Towards Net Zero Energy Resilient Public Communities

IEA ECB Annex 73
TC 7.6 Federal Buildings WG

Dr. Alexander Zhivov

USACE Engineer Research and Development Center, Champaign, IL USA

January 11, 2021
Virtual from USA

Agenda

- Introductions
- Guide status
- Case Study book
- Pilot Studies
- Modeling tool and user's manual status
- Complimentary deliverable: Guide for Resilient Thermal Energy Systems Design in Cold and Arctic Climates
- TC 7.6 sponsored paper sessions
- Website status
- Training
- Non-ASHRAE conference participation
- New business?

Background

This research has been conducted under:

- Department of Defense Environmental Security Technology Certification Program EW18-D1-5281: “Technologies Integration to Achieve Resilient, Low-Energy Military Installations”;
- International Energy Agency Energy in Buildings and Communities Program Annex 73 “Energy Master Planning for Resilient Public Communities”;
- The Office of the Deputy Assistant Secretary of the Army project “Analysis of energy requirements and technical, resilience and economical evaluation of energy supply solutions to mission critical facilities “ and Building Envelope and Thermal Energy Systems Resilience for Cold Climates”, and
- U.S. Army Program 633734T1500, Military Engineering Technology Demonstration

Scope

Decision-making process and a computer-based modeling tools for achieving net zero energy resilient publicly owned communities (military garrisons, hospital campuses, universities, public housing, etc.)

Receptors

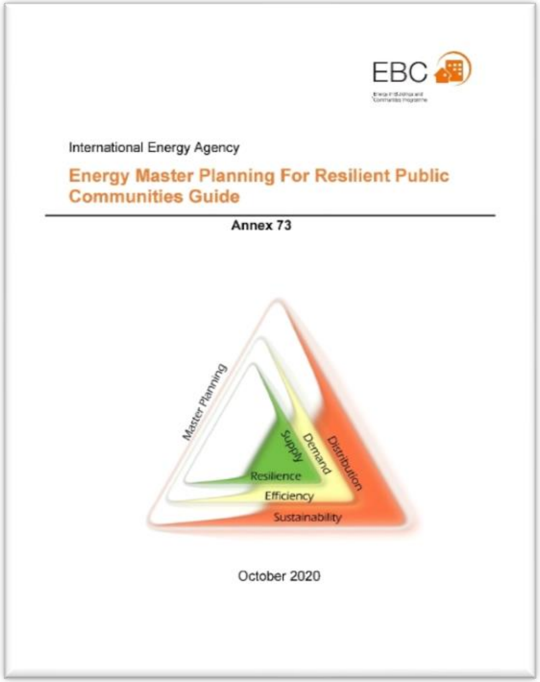
- Decision makers, planners, building owners, architects, engineers, energy managers and mission operators of public-owned and operated communities e.g.:
  - ♦ National Armed Forces through their Infrastructure Components, military garrisons,
  - ♦ University and high school campuses,
  - ♦ Hospitals and public housing which are responsible for all costs related to new construction, renovation and O&M.
- Industry, energy service companies, architects, engineers and financiers supporting public communities

Expected Deliverables

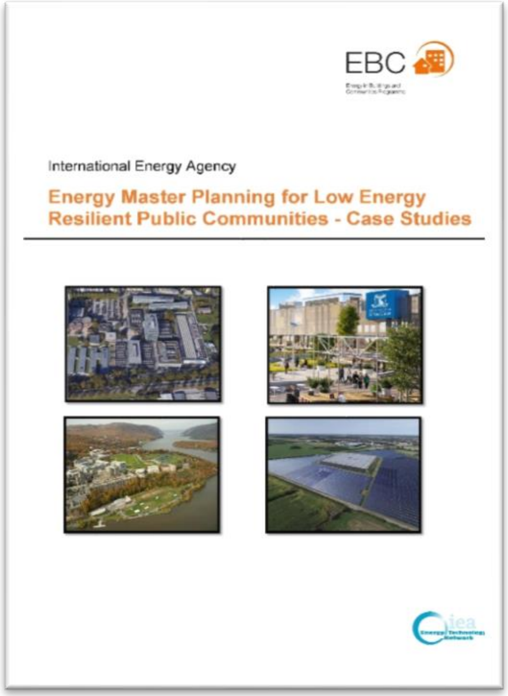
- A “Guide for Energy Master Planning in Low Energy Public Communities”
- Enhancements for Energy Master Planning Tools
- A Book of Case Studies (Examples of Energy Master Plans)
- Dissemination and training in participating

countries

Deliverables

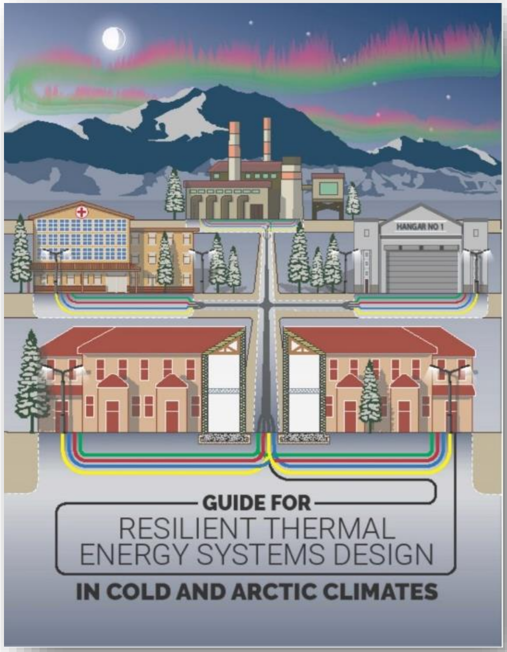


~550 pages



~330 pages

+ Bonus



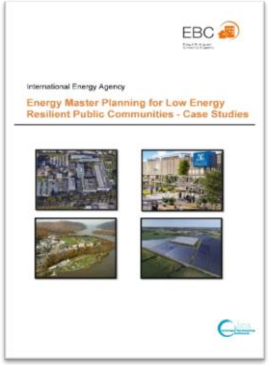
~150 pages

Participants:
8 countries and 36 organizations

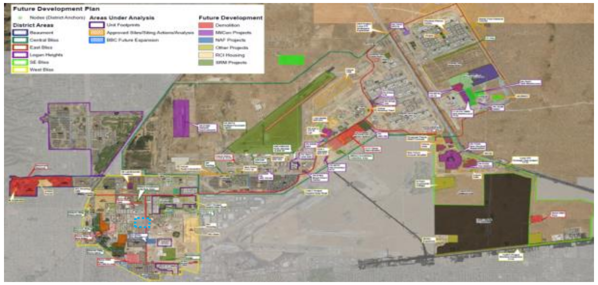
Collaboration and Leveraging

- **Thermal Energy Systems Resilience in Cold and Arctic Climates:** (CRREL, USACE Alaska District, Cold Climate Housing Research Center, Fort Wainwright, Fort Greely (Congressional Program: Secure and resilient power generation in cold region environments), Danish MOD;
- **Case Studies:** PNNL and CTC (Fort Bliss Case Study), AECOM (Guam Case Study), IEA EBC Annex 73 (Case Studies from IDEA, Austria, Denmark, Germany, Finland, Australia);
- **Database of Technologies:** USDOE (DER-CAM, CHP, Microgrid Program), Danish Energy Agency, International District Energy Association, NREL;
- **Guide: IEWP integrated with Resilience analysis** (PNNL and CTC, DASA, AFCEC, AECOM, NAVFAC);
- **Demonstration:** Fort Leonard Wood, MO team (leveraged by FLW funding for IEWP) and Norfolk Naval Station.

Case Studies of Energy Master Plans

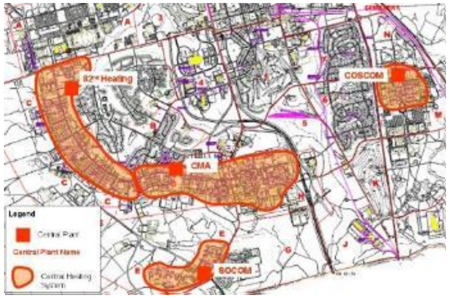


32 Case studies of energy master plans for military installations, University campuses, Medical centers and public housing from Australia (2), Austria (2), Denmark (10), Finland (6), Germany 4), Canada (1), Norway (1) and the USA (7)



Fort Bliss, USA

Guam, USA



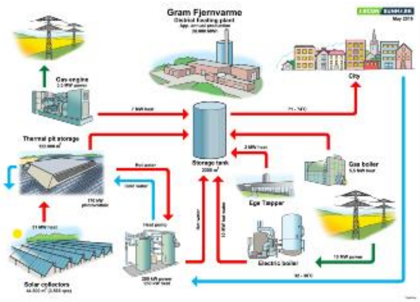
Fort Bragg, USA

University of Texas, Austin

Nymindegab military campus, Denmark

“Ford Plant” area development Minneapolis, MN

USMA West Point, USA

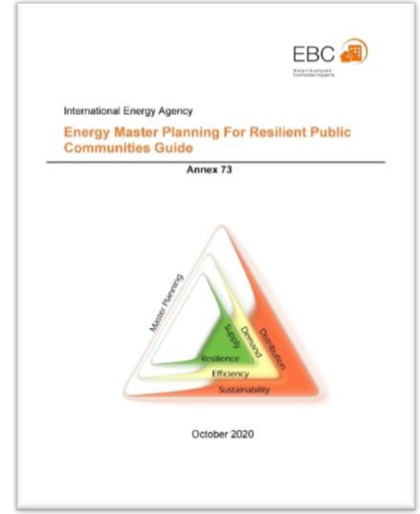


Town of Gram, Denmark

The Univ. of British Columbia, Canada

Volkswohnung KA Karlsruhe, Germany

Guide Content



EXECUTIVE SUMMARY

CHAPTER 1. INTRODUCTION

CHAPTER 2. ENERGY PLANNING AS A PART OF THE COMMUNITY MASTER PLAN

CHAPTER 3. METHODOLOGY OF ENERGY PLANNING PROCESS

CHAPTER 4. ESTABLISHING ENERGY RELATED FRAMING GOALS AND CONSTRAINTS

CHAPTER 5. DEFINING, MEASURING AND ASSIGNING RESILIENCE REQUIREMENTS

CHAPTER 6. DATA REQUIRED FOR ENERGY MASTER PLANNING AND RESILIENCE ANALYSIS

CHAPTER 7. SELECTION OF ENERGY SYSTEM ARCHITECTURE AND TECHNOLOGIES ARCHITECTURES

CHAPTER 8. ENERGY PERFORMANCE CALCULATION METHOD OF COMPLEX ENERGY SYSTEMS

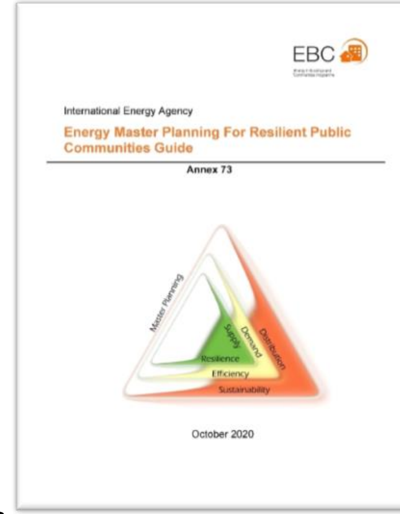
CHAPTER 9. MULTI-CRITERIA ANALYSIS OF ALTERNATIVES AND SCENARIO SELECTION: INTEGRATING ECONOMIC, ENERGY, AND RESILIENCY TARGETS

CHAPTER 10. ECONOMICS AND BUSINESS MODELS FOR ENERGY MASTER PLANNING

APPENDICES:

- Appendix A. Sources of information for establishing energy related framing goals and constraints
- Appendix B. Case Studies Summary
- Appendix C. Requirements for Building Thermal Conditions under Normal and Emergency Operations in Extreme Climates
- Appendix D. Critical mission requirements to energy systems
- Appendix E. Best practices of energy systems architecture
- Appendix F. Database of energy systems technologies
- Appendix G. Energy Master Planning and Resilience Analysis Tool Manual
- Appendix H. Simulation tool. Owner’s Manual.
- Appendix I. Examples of Business and Financial models.

Guide Content



EXECUTIVE SUMMARY

CHAPTER 1. INTRODUCTION

CHAPTER 2. ENERGY PLANNING AS A PART OF THE COMMUNITY MASTER PLAN

CHAPTER 3. METHODOLOGY OF ENERGY PLANNING PROCESS

CHAPTER 4. ESTABLISHING ENERGY RELATED FRAMING GOALS AND CONSTRAINTS

CHAPTER 5. DEFINING, MEASURING AND ASSIGNING RESILIENCE REQUIREMENTS

CHAPTER 6. DATA REQUIRED FOR ENERGY MASTER PLANNING AND RESILIENCE ANALYSIS

CHAPTER 7. SELECTION OF ENERGY SYSTEM ARCHITECTURE AND TECHNOLOGIES ARCHITECTURES

CHAPTER 8. ENERGY PERFORMANCE CALCULATION METHOD OF COMPLEX ENERGY SYSTEMS

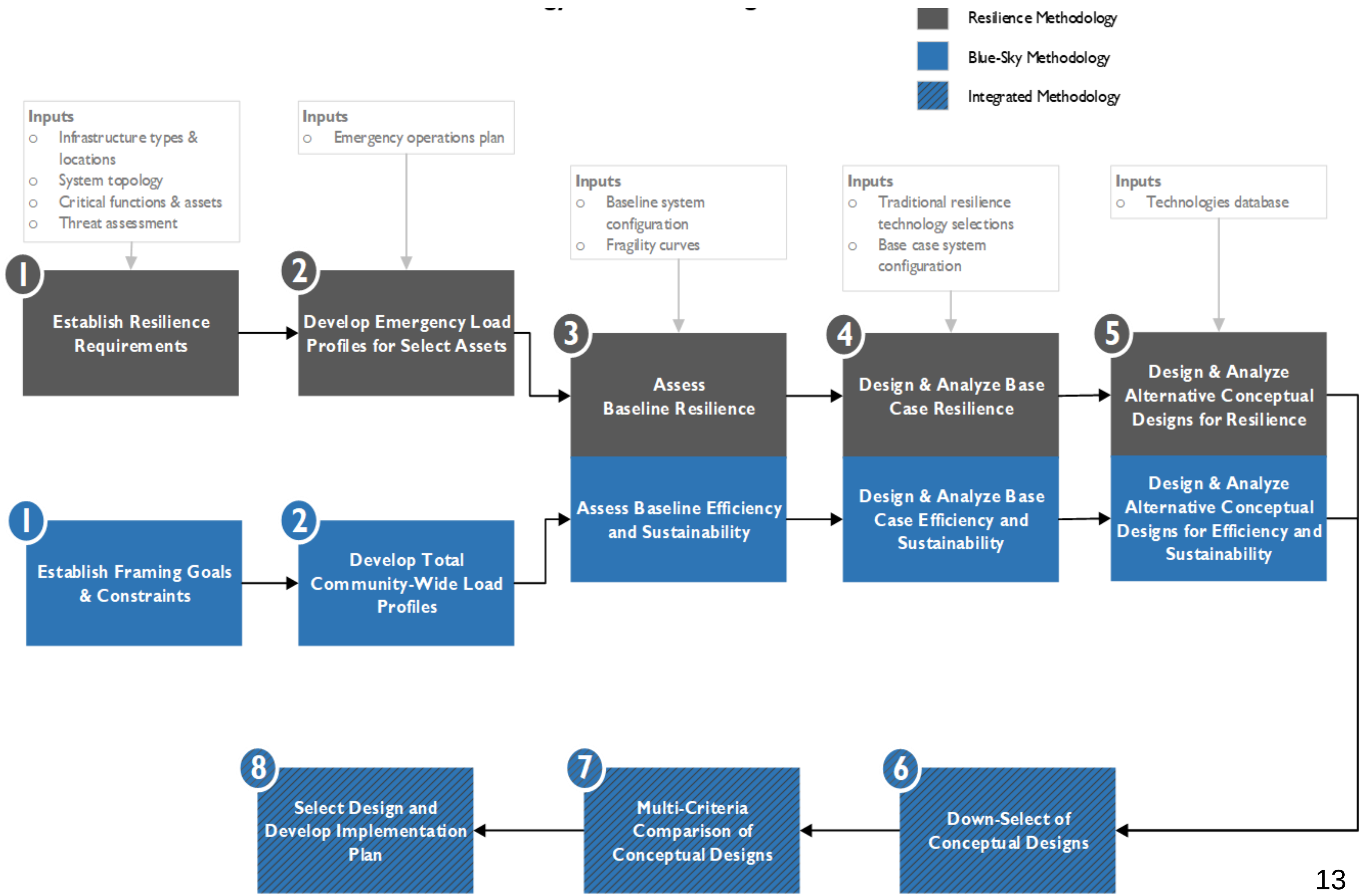
CHAPTER 9. MULTI-CRITERIA ANALYSIS OF ALTERNATIVES AND SCENARIO SELECTION: INTEGRATING ECONOMIC, ENERGY, AND RESILIENCY TARGETS

CHAPTER 10. ECONOMICS AND BUSINESS MODELS FOR ENERGY MASTER PLANNING

APPENDICES:

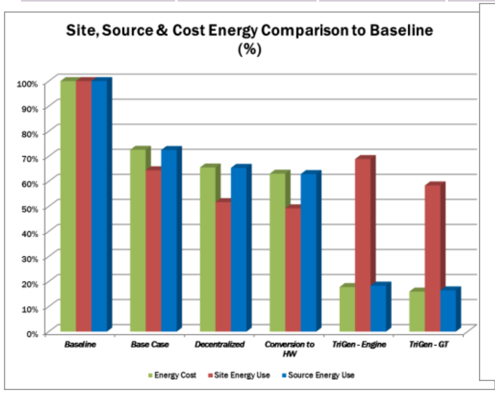
- Appendix A. Sources of information for establishing energy related framing goals and constraints
- Appendix B. Case Studies Summary
- Appendix C. Requirements for Building Thermal Conditions under Normal and Emergency Operations in Extreme Climates
- Appendix D. Critical mission requirements to energy systems
- Appendix E. Best practices of energy systems architecture
- Appendix F. Database of energy systems technologies
- Appendix G. Energy Master Planning and Resilience Analysis Tool Manual
- Appendix H. Simulation tool. Owner’s Manual.
- Appendix I. Examples of Business and Financial models.

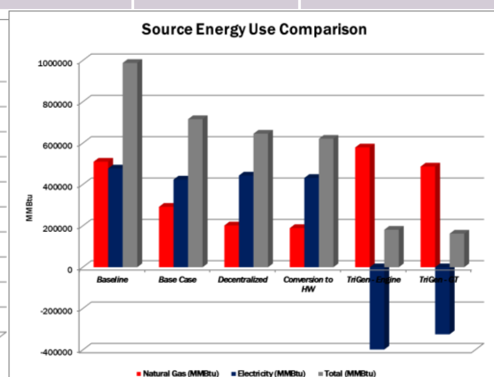
Integration of Energy Systems Resilience Analysis into Energy Master Plan

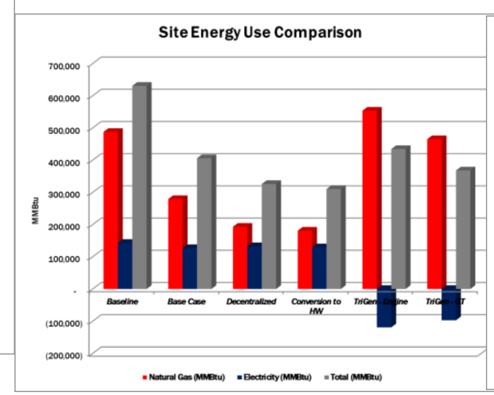


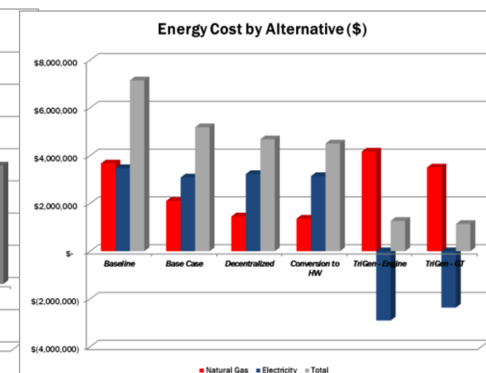
Comparison of Alternatives against Baseline and Base Case

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









Quantifying energy system resilience

The proposed quantitative approach includes (but not limited to) the following metrics:

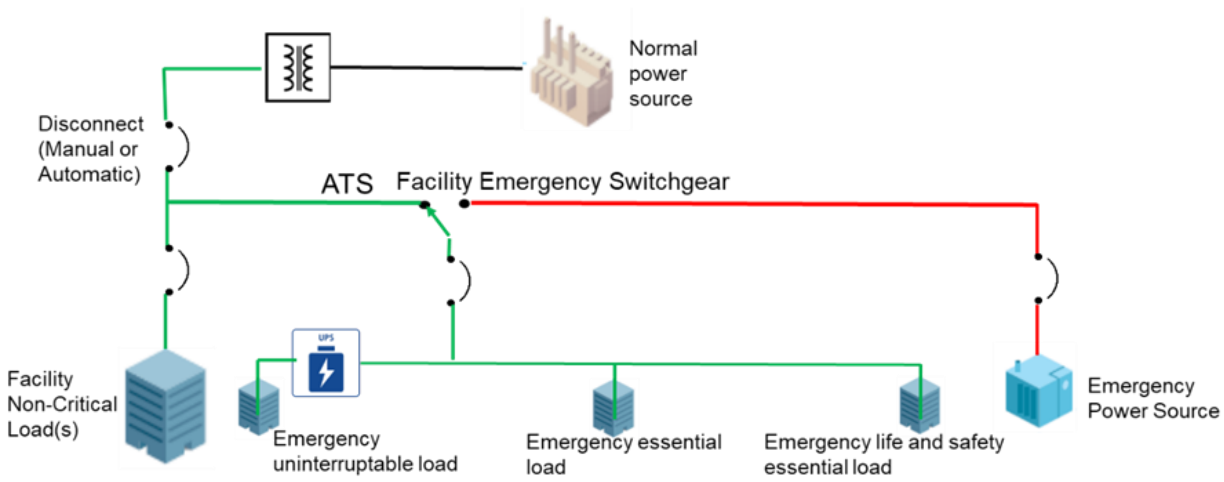
- **Energy System Robustness (ER)**
- **Energy System Recovery time**
- **Energy Availability (EA)**
- **Energy Quality (EQ).**

- The first three parameters are critical for selection of the energy supply system architecture and technologies it is comprised of to satisfy requirements related to energy system resilience;
- Most of the mission specific energy quality requirements (both electric and thermal), including the level of tolerance to short-term interruptions, can be handled by the building-level energy systems (electric nano-grids), or building thermal systems (that include the building envelope, thermal storage and HVAC system), which are designed based on class or tier of such requirements.

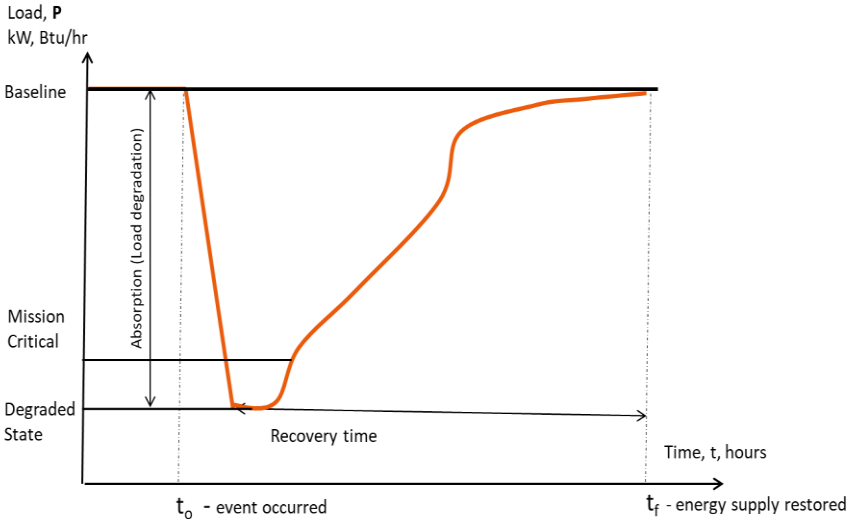
Energy System Robustness

Requirements for Energy Robustness depend on a load that is critical to the mission during emergency (Black-Sky) conditions and that can be measured as the percentage of the:

1. **Total mission essential load requirements**
2. **Overall building energy load under normal (Blue-Sky) conditions**



Energy System Robustness



$$R_{m.c.} = \frac{E_{event}}{E_{m.c.}}$$

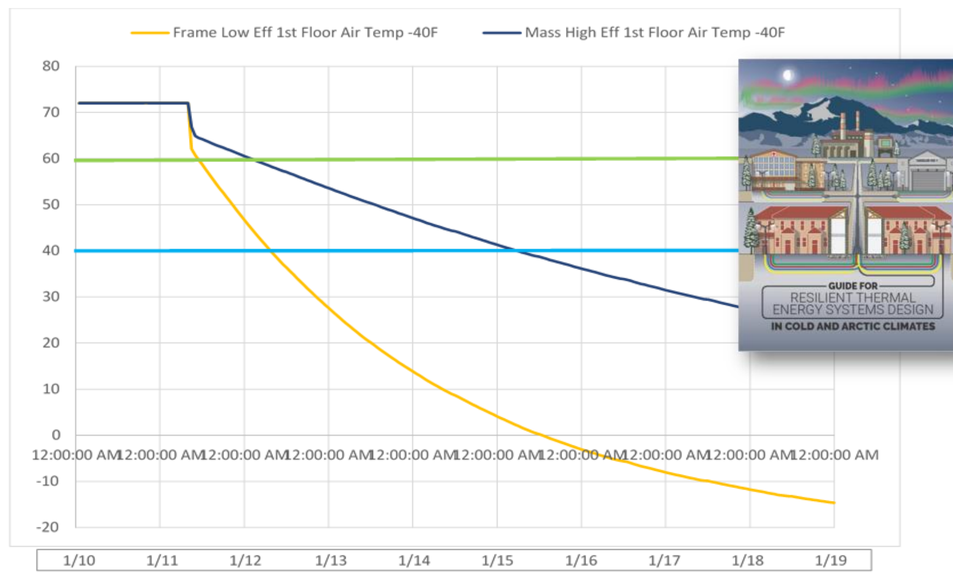
$$E = \int_{t_0}^{t_f} P(t)dt$$

$$R_{baseline} = \frac{E_{event}}{E_{baseline}}$$

R$_{m.c.}$ and **R** $_{baseline}$ = system robustness against the mission-critical load and the baseline load;

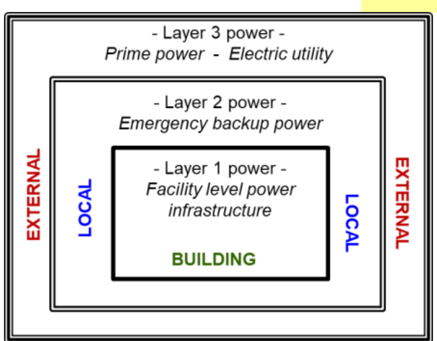
E$_{event}$, **E**$_{m.c.}$, and **E**$_{event}$ a= energy supplied to the building during the period between t$_o$ and t$_f$ with the baseline load, mission-critical load and degraded due to event load

Robustness is defined as "the ability to absorb shocks and continue operating" (NERC). In many critical facilities, there may be many mission assets that are considered uninterruptible, critical but interruptible, and life- and safety-related. Since it is imperative to the mission that these assets remain online, any undelivered load to such facilities or assets would be considered a mission failure. Energy Robustness is a metric that shows power availability, P (in kW and/or kBtu/hr), to satisfy critical mission loads over a period of time immediately following the event, measured as a fraction of the mission-critical requirement or as a fraction of the baseline energy requirement.



Energy Availability & Max Single Event Downtime

Resilience Metric	Facility Level	Resilience Sub-Metric	Category	Degraded State Availability	Acceptable Average Weekly Downtime (Minutes)	Maximum Single Event Downtime (Minutes)
Low	Primary	Low	LP/1	0.92	806.4	2,419
		Moderate	LP/1+	0.95	504	1,500
	Secondary	Low	LS/0	0.9	1008	3,024
		Moderate	LS/0+	0.92	806.4	2,419
Moderate	Primary	Low	MP/2	0.99	100.8	302
		Moderate	MP/2+	0.995	50.4	150
	Secondary	Low	MS/1	0.95	504	1,500
		Moderate	MS/1+	0.99	100.8	302
Significant	Primary	Moderate	SP/3	0.999	10.08	30
		Significant	SP/3+	0.9995	5.04	15
	Secondary	Moderate	MS/2	0.95	504	1,500
		Significant	MS/2+	0.99	100.8	302
High	Primary	Significant	HP/4	0.9999	1.008	3
		High	HP/4+	0.99999	0.1008	0.3
	Secondary	Significant	HS/3	0.9995	5.04	15
		High	HS/3+	0.9999	1.008	3



Evaluate → Criticality + Remoteness + Redundancy

- Then determine -

↓

Resilience Phase
= Availability + Recovery

Recommended thermal conditions for buildings located in cold/Arctic climate – Emergency operations (Black sky)

Scenario Type of Requirement	Emergency (Black Skies) Space Occupancy					
	Mission-Critical Operation		**Tertiary Space (Non-Mission-Critical Bordering Mission-Critical Space)**		**Hibernated: Can Be Unoccupied for Extended Period of Time (from Days to Weeks)** **Building Freezing/ Not Freezing**	
	DP	**Minimum Dry Bulb Temp**	**Humidity Not To Exceed**	**Minimum Dry Bulb Temp**	**Humidity Not to Exceed**	**Minimum Dry Bulb Temp**
Human Comfort	< 60 °F (16 °C) [1]	> 60 °F (16 °C) [5]	N/A		N/A	
Process Driven	Process specific – see examples in Tables D-1 & D-2		N/A		N/A	
	Humidity not to exceed	Minimum Dry Bulb Temp	Humidity not to exceed	Minimum Dry Bulb Temp		
Building Sustainment	80%[3]	40 °F (4.4 °C)[2]	80%[3]	40 °F (4.4 °C)[2] 55 °F (12.7 °C)[4]	80%[3]	N/A 40 °F (4.4 °C)[2] or N/A if drained

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 Availabili ty	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

Alternative Designs

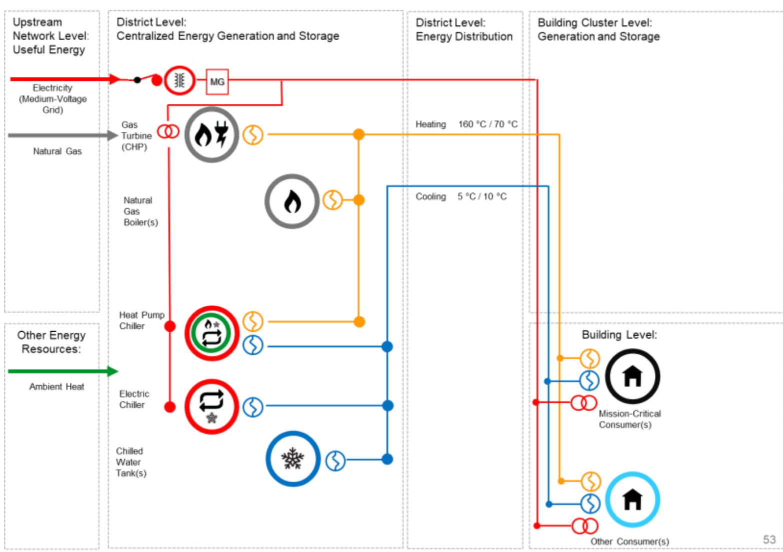
- The alternative conceptual designs should integrate blue-sky goals with resilience goals such that performance is co-optimized for the planner.
- These designs should explore additional technologies beyond the Base Case conceptual design and should also consider alternative system configurations. It 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

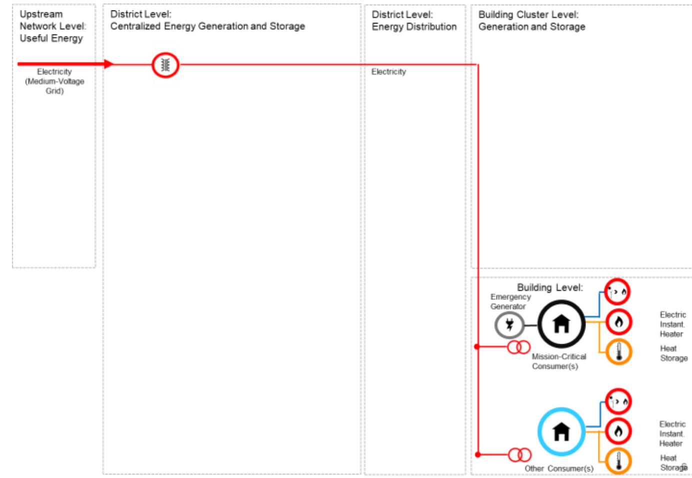
Examples of Thermal System Architectures

60+ examples of 2nd to 4th generation of energy system architectures have been developed for communities with and without mission critical facilities with following energy needs: power only, power + heating, power + heating and cooling, power and cooling only.

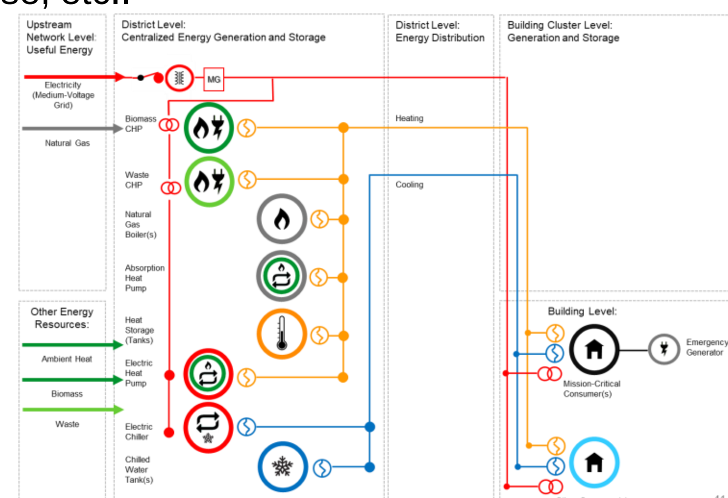
Example of District heating, cooling and power systems (Case Study from UT Austin Medical Center)



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

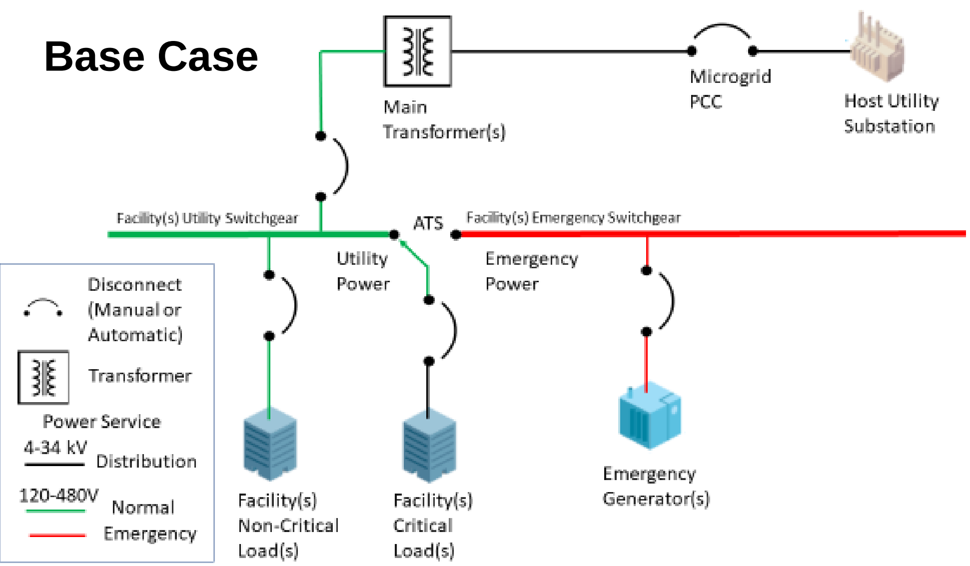


Example of generic power, heating and cooling systems with CHP base load generation seasonal storage, waste heat use, etc..

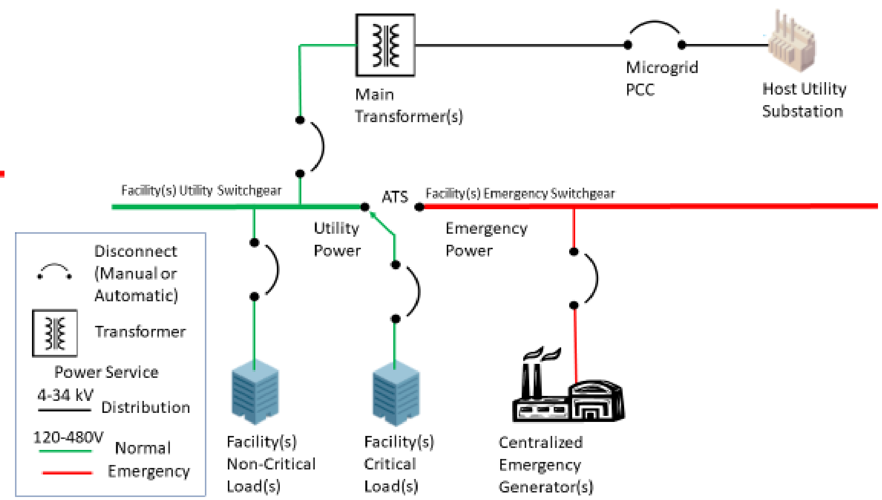


Examples of Electric System Architectures

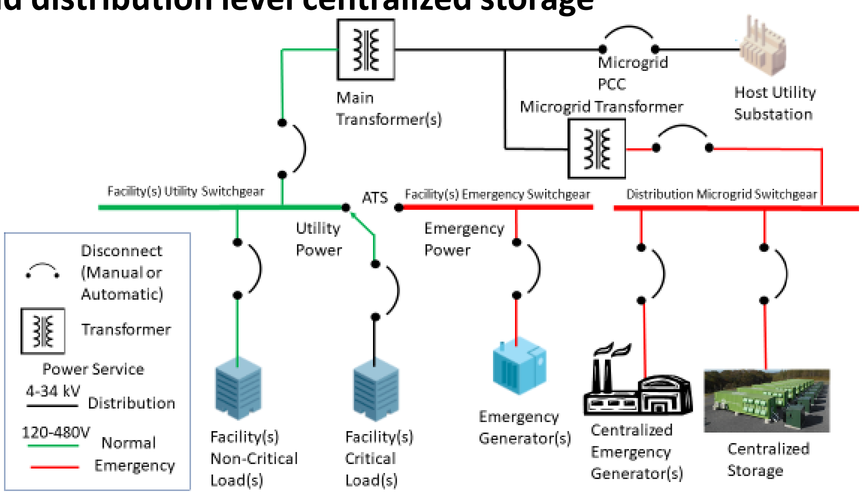
Base Case



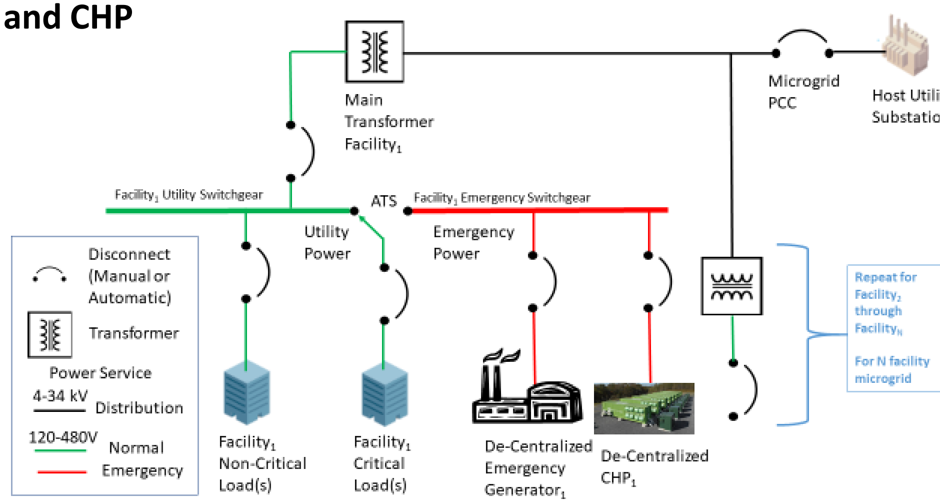
With centralized emergency generators



With distribution level centralized emergency generators and distribution level centralized storage



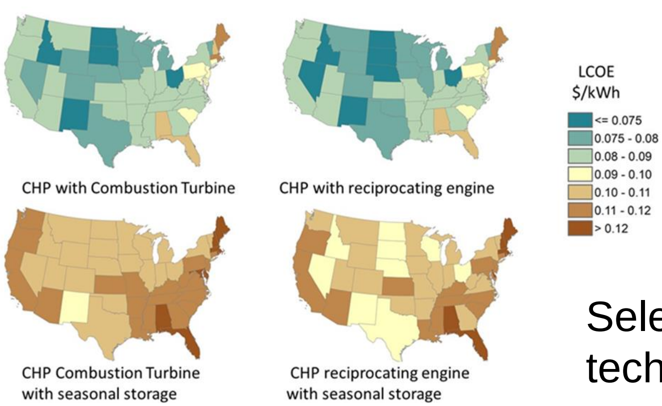
With de-centralized emergency generators and CHP



Structure of the Database

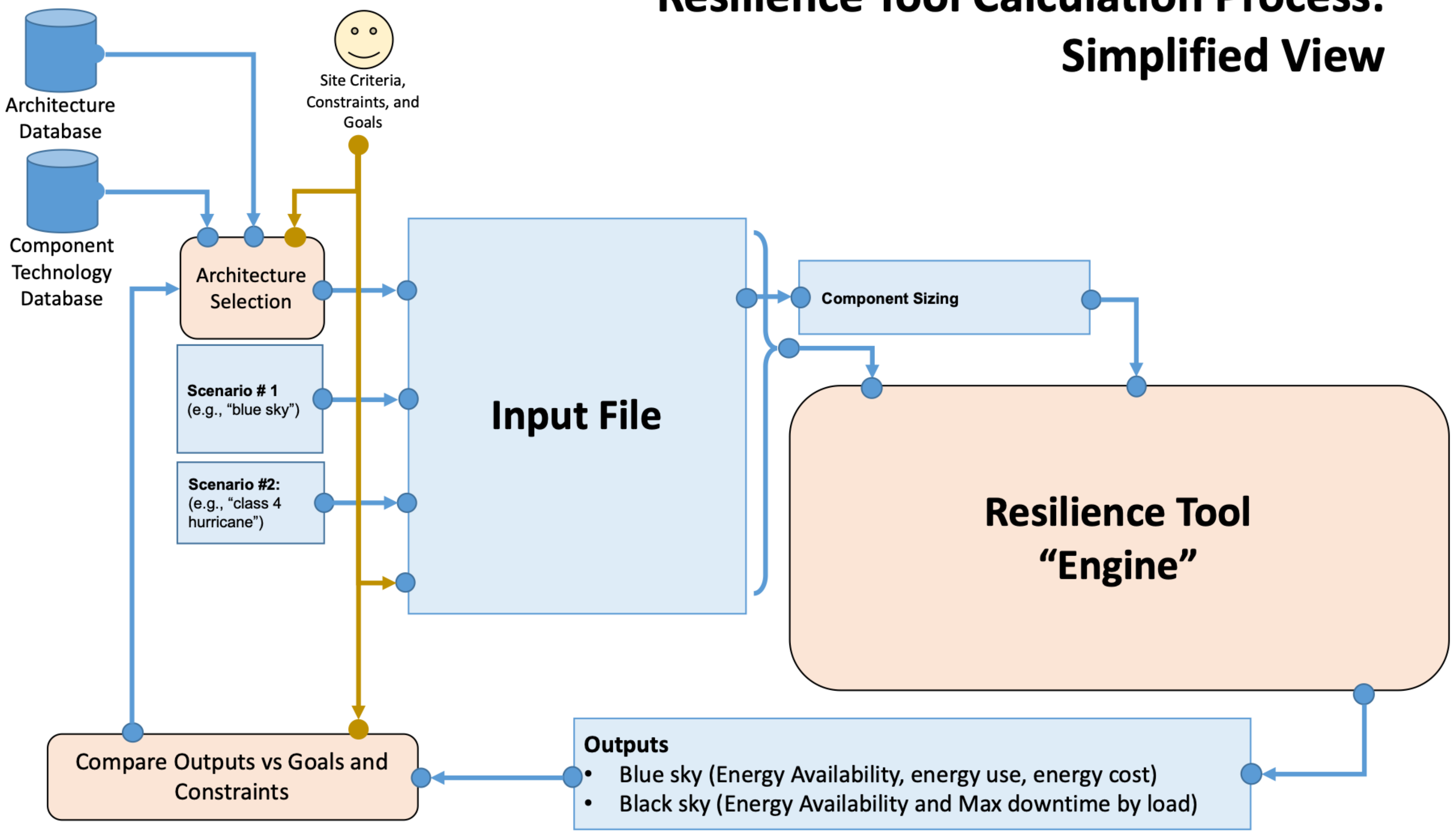
Data base of energy supply systems technologies with technical, economic and resilience characteristics

- **Overview**
  - Introduction
  - User guide
  - Matrix
- **Energy systems**
  - Energy systems
  - LCOE results
  - LCOE assumptions
  - LCOE calculation
- **Energy storage and production**
  - Energy storage
  - Boiler plants
  - CHP, CHCP plants
  - Heat pumps and chillers
  - Renewable energy
- **Energy networks**
  - District heating network
  - District cooling network
  - Natural gas network
  - . Electric network
- **Miscellaneous**
  - HVAC
  - Resiliency
  - Miscellaneous
  - Non energy



Selected maps with technology cost-effectiveness

Resilience Tool Calculation Process: Simplified View



Subtask E. Energy Master Planning and Resilience Analysis Tool

Energy Master planning Tools

- energyPRO
- REopt Lite
- CityGML
- HOMER Pro

Microgrid Design Tools:

- Microgrid Design Toolkit
- GridLAB-D
- DER-CAM+ DECISION SUPPORT TOOL FOR DECENTRALIZED ENERGY SYSTEMS — TOPOLOGY | ANALYTICS | PLANNING | OPERATIONS
- DSS
- CYME INTERNATIONAL T&D — EATON'S CYME POWER ENGINEERING SOFTWARE

Resilience analysis tool

US DOD ERA tool

MIT LINCOLN LABORATORY

Unique Contributions of This Effort

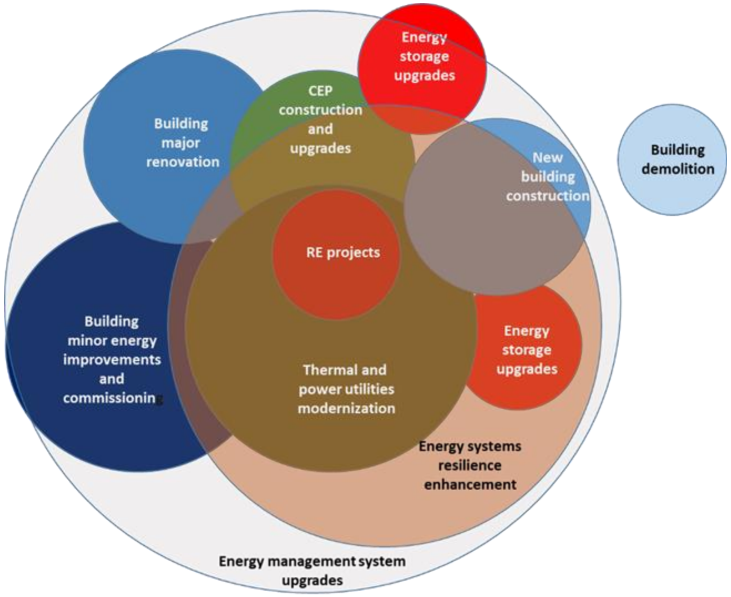
- Incorporates ***topology*** (what is connected to what)
- Handles multiple ***flow types*** (e.g., cold/hot water, electricity, etc.)
- Designed to be part of a larger ***energy master planning process***
- ***Resilience*** based on
  - ***threat scenarios*** (*design basis threat*)
  - failure prediction from ***actual component failure modes***
- Incorporates ***multiple load types/tiers***
- Uses all of the above to assess the ***cost*** implications of all of the following:
  - reliability/resilience
  - energy usage implications
  - and efficiency of energy and/or mass flows through a district system network
- Engine to be available under an ***open source license***

Economics of Energy Master Plan Implementation

Selection of alternatives for an EMP shall be based on cost effectiveness of the entire EMP instead of individual projects that comprise the EMP.

Most common business models used for communities EMP implementation

- Appropriated Funding
- Fixed Payment Model and Utility Fixed Repayment Model
- Energy (Saving) Performance Contracting-Model (ESPC)
- UESC
- Blended funding (public and private combined funding)
- ESPC Energy Sales Agreements
- Power Purchase Agreements
- Enhanced Use Lease

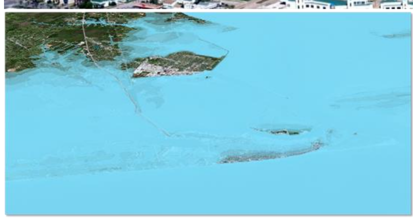


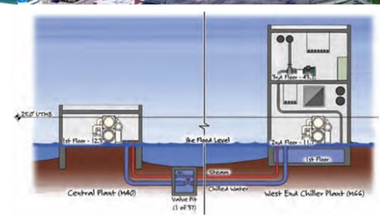
Comparison of EMP business models.

Business Model	Description	Pros	Cons
Appropriated Funds	Funds appropriated by the governing agency as part of the yearly budgetary process, execution supervised by agency and subcontracting parties	- Straight forward - follows the normal processes for capital improvement program - Can be done incrementally for several years - Manage resource to highest priority areas	- Subject to normal budget priorities - Must be managed internally - Follows normal design-build processes - no extended guarantees - No energy performance guarantees - No budget limitation guarantee
Fixed Payment	Funded by a utility. Paid back via fixed payments on the utility bill or on the property tax bill	- Easily implemented - Usually low interest rates - Payment stays with the property in case property is sold	- No energy guarantee - Usually limited to small projects - EMP implemented in pieces
ESPC	Energy Savings Performance Contact	- Budget Neutral - Energy/Operations savings pay for the upgraded systems Third Party manages the contract - Energy savings are guaranteed - resulting in lowered financing rates - Multiple technical updates can be built in	- Not readily understood by many municipal officials - Typically need a 3rd party expert to advocate for the customer - Long approval cycles on final project/financing by customer - Concerns by some decision makers on long term debt
UESC	Utility Energy Savings Contract	- Budget Neutral - Energy/Operations savings pay for the upgraded systems Third Party manages the contract - Customer contracts with their utility - people they know - Customer decides level of energy guarantee	- Not readily understood by many municipal officials - Typically need a 3rd party expert to advocate for the customer - Long approval cycles on final project/financing - Concerns by some decision makes on long term debt - Not all utilities offer this service
Blended Funding	Combing appropriated funding with ESPC/UESC	- Same as ESPC/UESC - Shorten financing term by injecting one time or multiple cash payments - Can get more ECM's in the project	- Same as ESPC/UESC - Ensuring that the cash payments are available in the budget
PPA	Power Purchase Agreement - buy power from a non-utility partner or developer	- Developer pays all costs - Customer buys power at a price - At the end of the contract period, customer can buy the equipment for fair market value or have it removed - Developer may pay a lease payment to use customer land - Consistency of long-term budget planning	- Long term procurement contract for customer - typically 20 years - Energy prices may be fixed or escalated - Locked in prices result in not being able to take advantage of potential future lower pricing
EUL	Enhanced Use Lease - customer leases underutilized land to a 3rd party in exchange for resiliency	- Developer pays all costs - Lease payment is often "In Kind Consideration" which is often required or needed customer infrastructure updates - If utility power is lost, the power being produced on the leased land is sent to the customer	- Lease is 30-40 years - Power from the leased land is sold to the utility grid or may be bought by the customer - Land is unavailable for future customer expansion

Two Models to Account for Improved Resilience

1. Value of resilience can be established (e.g., private and public sector, academia) based on insurance premium and the value of potentially loss of goods and services;
2. Value of resilience can’t be established (e.g., military, medical applications) and LCCA can be based on benchmarking against the Business-as-Usual approach to meet minimum requirements to resilience.

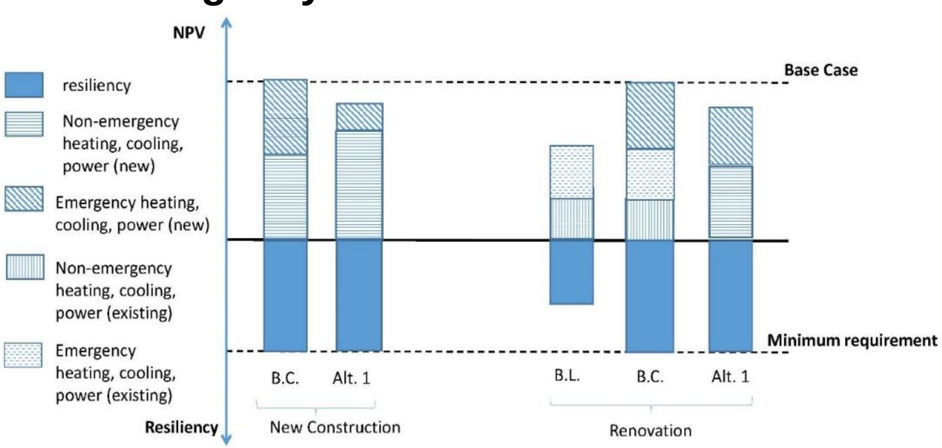




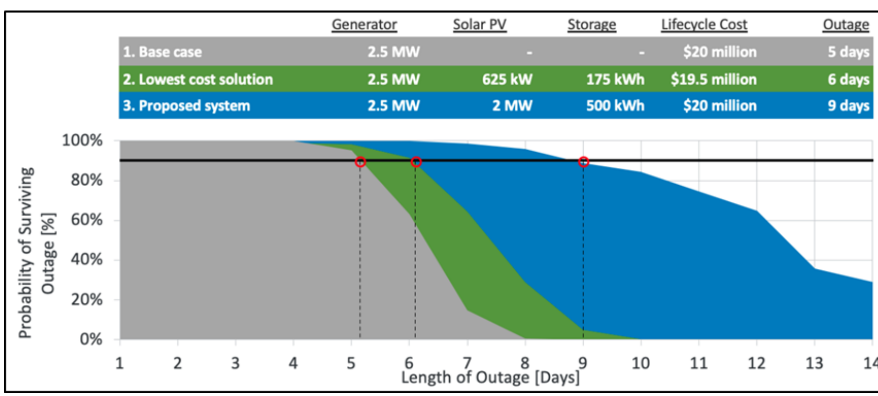
The University of Texas Medical Branch at Galveston - Impact of Hurricane Ike, September 13, 2008:

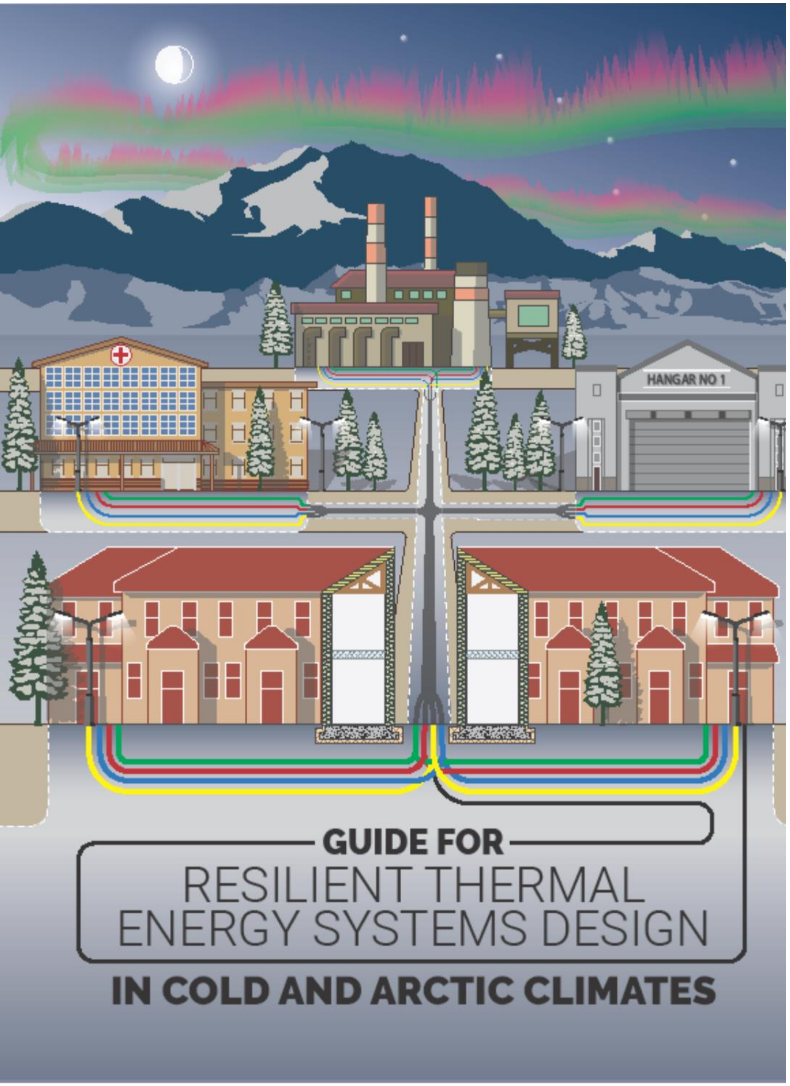
- Cost of stabilization: $14,000,000
- Unable to operate hospital: 90 Days
- Lost business revenue: $2,000,000/day
- Underground steam distribution system a complete loss
- Lost research materials ~ $2 billion
- Estimated over $1 billion in damages

LCC based on system operation during normal and emergency scenarios



Amount of time that a critical load can be met at a certain probability



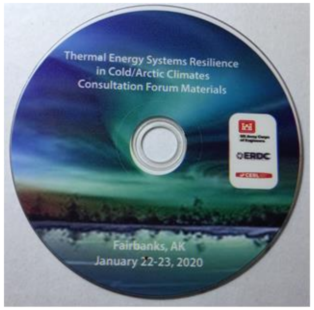


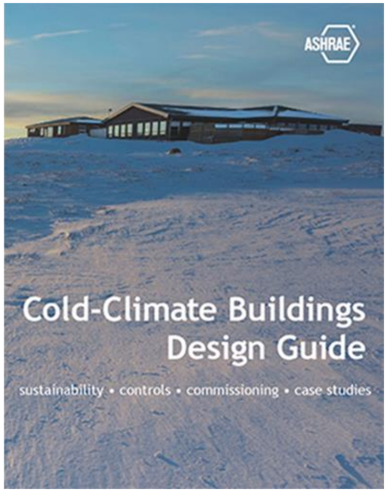
Chapter 1. INTRODUCTION
Chapter 2. REQUIREMENTS FOR BUILDING THERMAL CONDITIONS UNDER NORMAL AND EMERGENCY OPERATIONS IN COLD AND ARCTIC CLIMATES
Chapter 3. PARAMETERS FOR THERMAL ENERGY SYSTEM RESILIENCE
Chapter 4. BUILDING ENVELOPE
Chapter 5. CONSIDERATIONS FOR FOUNDATION CONSTRUCTION ON PERMAFROST
Chapter 6. BEST PRACTICES FOR HVAC, PLUMBING AND HEAT SUPPLY
Chapter 7. DISTRICT HEATING SYSTEMS
Chapter 8. EVALUATION OF MAXIMUM TIME TO REPAIR
Appendices
Appendix A Building Enclosure Testing on Alaska Military Base Projects
Appendix B . Thermal Energy System Resilience: Thermal Decay Test (TDT) in Cold/Arctic Climates
~ 150 pp.

Consultation Forum
January 22-23, 2020

~ 60 Participants from the USA, Canada and Denmark

Forum Materials: 32 white papers, Nat. Codes, 4 Guides and 6 references





For presentations, visit http://wiki.cchrc.org

Co-Sponsors

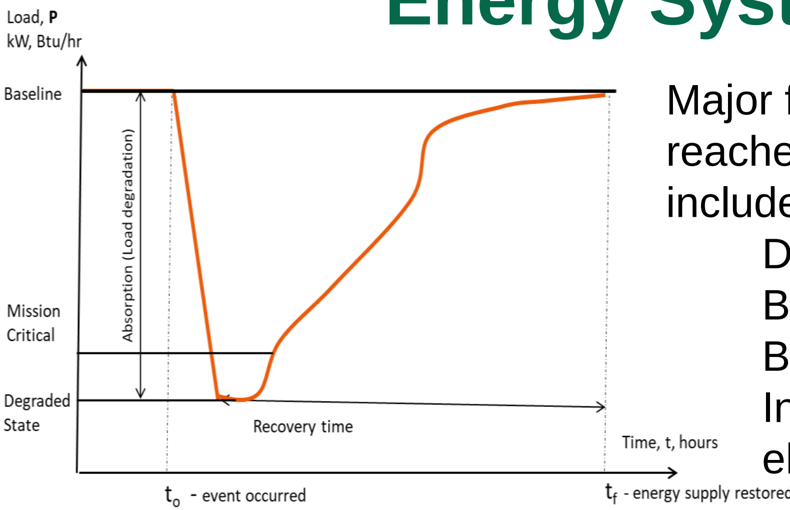
Why do we care about thermal systems resilience?

Damage to buildings

Uncomfortable
environment,
low productivity,
jeopardized mission

Frozen water pipes,
damaged furniture
and other
property, jeopardized
mission

Energy System Robustness



Major factors affecting the time, when the internal temperature reaches threshold based on building habitability or sustainment include:

- Difference between inside and outside air temperature
- Building envelope leakage rate
- Building envelope insulation properties
- Internal thermal load (people and equipment connected to electric power).

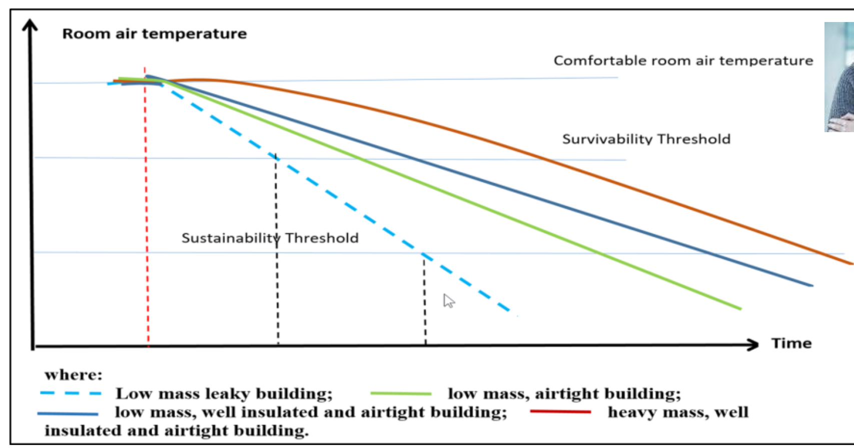
Robustness is defined as "the ability to absorb shocks and continue operating" - a metric that shows energy availability to satisfy critical mission loads over a period of time immediately following the event

$$R_{m.c.} = \frac{E_{event}}{E_{m.c.}}$$

$$E = \int_{t_0}^{t_f} P(t)dt$$

$$R_{baseline} = \frac{E_{event}}{E_{baseline}}$$

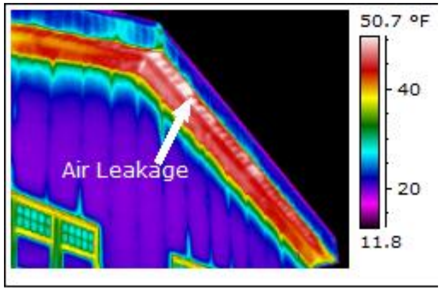
R$_{m.c.}$ and **R** $_{baseline}$ = system robustness against the mission-critical load and the baseline load; **E**$_{event}$, **E**$_{m.c.}$, and **E**$_{event}$ a= energy supplied to the building during the period between t_o and t_f with the baseline load, mission-critical load and degraded due to event load



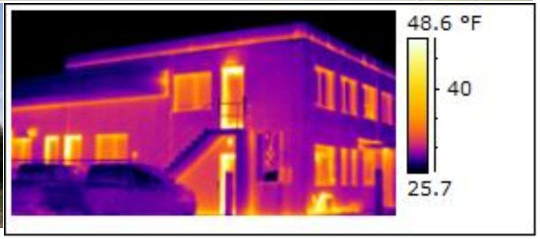
Emergency habitability/survivability threshold: indoor air temperature below 60.8 °F (16 °C) [ACGIH 2018]
Sustainability Threshold: T ≥40 °F (4.4 °C) Dry Bulb, where water piping is at risk

Building air tightness test

Ft. Wainwright



Ft. Greely

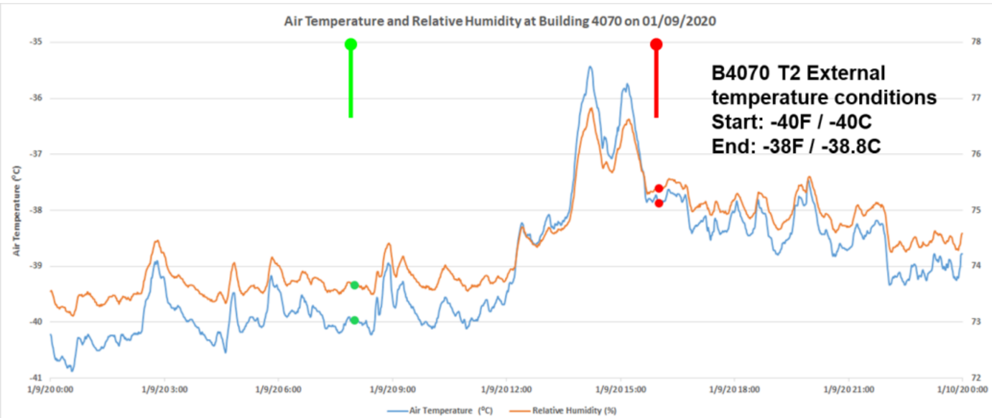


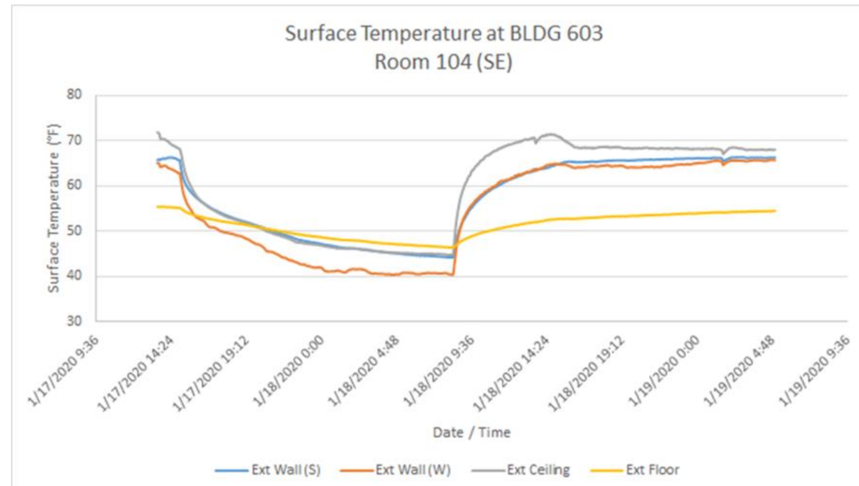
FTG & FTW ABT-2019	Year of Const.	Bldg. Const. Type	Six-Sided Area (ft^2/m^2)	CFM75/ ft^2 (m^3/h.m^2)	EqLA75 (ft^2/m^2)	ACH
FTW 3002	2016	IMP	39,822 / 3,703.5	0.208 / 3.744)	5.7 / 0.53	0.342
FTW 3013	1999	Wood Framed	8,488.8 / 789.5	0.095 / 1.710	0.5 / 0.047	0.217
FTW 4070	1950s	CMU Upgraded				
FTG 603	1955	CMU/Concrete/EIFS	32005.6 / 2,976.5209	0.155 / 2.790	3.3 / 0.307	0.399
FTG 650	1955	CMU/Concrete/EIFS	28,501.6 / 2,650.6489	0.146 / 2.628	2.8 / 0.260	0.261

* Alaska Thermal Imaging, Inc, Palmer, Alaska, http://alaskathermalimaging.com/Home_Page.html

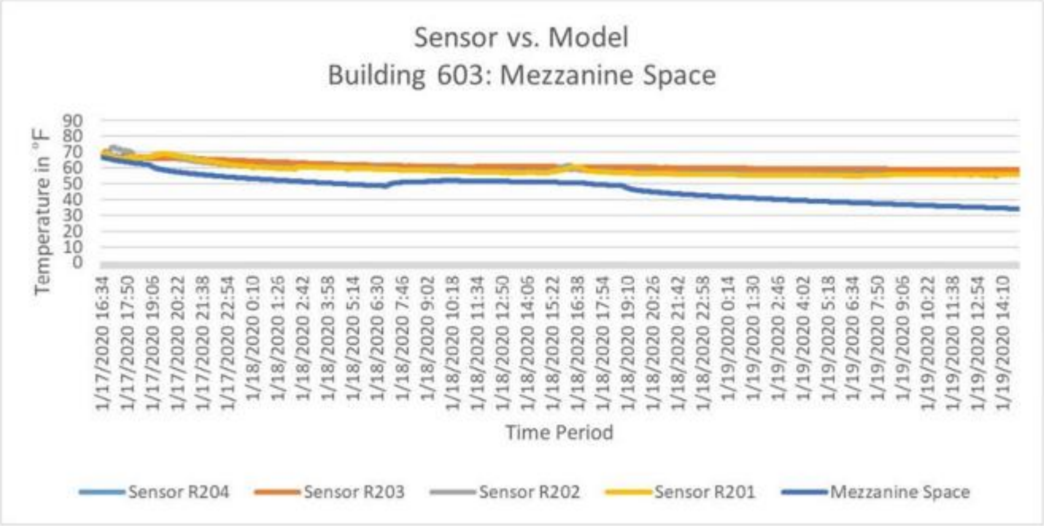
† CFM75 is air leakage rate in cubic feet per minute at 75 Pa, i.e., the static pressure between the building's interior and the buildings ambient; and CFM is air leakage rate in cubic feet per minute at standard pressure and EqLA75 is Equivalent Leakage Area at 75 Pa.

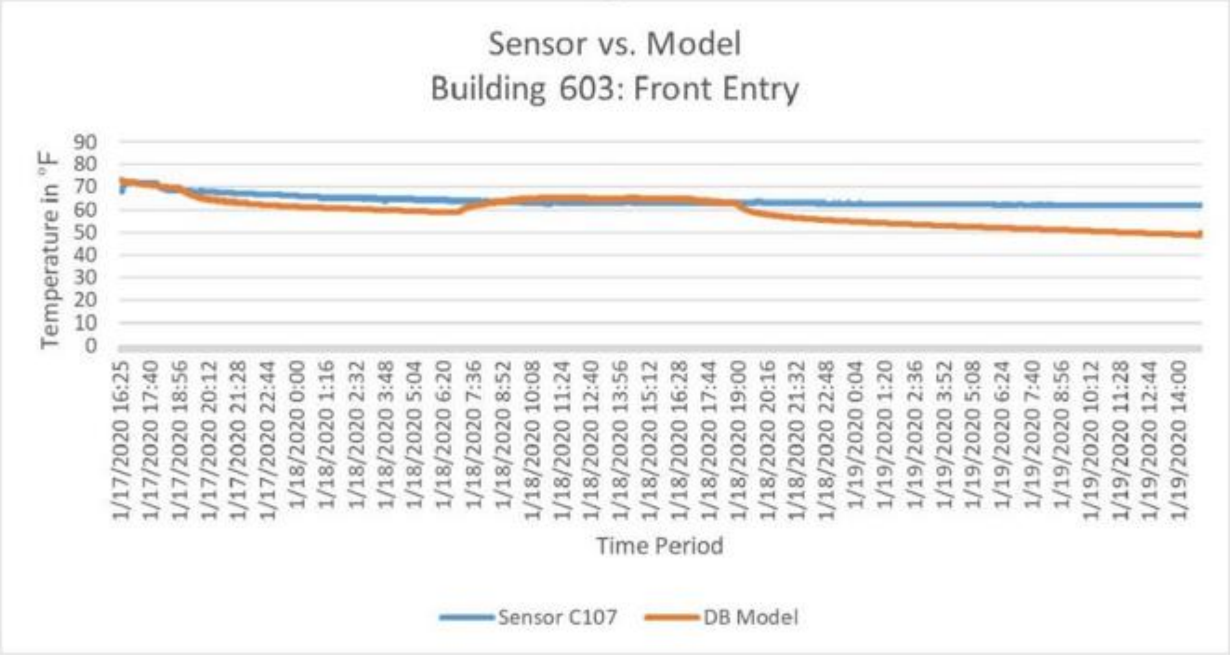
Temperature decay test at Ft Wainwright and Ft Greely





Building Model Vs TDT Test Results



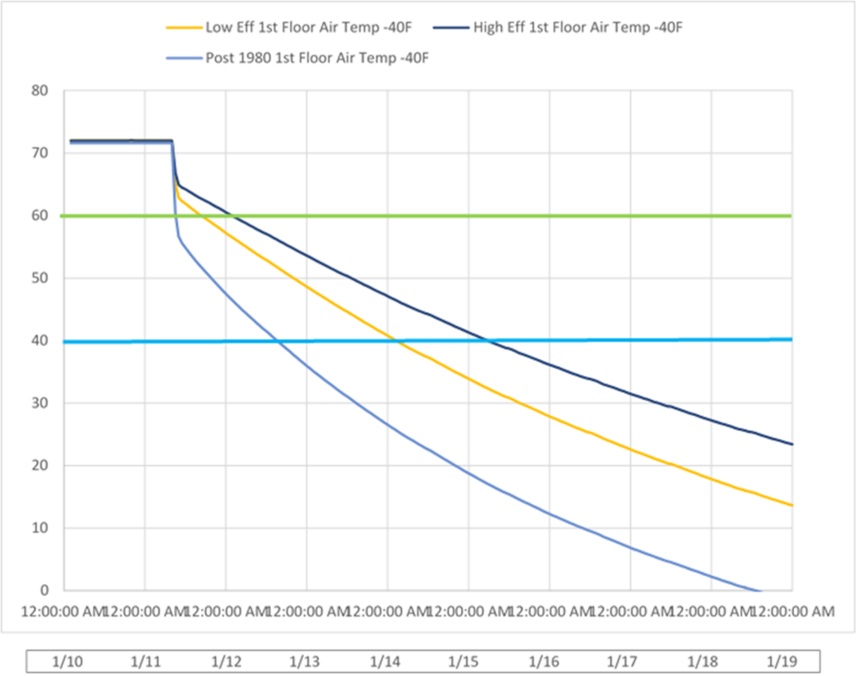


Parametric Analysis Using the Bldg. 4070 Model

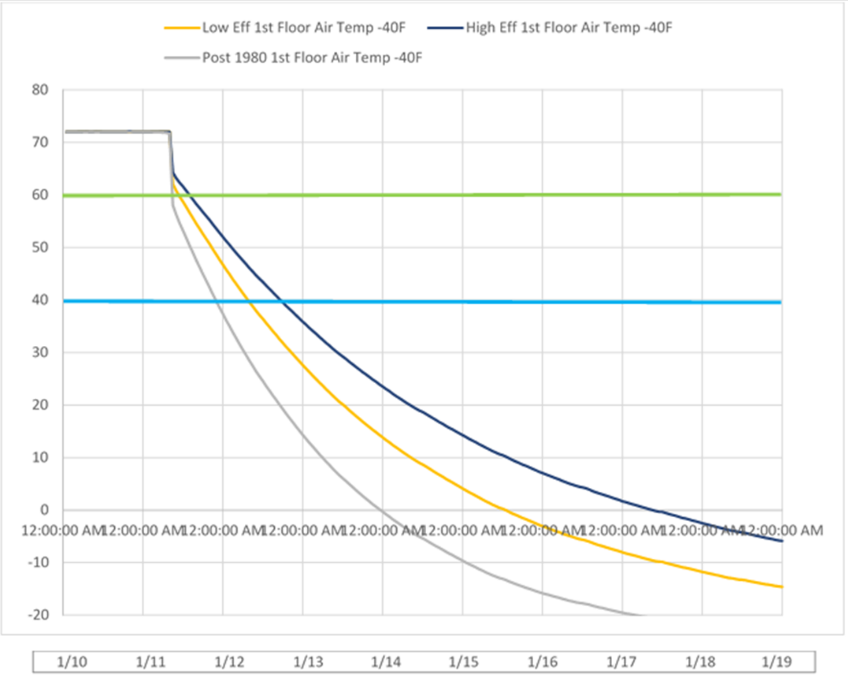
Building Parameters	Temp ODB	Mass Building			Frame Building		
		Typical/Post 1980	Low Efficiency	High Efficiency	Typical/Post 1980	Low Efficiency	High Efficiency
Walls (R-Value IP)		20.5	40	50	20.5	40	50
Roof (R-value IP)		31.5	45	60	31.5	45	60
Air Leakage (ACH)		0.4	0.25	0.15	0.4	0.25	0.15
Window (R-Value / U value)		Double Pane; R= 1.78 / U=.56	Double Pane; R= 3.34 / U=.3	Triple Pane; R= 5.25 / U=.19	Double Pane; R= 1.78 / U=.56	Double Pane; R= 3.34 / U=.3	Triple Pane; R= 5.25 / U=.19
MTTR Hab. (60F)	**-60 F**	< 1 hours	2 hours	5 hours	<< 1 hour	1 hours	2 hours
MTTR Sust. (40F)	**-60 F**	9 hours	28 hours	41 hours	4 hours	14 hours	21 hours
MTTR Hab. (60F)	**-40 F**	1 hours	3 hours	10 hours	< 1 hour	2 hours	4 hours
MTTR Sust. (40F)	**-40 F**	20 hours	36 hours	51 hours	10 hours	18 hours	24 hours
MTTR Hab. (60F)	**-20 F**	2 hours	6 hours	15 hours	1 hour	3 hours	6 hours
MTTR Sust. (40F)	**-20 F**	31 hours	46 hours	60 hours	15 hour	22 hours	28 hours
MTTR Hab. (60F)	**0 F**	3 hours	13 hours	29 hours	2 hours	5 hours	9 hours
MTTR Sust. (40F)	**0 F**	43 hours	59 hours	90 hours	21 hours	28 hours	33 hours
MTTR Hab. (60F)	**20 F**	10 hours	28 hours	45 hours	3 hour	8 hours	15 hours
MTTR Sust. (40F)	**20 F**	60 hours	78 hours	95 hours	28 hours	35 hours	40 hours
MTTR Hab. (60F)	**40 F**	29 hours	54 hours	72 hours	8 hour	17 hours	23 hours
MTTR Sust. (40F)	**40 F**	93 hours	112 hours	123 hours	41 hours	47 hours	50 hours

Temperature Decay in Mass Vs Frame Buildings

Mass Building: High efficiency, Low efficiency, & Typical 1980 Heating Failure Results at outdoor air T = -40 °F (-40.0 °C)



Frame Building: High efficiency, Low efficiency, & Typical 1980 Heating Failure Results at outdoor air T = -40 °F (-40.0 °C)



Publications

Three technical paper session at the 2021 ASHRAE winter conference sponsored by TC 7.6. The following papers have been accepted for presentation:

- Session CS1. Energy Master Planning for Resilient Public Communities - Best Practices.
  1. Energy Master Planning for Resilient Public Communities - Best Practices from Denmark
  2. Energy Master Planning for Resilient Public Communities - Best Practices from North American Universities
  3. Energy Master Planning for Resilient Public Communities - Best Practices from Austria
- Session CS2. Energy Systems Resilience: Concept and Tools
  1. Defining, Measuring and Assigning Resilience Requirements to Electric and Thermal Energy Systems
  2. Incorporating resiliency analysis into energy master planning computer-based tool
- Session CS3. Thermal Energy Systems Resilience for Cold/Arctic Climates
  1. Requirements for Building Thermal Conditions under Normal and Emergency Operations in Extreme Climates.
  2. Building Enclosure Testing on Alaska Military Base Projects
  3. Best Practices for HVAC, Plumbing and Heat Supply in Arctic Climates

Publications (Cont)

- Technical paper session with two technical papers have been prepared, submitted and accepted by the ASHRAE for the 2021 annual conference:
  - ♦ Bjorn Oberg, Angela Urban, Emmette Leffel, Jonathan Goebel, Matt Perry, Dragos Vas, Dayne Broderson, Richard Liesen, Alexander Zhivov. Thermal Energy System Resilience: Thermal Decay Test (TDT) in Cold/Arctic Climates, Part I Data Collection and Protocol.
  - ♦ Liesen, Richard J., Brianna Morton, Brandy Diggs-McGee, and Alexander Zhivov. Thermal Energy System Resilience: Thermal Decay Test (TDT) in Cold/Arctic Climates, Part II Modeling.
- 5 papers have been submitted and accepted to be presented and published at Cold Climate HVAC & Energy 2021, 10th International SCANVAC Cold Climate Conference, 20-21 April 2021;
- 2 paper have been submitted and accepted by the IBPC2021 8th International Building Physics Conference, Copenhagen Denmark, 25-27 August 2021.
- Papers from 2020 ASHRAE Winter Conference, Orlando, FL. February 1 - 5, 2020
  - ♦ Terry Sharp, Matthias Haase, Alexander Zhivov, Behzad Rismanchi, Rüdiger Lohse, Jorgen Rose, Natasa Nord. 2020. Energy Master Planning: Identifying Framing Constraints that Scope Your Technology Options
  - ♦ Robert Jeffers, Amanda M. Wachtel, Alexander M. Zhivov, Calum B. Thompson, Avinash Srivastava, Patrick W. Daniels. Integration of Resilience Goals into Energy Master Planning Framework for Communities.
  - ♦ Angela Urban, Elizabeth Keysar, Kathleen Judd, Michael Case, Avinash Srivastava, Calum Thompson, Alexander Zhivov. Energy Master Planning for Resilient Public Communities—Best Practices from U.S. Military Installations

Dissemination

- Integration of energy systems resiliency analysis into energy master planning process
- Energy requirements for mission critical operations
- Technologies and thermal energy systems architectures for resilient public communities
- Electrical systems architectures for mission critical operations
- Incorporating resiliency analysis into energy master planning computer-based tool
- Guide for Energy Master Planning in resilient public communities – received contract with Springer publishing company
- Guide for resilient thermal energy systems design in cold/Arctic climates – ASHRAE expressed an interest in publication as a complementing document to the Cold Climate Design Guide (undergoing review and approval by TC 2.10 and CCDG WG).

Energy Master Planning for Resilient Public Communities

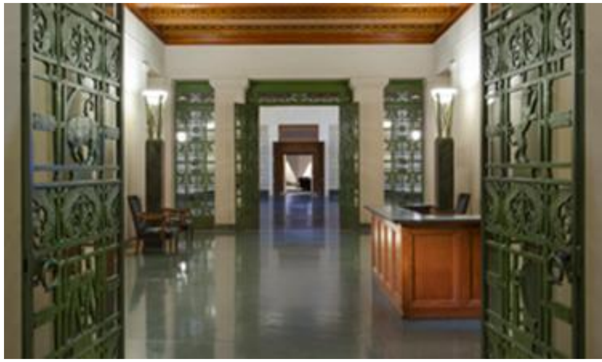
Virtual Training

October 13-16, 2020

Presentations and recordings are now available at https://nationalacademies.org/energy-master-planning-2020.

The National Academies of
SCIENCES · ENGINEERING · MEDICINE

ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER



FEDERAL FACILITIES COUNCIL

Website

Annex 73 have been moved to the IEA EBC platformed and populated with the current information https://annex73.iea-ebc.org/

HOME ABOUT SUBTASKS PUBLICATIONS ▾ PARTICIPANTS NEWS MEETINGS MEMBER AREA

HOME / MEETINGS / MEETING

Energy Master Planning for Resilient Public Communities

October 13-16, 2020
USA

Until recently, energy systems for new facilities have been planned on an individual basis without consideration for how those energy choices might impact future energy generation needs across the entire community. Now, many communities across the world are formulating energy master plans that will coordinate ongoing and future energy initiatives to minimize energy use, reduce costs, increase the diversity of energy supply, and prioritize resilience to potential energy disruptions.

Join us for a virtual training workshop to hear from energy experts from around the world on how federal and military installations can successfully create and implement energy master plans. Presentations and moderated discussions will include numerous case studies describing ongoing and completed projects at military installations, university campuses, and other public communities from across the globe.

- Workshop Flyer

Agenda and Presentations

- Speaker Bios and Photos

Tuesday, October 13, 2020

SESSION 1: ENERGY MASTER PLANNING AND RESILIENCE ANALYSIS

10:00 – 10:05 a.m. **Federal Facilities Council Welcome**
-- Mr. Cameron Oskvig, Director, Federal Facilities Council (FFC) and Board on Infrastructure and the Constructed Environment (BICE)

10:05 – 10:10 a.m. **1.1 Welcome and Introduction to Virtual Training Workshop**
-- Dr. Alexander Zhivov, Senior Research Engineer, U.S. Army Corps of Engineers (USACE) Engineer Research and Development Center (ERDC), Construction Engineering Research Laboratory (CERL)

Thank you

Questions and comments?