenhouse gas (GHG) emissions. It is essential that the baseline capture the quantity and type of energy used (transformed) by the community/installation



Example of energy use and cost for a nominal community

Total Community-wide Energy Use

The total energy use in the community can be grouped by different users, losses in generation, conversion, and transmission using the following categories:

End uses

- a. Building Functions
- b. Industrial Processes
- c. Central Services – Compressed Air/Water/Sewer

Distribution losses

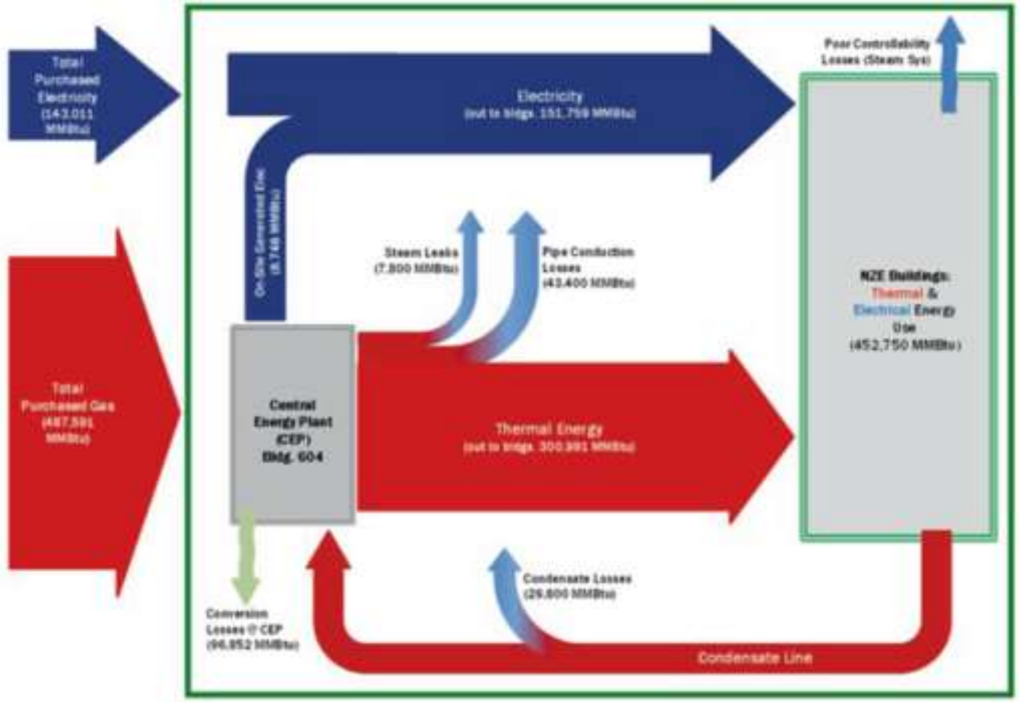
- d. Hot water, chilled water, and steam network
- e. Onsite electrical

Onsite Conversion Losses

- f. Turbines
- g. Boilers
- h. Engines

Offsite Conversion and Distribution Losses

- i. Purchased natural gas
- j. Purchased electricity.



Schematic of baseline energy uses and wastes for a campus areas

Base Case

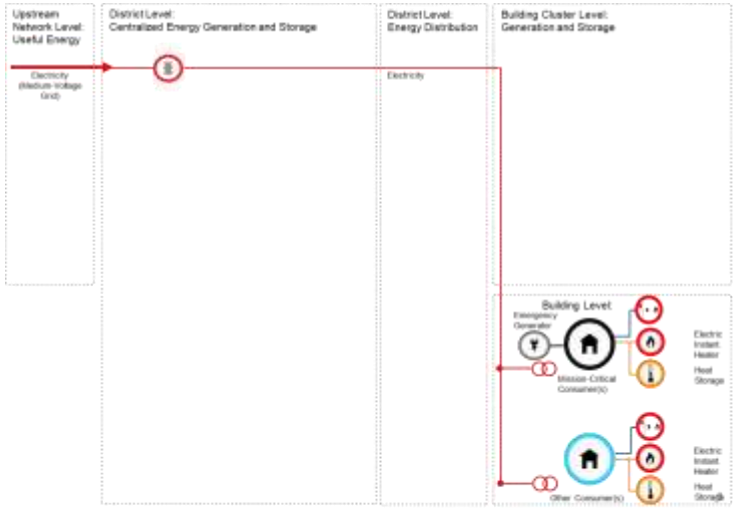
- The baseline data can be used to project a base case scenario for energy use given the availability of information on an increase or decrease of energy use due to: new construction; consolidation and demolishing processes; building repurposing and change of mission or new requirements to thermal comfort and indoor air quality; use of new and existing utility contracts; and the dates when known contracts will expire.
- The base case is defined as a future “business as usual” alternative that includes all existing and already planned facilities. Facilities marked for demolition in the baseline are not included. The baseline models of buildings and energy systems shall be adjusted to reflect all planned modifications. The base case shall include the data on site and primary energy use and energy cost with categories similar to ones used for the baseline. It is important to present the data showing the cost of implementation of the base case as well as changes in site, and source energy use, energy cost, and GHG compared to the baseline.
- During this step, team compares the base case analysis results against the installation’s vision and goals. The analysis should assess implementation costs and quantify gaps for energy systems including their resilience against community framing goals. The base case will serve as a benchmark for life cycle cost analysis (LCCA) of alternative systems.

Establishing energy system alternatives

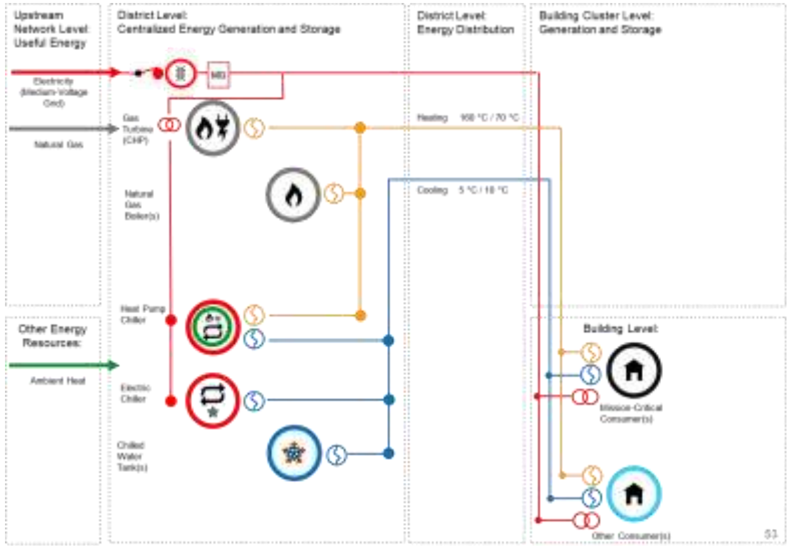
- Once the baseline and base case have been established, energy planners can start exploring options or alternatives. A handful of alternatives shall be selected that will be analyzed in depth. Electric and thermal energy systems consist of four major elements: energy generation, energy distribution, energy storage, and energy demand. The goal is to find the optimum balance of these elements for the entire energy system, where each element is considered in the calculation of the amount of energy delivered and lost, in various forms, by the energy systems as well as its impact on energy system resilience.
- Alternatives can explore different levels and scopes of building stock renovation and energy supply strategies
- Supply strategies can include, but not be limited to, decentralized energy supply, steam to hot water district systems conversion, energy supply using only renewable energy sources, short-term and seasonal thermal energy storages, batteries, etc.
- For each alternative, it is important to present the data showing the cost of its implementation as well as changes in site, and source energy use, energy cost, GHG compared to the baseline and the base case as well as systems' energy resilience compared to the base case.

Examples of Thermal System Architectures

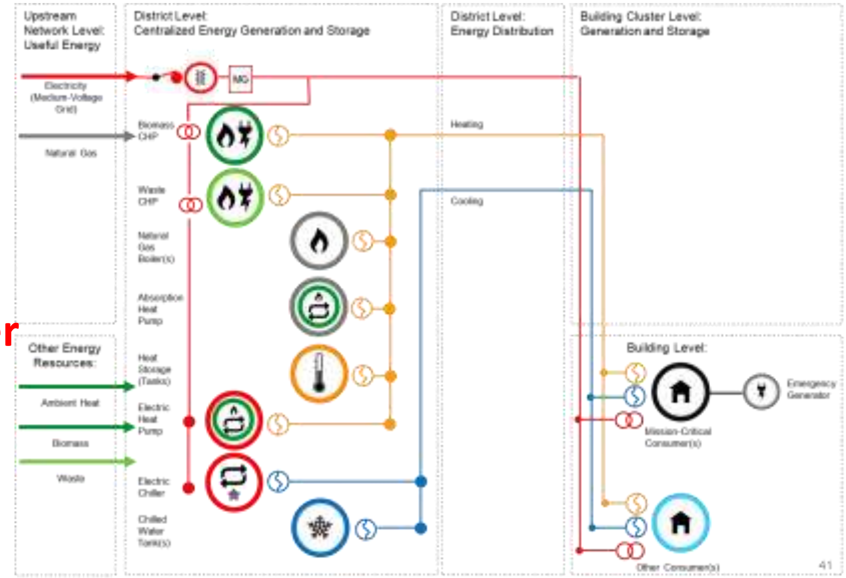
Example of generic power only system with buildings heating and cooling using electric boilers and chillers



Example of District heating, cooling and power systems (Case Study from UT Austin Medical Center)

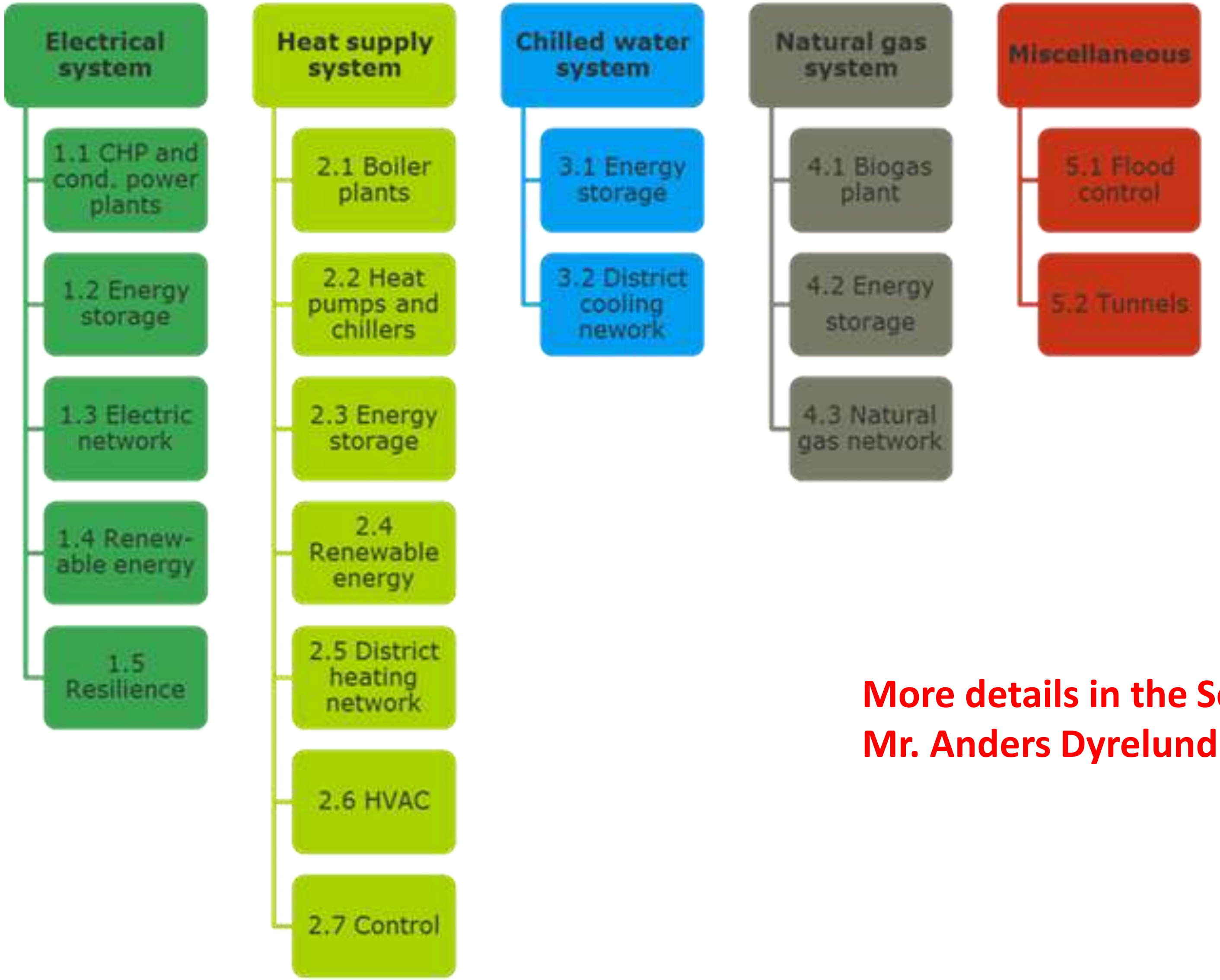


Example of generic power, heating and cooling systems with CHP base load generation seasonal storage, waste heat use, etc..



More details in the Session 2 presentations on October 14 by Ms. Susanne Osche and Mr. Ben Schenkman

Structure of Technology Database



More details in the Session 2 presentation on October 14 by Mr. Anders Dyrelund

Resilience

- A resilient energy system is one that can prepare for and adapt to changing conditions, and recover rapidly from disruptions, e.g., deliberate attacks, accidents, and naturally occurring threats.
- Resilience of the energy system impacts the primary functionality of military installations, hospitals, and education campuses during disruptions. Major disruptions of energy supply (both electrical and thermal) have degraded critical capabilities and caused significant social and economic impacts to private and public communities
- Concepts of resilience and reliability of energy systems are often confused. Reliability-focused planning limits itself to high-probability events with relatively low consequences. For the resilience focused planning, in addition to the information on statistical system element failure, system reliability should be adjusted for expected low probability, high consequence threats and hazards expected for the locality of interest, which are called Design Basis Threats.
- Definition of resilience and its metrics which can be used in resilience-inclusive EMP process will be discussed later today during session 1.5.

Blue-sky Vs Black-sky System Operation

- Blue sky system operation is operation under normal conditions, when system reliability is solely a function of the inherent design characteristics of the system.
- Black Sky system operation is operation under any man-made or natural events, that disrupt the normal functioning of the system for extended periods of time. This can include mega earthquakes, cyber terrorism, and high-altitude electromagnetic pulse.

Energy Related Framing Goals and Constraints

- **Used in comparison of alternatives:**
  - Energy use (site and primary)
  - System resilience (Energy availability and Maximum down time)
  - Use of Renewables
  - Environmental impact
  - System economics
  - Power from the grid available (may be limited by existing commercial equipment, power lines, contract)
  - Gas from the grid available (may be limited by existing gas line cross-section, contract, etc.)

Will be discussed later in the next presentation by Mr Terry Sharp

- **Used for system architectures and technology database down selection:**
  - Connected to outside community or not (remote or island locations) (minimizes categories of system architectures)
  - Exiting or potential energy supply from outside the community boundaries (minimizes categories of system architectures): Power, hot water, steam, chilled water
  - Fuel available: Gas, coal, fuel oil, biomass, biogas
  - Renewable energy sources available: solar thermal, solar PV, geothermal, sea/river water cooling, geothermal,
  - Current energy systems on the campus: centralized or decentralized (no distribution lines available)
  - Future energy systems which can be considered (centralized or decentralized)
  - Operational and personnel constraints (operators don’t have skills to operate certain types of systems)
  - Environmental constraints for using different types of technologies: e.g., water, emissions from CHP, …
  - Building space constraints (no mechanical room for decentralized systems, thermal storage, etc..)
  - Community space constraints (e.g., for seasonal storage, PV or thermal solar panels array,….)
  - Community layout constraints (e.g., for placing central heating or cooling systems’ pipes

Data Required for Energy Master Planning and Resilience Analysis

- General information
- Campus and building level information
- Information on building archetypes and topology
- HVAC systems
- Energy generation systems
- Existing distribution systems
- Basic fuel availability and potentials
- Possible synergies
- Information required for unique building modeling
- Information required for resilience analysis

Campus and Building Information

- Map and boundaries of the area under consideration preferably in digital format
- Which exiting buildings will be demolished and which will be built?
- Which buildings are planned to be retrofitted under a sustainment, restoration, and modernization program and what are current scopes of these projects?
- GIS Data for the site
- Real Property Inventory data with detailed characteristics for each building
- List of planned facilities’ electrical distribution systems (GIS and single line drawings)
- Hot water/steam, cold water, potable water distribution system
- Storm drainage and wastewater (sewer) system
- Natural gas distribution system

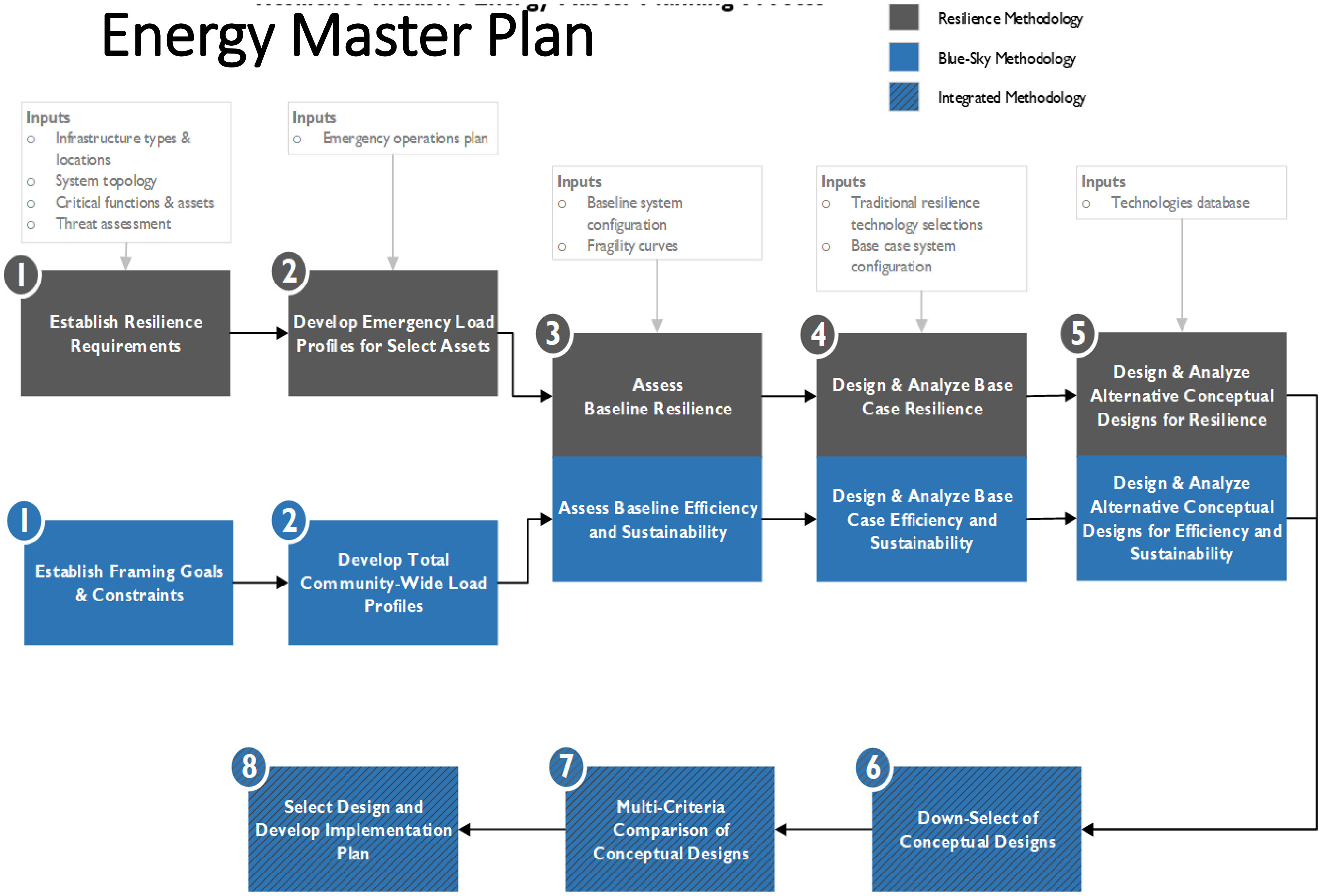
Campus and Building Information (Continued)

- Petroleum, Oils, and lubricants (POL – fuel oil tanks, lines, pumps)
- List of existing backup generators
- Transportation network (Roads)
- Supervisory control and data acquisition (SCADA) systems information
- Energy and Water Reporting System Data (one year required, 3 years preferred)
- Solid Waste Report (one year required, 3 years preferred)
- Prior reports/audits/analysis
- Energy bills (gas, electricity, etc.)
- Water and waste collection bills
- Building-specific energy and water metering data

Data Required for Resilience Analysis

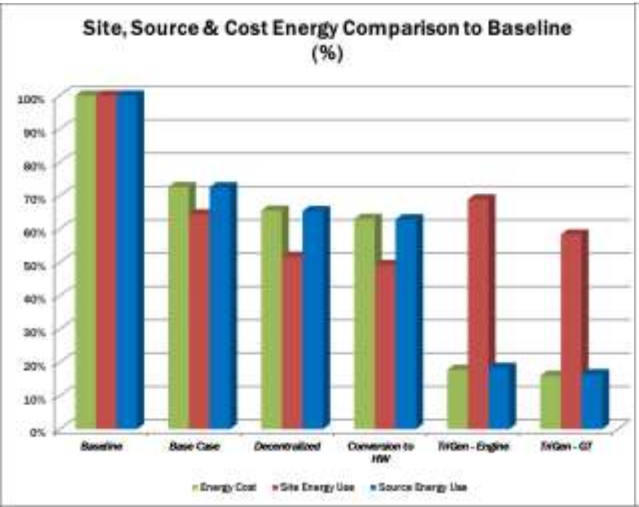
- Which buildings are mission critical based on operations (results from criticality analysis)?
- Which buildings and operations are mission critical based on life and safety (e.g., hospitals, dining facilities, …….)
- What is the total load: electrical and thermal (provided by external electrical and thermal grids) and onsite generation?
- What are priority loads provided by reduced capacity of external grid and from onsite generation and/or storage?
- What are critical loads when supply from onsite generation and/or storage is limited? How they are different when energy supply from external grids is interrupted for less than an hour (several hours, a day, 14 days)?
- Allowable down time of electrical and thermal systems for mission-critical and life and safety operations (none, 60sec, …)?
- What are electrical and thermal energy requirements for mission-critical operations (e.g., frequency range, voltage range, steam, temperature of hot or chilled water, etc.)
- What are mandatory requirements for energy systems (redundancy, efficiency, reliability, and resilience), and to which threats do these requirements pertain?
- What are the major natural threats to the locality of the community, based on threat assessment?
- Any risk analysis studies conducted to assess impacts of different threats on specific buildings, infrastructure, and energy systems? Their results.
- Any past, current or planned efforts to harden buildings, infrastructure, or energy systems and distribution lines
- List of onsite generation and energy storage equipment and its characteristics, expected life and age, conditions

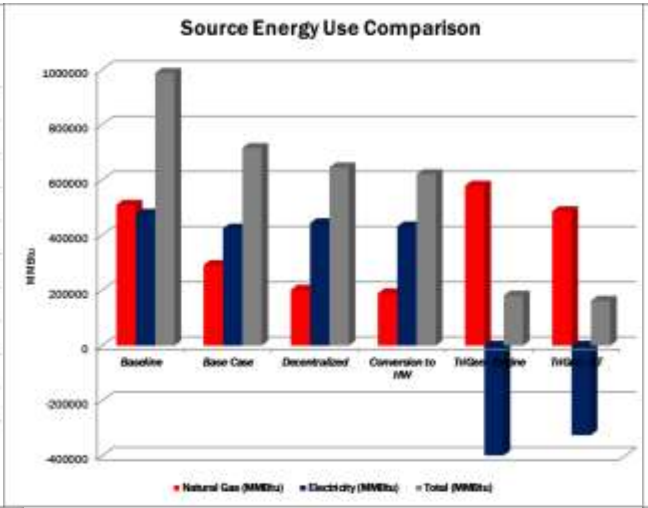
Integration of Energy Systems Resilience Analysis into Energy Master Plan

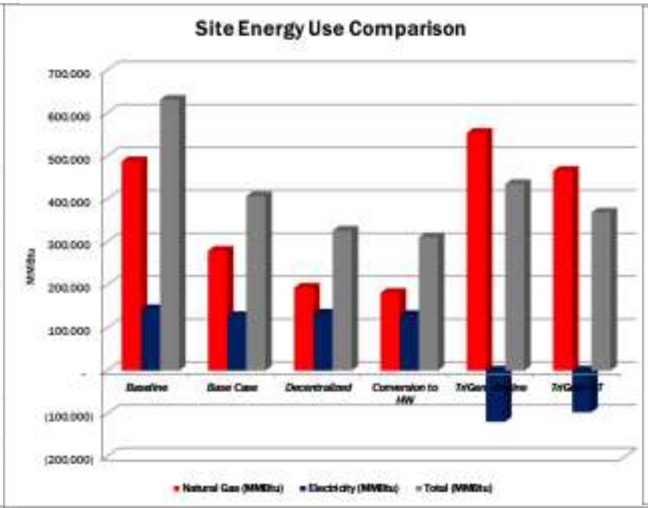


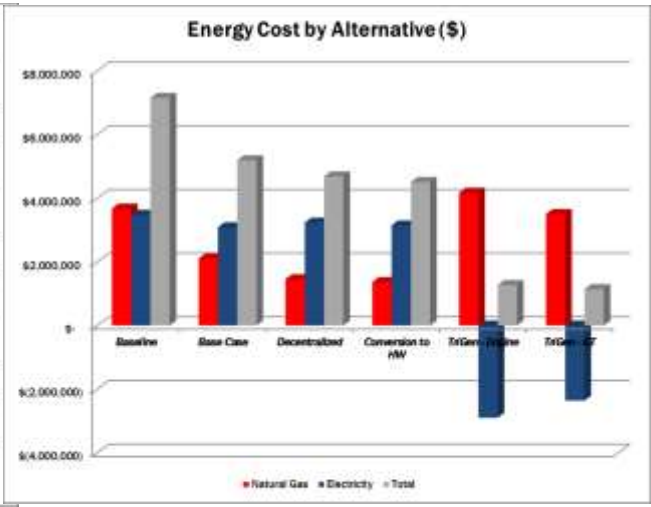
Comparison of Alternatives against Baseline and Base Case

Alternative	Site Energy (MMBtu)	Source Energy (MMBtu)	Energy Cost ($)	On-Site Power Generation (MWh)	Maintenance Costs ($/yr)	Capital Costs ($)	% of Mission Critical Power Generated On-Site	Peak Power (MW)	Grid Capability To meet Peak Power	LCC ($)	SPB/DPV
TriGen with Engines	434,378	181,457	1,271,890	69,122	2,198,667	130,430,694	100	12	18	232,125,392	10/13
TriGen with Turbines	367,992	162,624	1,142.647	62,744	1,968,089	158,430,694	100	12	18	255,470,743	16/20
Baseline	630,602	988,165	7,151,497	2,563	2,455,446	-	0	13.8	18	NA	NA
Base Case	406,129	716,339	5,190,838	1,729	1,872,823	86,350,800	100	16.8	18	306,942,547	NA









Resiliency analysis and gap evaluation: Baseline

- Thermal and electric energy availability and max allowable outage duration are calculated for each mission-critical facility and compared to requirements set by mission operators

Critical Facilities	Required		Baseline	
	Energy Availability	Max Allowable Outage Duration (minutes)	Energy Availability	Max Observed Outage Duration (minutes)
Facility 1	95.0%	120	94.0%	180
Facility 2	80.0%	60	80.0%	80
Facility 3	99.0%	26	98.0%	26
Facility 4	95.0%	120	90.0%	140
Facility 5	99.995%	26	99.0%	30

- Values in the table are notional and for illustration purposes only. More details will be presented in Session 1.5

Base Case

- The Base Case design for mission-critical energy systems only targets elimination of the resilience metric gap and does not consider blue-skies metrics for efficiency or sustainability. Base Case design options include only traditional technologies.
- The planner may have to run the systems model iteratively to ensure that systems are not under- or over-built but meet the resilience metric requirements as closely as possible.
- The purpose of the Base Case design is to serve as a cost savings comparison for the alternative designs.

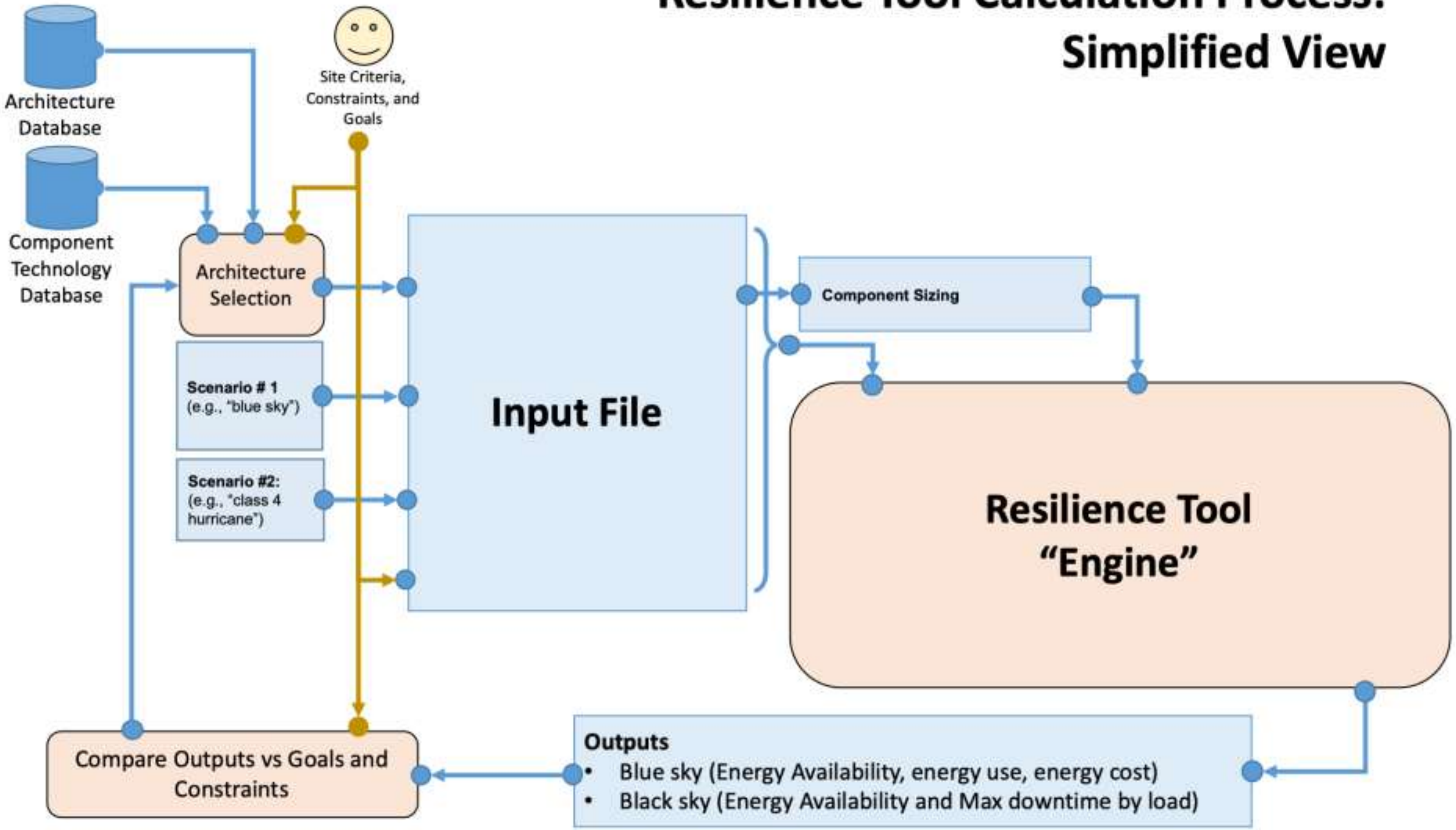
Critical Facilities	Required		Base Case	
	Energy Availability	Max Allowable Outage Duration (minutes)	Energy Availability	Max Observed Outage Duration (minutes)
Facility 1	95.0%	120	95.0%	120
Facility 2	80.0%	60	83.0%	60
Facility 3	99.0%	26	99.0%	26
Facility 4	95.0%	120	95.0%	105
Facility 5	99.995%	26	99.995%	26

Alternative Designs

- The alternative conceptual designs should integrate blue-sky goals with resilience goals such that performance is co-optimized for the planner.
- These designs should explore additional technologies beyond the Base Case conceptual design and should also consider alternative system configurations. It is important to review and consider enhancement of the building-level electric nanogrids regarding equipment redundancy and storage capacity as well as improvements in the building envelope resilience regarding thermal and air barrier efficiency, increase in the building mass
- These measures can allow downscaling of requirements to resilience of electric and thermal energy supply systems.

Critical Function	Required		Alternative 1		Alternative 2		Alternative 3	
	Energy Availability	Max Allowable Outage Duration (minutes)	Energy Availability	Max Observed Outage Duration (minutes)	Energy Availability	Max Observed Outage Duration (minutes)	Energy Availability	Max Observed Outage Duration (minutes)
Facility 1	95.0%	120	97.0%	110	95.0%	120	96.0%	105
Facility 2	80.0%	60	82.0%	55	85.0%	58	81.0%	60
Facility 3	99.0%	26	99.99%	26	99.99%	26	99.0%	26
Facility 4	95.0%	120	95.0%	115	95.0%	120	97.0%	90
Facility 5	99.995%	26	99.995%	26	99.995%	26	99.999%	26

Resilience Tool Calculation Process: Simplified View



Will be discussed on Wednesday, October 14 in Session 2.6 by Mr. Michael O'Keefe and Dr. Anders Andersen

Multi-Criteria Analysis of Alternatives: Integrating Economic, Energy and Resiliency Targets

- Analysis of the base case and alternatives produces quantitative results that allows to determine how close the users were able to come to achieving their goals and objectives and compare the baseline, base case, and alternatives using defined criteria.
- There might be additional conflicting qualitative and quantitative criteria (e.g., risk, safety, comfort, fuel availability, etc.) which can support decisions in defining the roadmap to achieving ultimate framing goals
- MCDA allows selecting a reduced set of good non-dominating alternatives to be presented to decision makers for the final choice.

Will be discussed on Friday, October 16 by Dr. Michael Case

Questions and Discussion

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