

Net Zero – Reducing Energy and Carbon in New York State Building Stock

Engineering Symposium in Rochester

April 23, 2019

Bill Bishop, PE, LEED AP, CEM

Senior Energy Engineer



Why Net Zero Buildings?

Greenhouse Gases and Global Warming

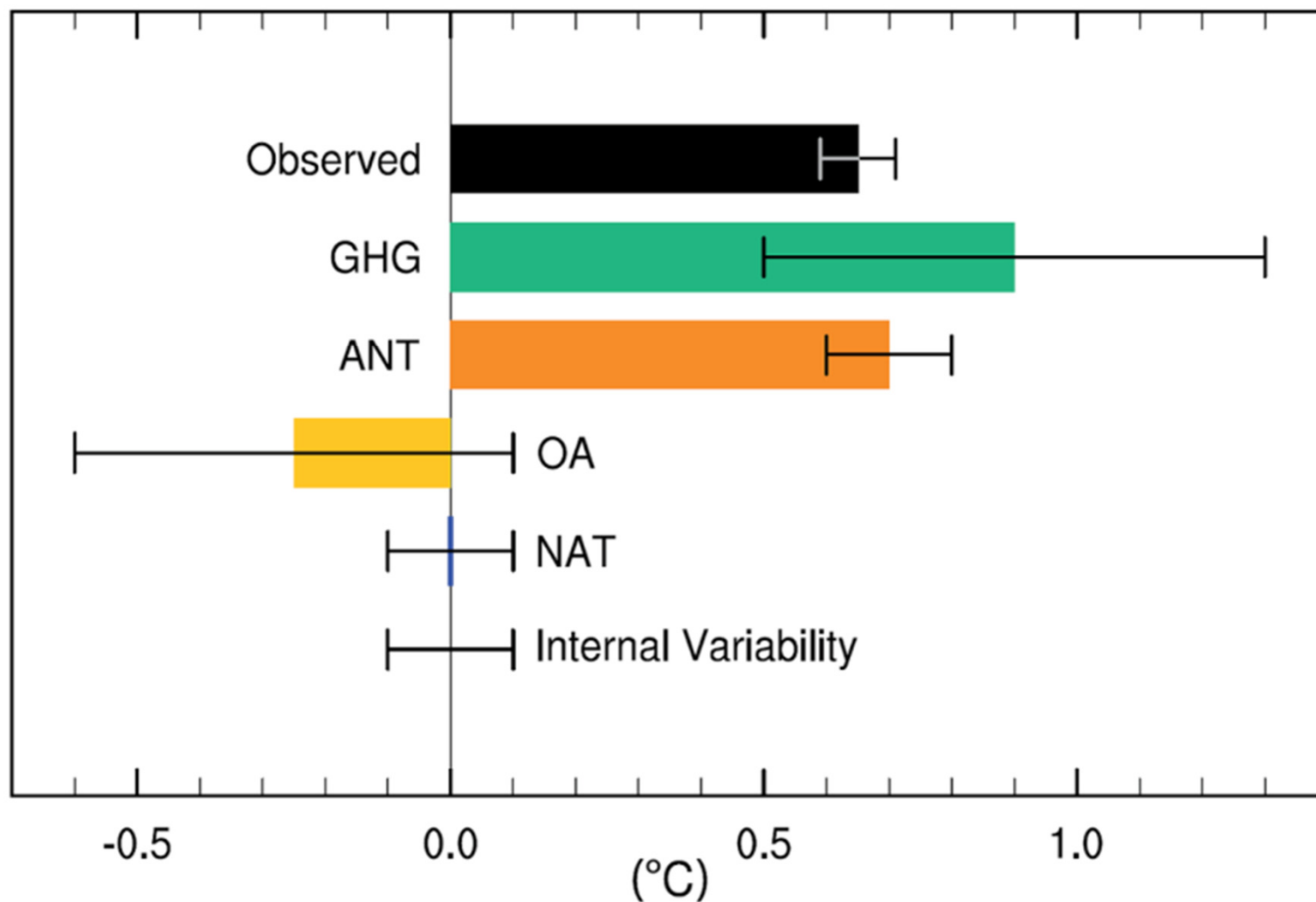
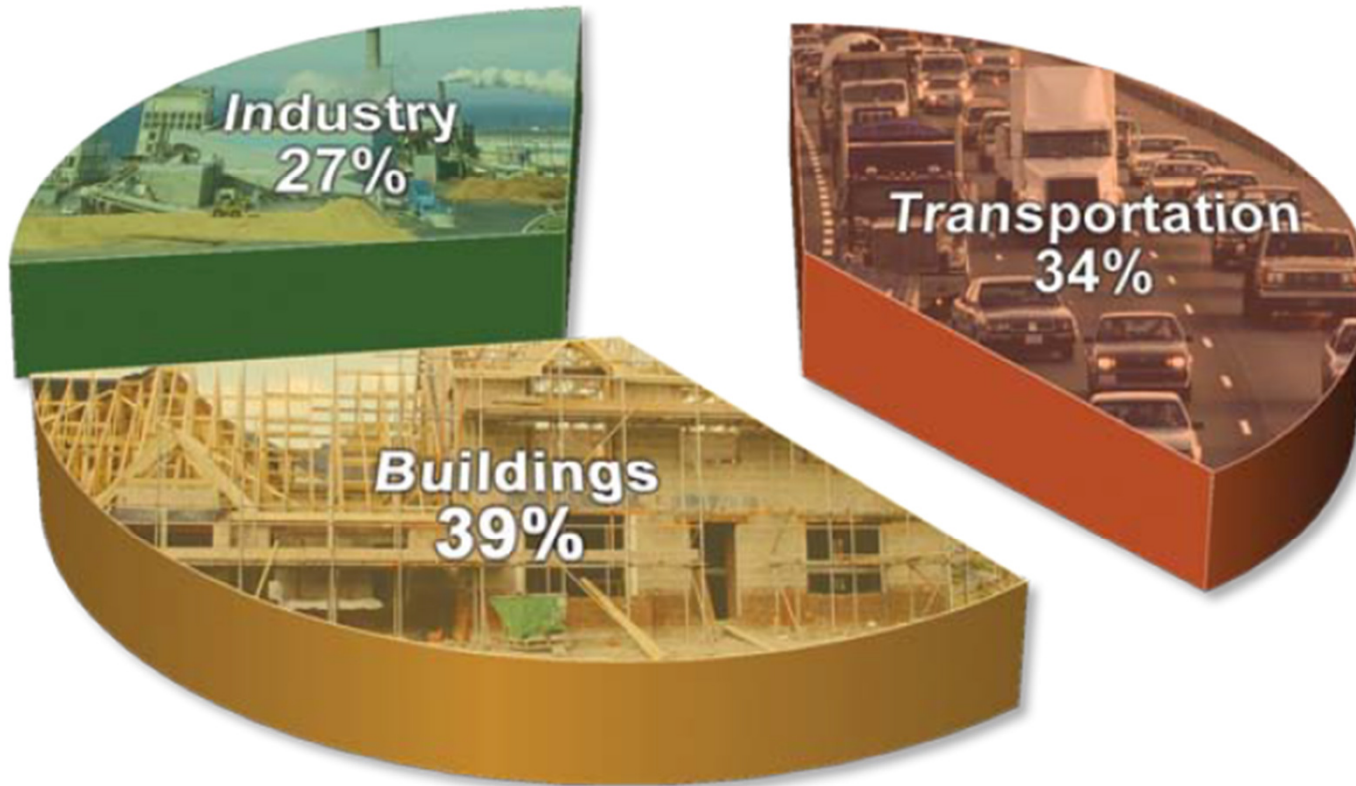


Figure TS10 from the IPCC Fifth Assessment Report. Observed temperatures are from HadCRUT4. GHG is all well-mixed greenhouse gases, ANT is total human forcings, OA is human forcings apart from GHG (mostly aerosols), NAT is natural forcings (solar and volcanoes), and Internal Variability is an estimate of the potential impact of multidecadal ocean cycles and similar factors. Error bars show one-sigma uncertainties for each. Source: IPCC.

Why Net Zero Buildings?

U.S. Energy & CO2 Emissions from Buildings

U.S. Energy Use



Why Net Zero Buildings?

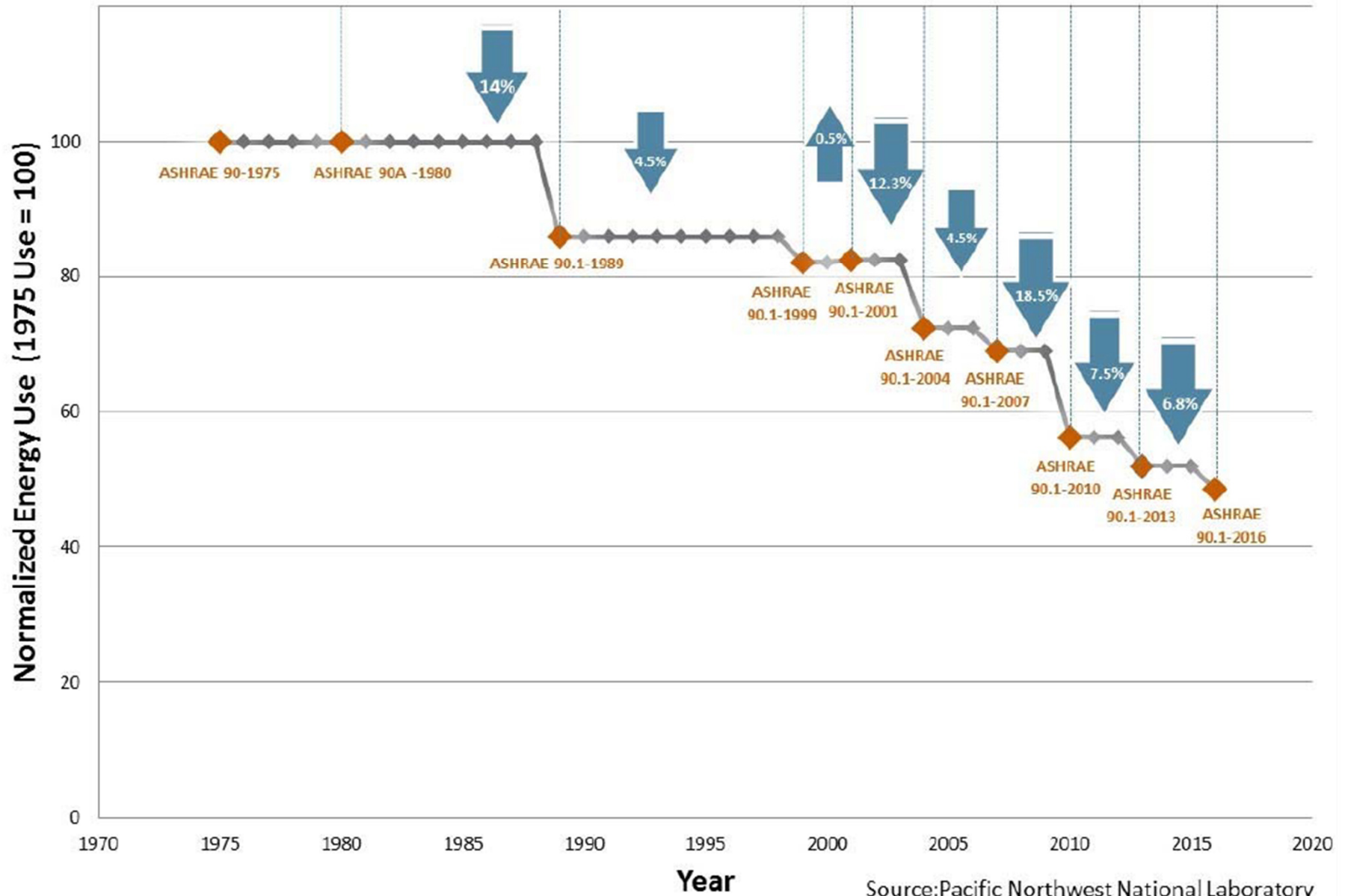
U.S. Energy & CO2 Emissions from Buildings

Some sobering statistics help drive home the reality of building energy use:

- Nearly 5 million commercial buildings and 115 million residential households in the United States consume over 40 percent of the nation's total primary energy
- Buildings consume 70 percent of electricity in the United States
- In 2007, carbon dioxide emissions attributable to lighting, heating, cooling, cooking, refrigeration, water heating, and other building services totaled 2517 million metric tons—40 percent of the U.S. total and 8 percent of the global total.

Net Zero Fundamentals – Energy Codes

Improvement in ASHRAE Standard 90.1 (Year 1975-2016)



Source: Pacific Northwest National Laboratory

Net Zero Fundamentals – Energy Codes

Commercial HVAC Efficiency Requirements

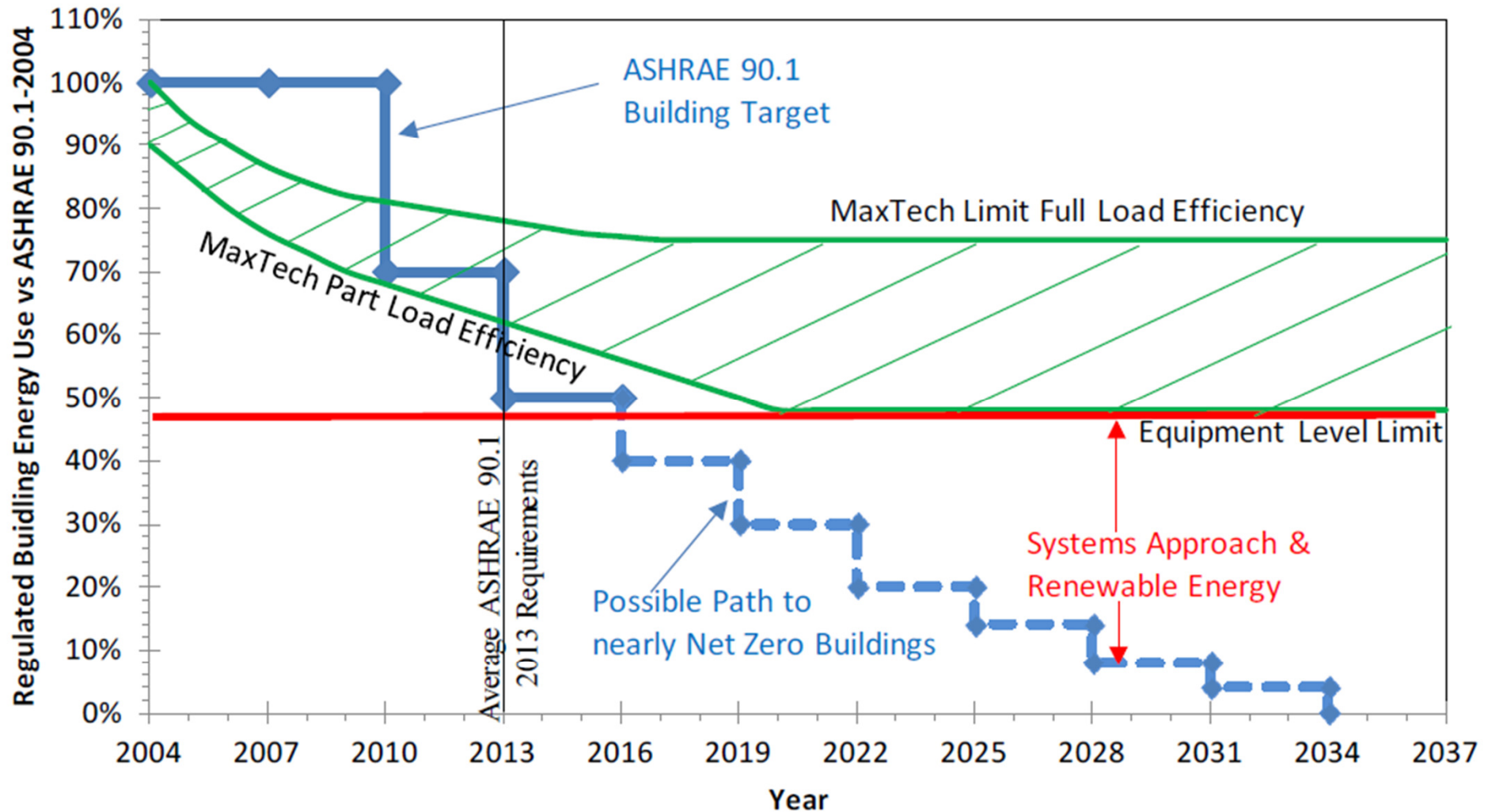


Chart is an estimate of possible future regulations to achieve Near Net Zero by 2034 based on studies done by Carrier on technical limits of HVAC equipment

Net Zero Fundamentals – Net Zero Energy

The most basic definition of a Net Zero Energy (NZE) building is that it generates as much energy as it uses over the course of a year. This building is directly connected to the electric grid for balancing energy production and use annually. When the grid goes down, the building goes down. Very simple.

Energy Use
Per Year



Energy Generation
Per Year



Net Zero Fundamentals – Net Zero Energy



Solar, Mains, EVs

View | LAN Access | Tools | Settings | Help

10/21/2016 6:22am – 10/21/2016 6:22pm

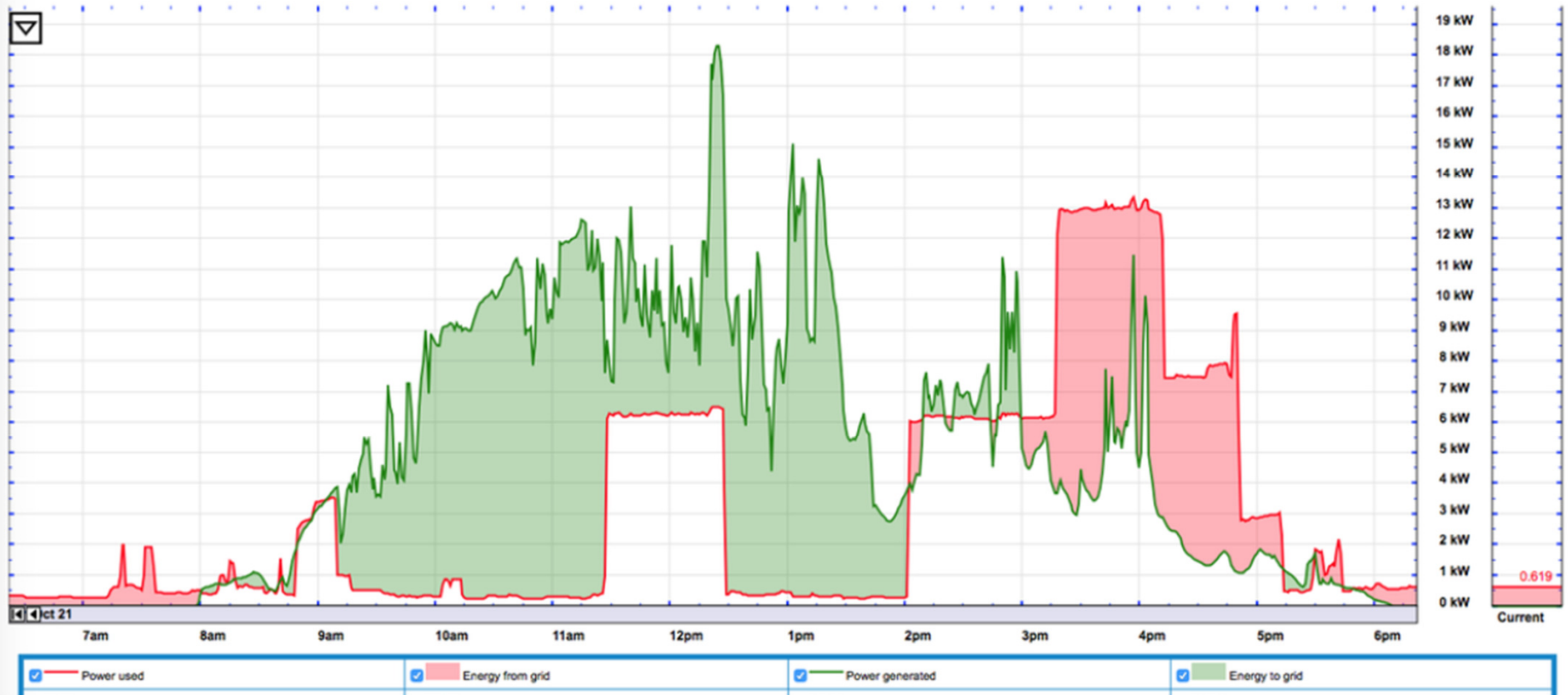
Summary for time-period shown in graph

Energy Used	36.7 kWh
Energy Generated	59.0 kWh
Net	22.3 kWh sold

Summary over last 30 days

Energy Used	891 kWh
Energy Generated	1.29 MWh
Net	397 kWh sold

- All
- 1y
- 6M
- 3M
- 1M
- 3w
- 1w
- 3d
- 1d
- 12h
- 6h
- 3h
- 1h
- 10m
- Auto
- 500kW
- 100kW
- 50kW
- 10kW
- 5kW
- 1kW
- 500W
- 100W
- 50W



<https://www.netzeromn.com/blog/the-heartbeat-of-a-netzero-house>

Net Zero Fundamentals – It's Not So Simple

Grid-Connected vs. Off-Grid



Net Zero Fundamentals – It's Not So Simple

Difficult Sites & High Energy Intensity Buildings



Net Zero Fundamentals – It's Not So Simple

Facilitating Off-Site Renewables



Net Zero Fundamentals – Net Zero Carbon

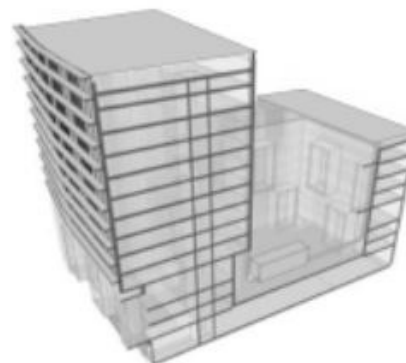
ZERO CODE™

Commercial • Institutional • Mid-Rise/High-Rise Residential Buildings

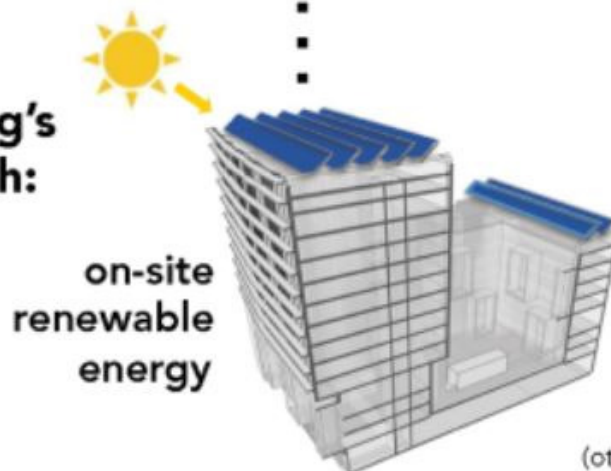
1 Design an energy efficient building

Efficiency Standard: ASHRAE 90.1-2016 minimum;
ASHRAE 189.1-2017; others

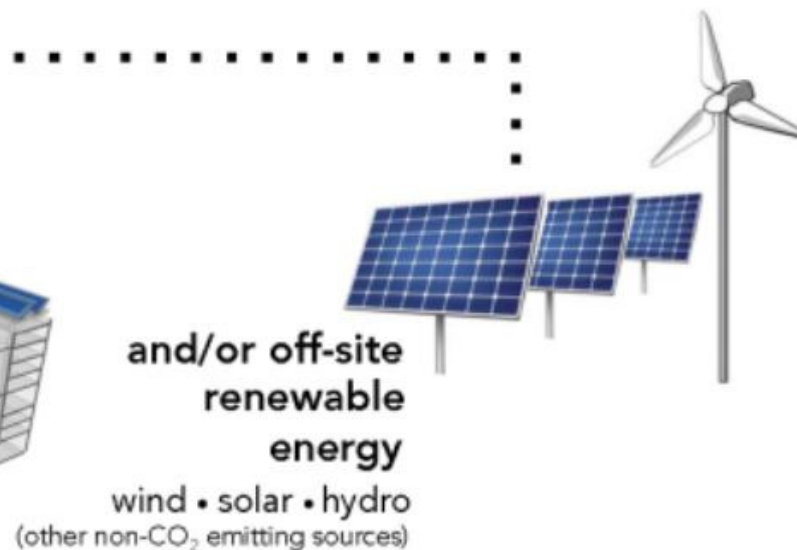
- Efficient building envelope / daylighting
- Passive heating / cooling / ventilation
- Efficient systems / equipment / controls



2 Address the remaining building's energy needs with:



on-site
renewable
energy



and/or off-site
renewable
energy

wind • solar • hydro
(other non-CO₂ emitting sources)

Net Zero Fundamentals – Net Zero Carbon

Advancing Net Zero

A World Green Building Council global project



WorldGBC definition:
A net zero carbon building is highly energy efficient with all remaining energy from on-site and/or off-site renewable sources

100% of buildings must operate at net zero carbon

2050

2030

All new buildings must operate at net zero carbon

GOVERNMENT ENGAGEMENT

TRAINING & EDUCATION

CORPORATE ENGAGEMENT

CERTIFICATION

Key Principles

1. Measure and disclose carbon

Carbon is the ultimate metric to track, and buildings must achieve an annual operational net zero carbon emissions balance based on metered data



2. Reduce energy demand

Prioritise energy efficiency to ensure that buildings are performing as efficiently as possible, and not wasting energy



3. Generate balance from renewables

Supply remaining demand from renewable energy sources, preferably on-site followed by off-site, or from offsets



4. Improve verification and rigour

Over time, progress to include embodied carbon and other impact areas such as zero water and zero waste



Net Zero Fundamentals – Net Zero Carbon

Carbon neutral building
with top tier efficiency



- 100% building energy load offset with on- or off-site renewables
- Best-in-class energy efficiency required
- Performance based
- For existing buildings, combustion allowed

Building with world class efficiency and characteristics, reinforcing a fossil fuel free future



- 100% building energy load offset with on-site renewables, driving efficiency
- Pathway for premium off-site renewables for high energy building types
- Performance based
- No combustion allowed

Summit of energy related aspiration and attainment



- Net positive
- 105% building energy load offset with on-site renewables, driving efficiency
- Resilient energy systems
- Pathway for premium off-site renewables for high energy building types
- Performance based
- No combustion allowed

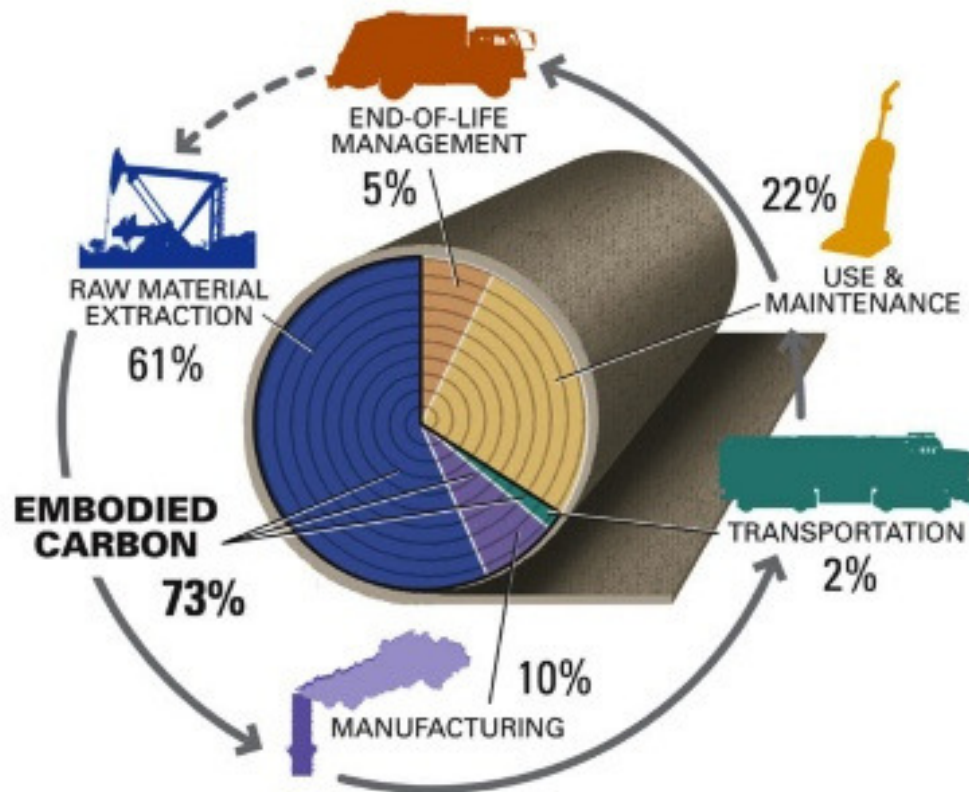
Summit of holistic aspiration and attainment; fully restorative



- Net positive
- 105% building energy load offset with on-site renewables, driving efficiency
- Resilient energy systems
- Pathway for premium off-site renewables for high energy building types
- Performance based
- No combustion allowed
- Fully integrated design
- Stronger focus on naturally (rather than electrically) derived services

Net Zero Fundamentals – Net Zero Carbon

Embodied Energy vs. Carbon Footprint



Embodied Energy = Sum of all energy needed to produce any product, as if that energy was incorporated or "embodied" into the product itself.

Carbon Footprint = Sum of all greenhouse gases emitted by the full life cycle of a product.

Net Zero Fundamentals – Net Zero Carbon

Transportation Energy



Learning Assessment Time!



If a building uses on-site fossil fuels, how much renewable electricity would it need to feed to the grid to be a Net Zero Energy building?

- A. The same amount that it takes from the grid
- B. Less than what it takes from the grid
- C. The amount it takes from the grid plus the fossil fuel energy
- D. The amount it takes from the grid - but occupants use bicycles

Learning Assessment Time!



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Learning Assessment Time!



To be a Net Zero Carbon building, what additional metric might be quantified besides renewable energy sourcing?

- A. Total building energy consumption
- B. Carbon emissions from building materials
- C. Carbon emissions from transportation
- D. All of the above

Learning Assessment Time!



To be a Net Zero Carbon building, what additional metric might be quantified besides renewable energy sourcing?

- A. Total building energy consumption
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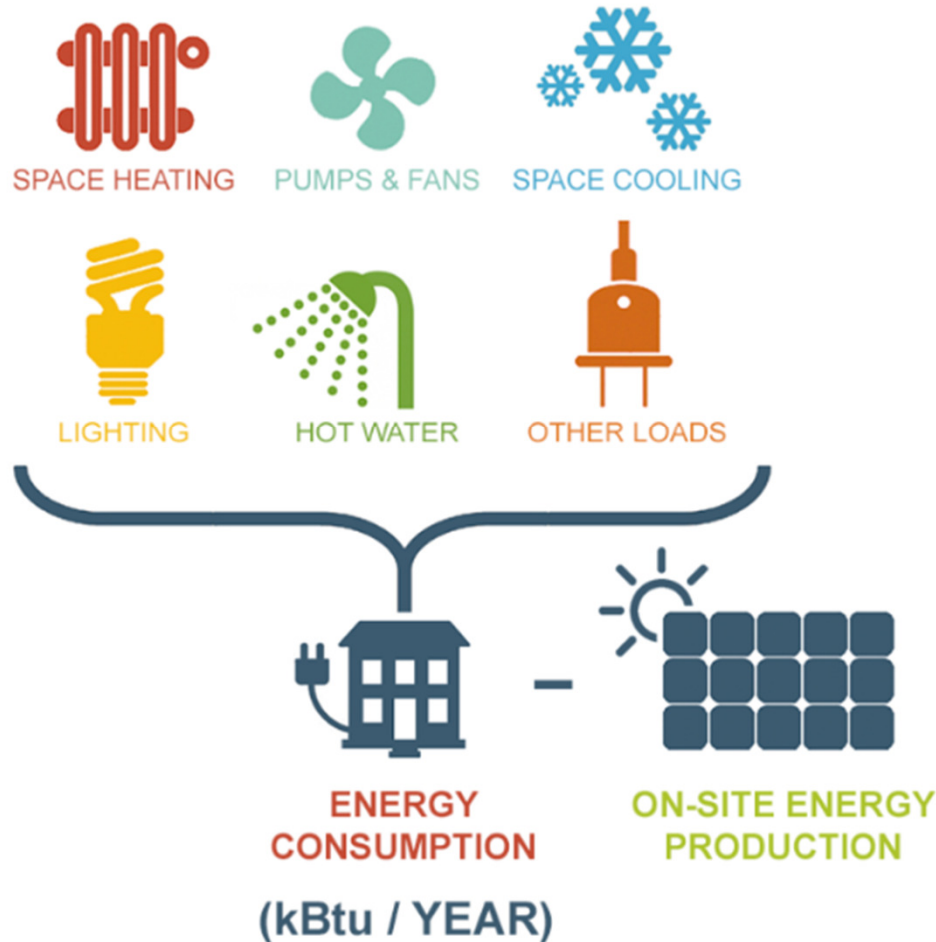
Net Zero Design – Outline

- Building energy and carbon - metrics
- Project design strategies
- Design elements & features
- HVAC & heat pumps
- “Smart buildings” and building controls

Net Zero Design – Building Design for Net Zero

Site Energy Use Intensity (EUI)

MEASURED FOR 365 DAYS



kWh x 3.412 kBtu/kWh

therms x 100 kBtu/therm

Conditioned floor area (ft²)

get **EUI** in kBtu/ft²-yr
or kWh/m²-yr

Net Zero Design – Building Design for Net Zero

Greenhouse Gas Emissions

- Written as “CO_{2e}” “CO_{2e}” or “CO_{2eq}” meaning CO₂-equivalent
- Includes contributions from CH₄ and N₂O
- Units of mass – lb, kg, MT (metric tons)
- Direct Emissions - from fuel directly burned at the building
- Indirect Emissions – associated with the energy utility
- Total Emissions = Direct + Indirect

Net Zero Design – Building Design for Net Zero

Greenhouse Gas Emissions

- Thermal factors (e.g. 0.091 MBtu/gal of propane)
- Emissions factors (e.g. 53.11 kg/MBtu for gas; 1200 lb/MWh for electricity (marginal factor in Upstate NY))
- Total annual emissions (or emissions reductions) in **MTCO₂e/yr**

100,000 kWh

10,000 therms gas

5,000 gal. fuel oil

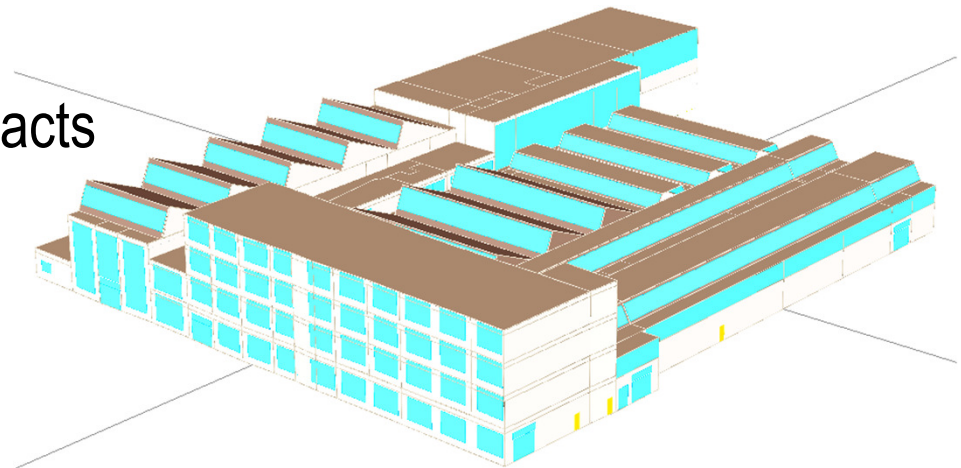
9,000 gal. propane

≈ 53 MTCO₂e

Net Zero Design – Building Design for Net Zero

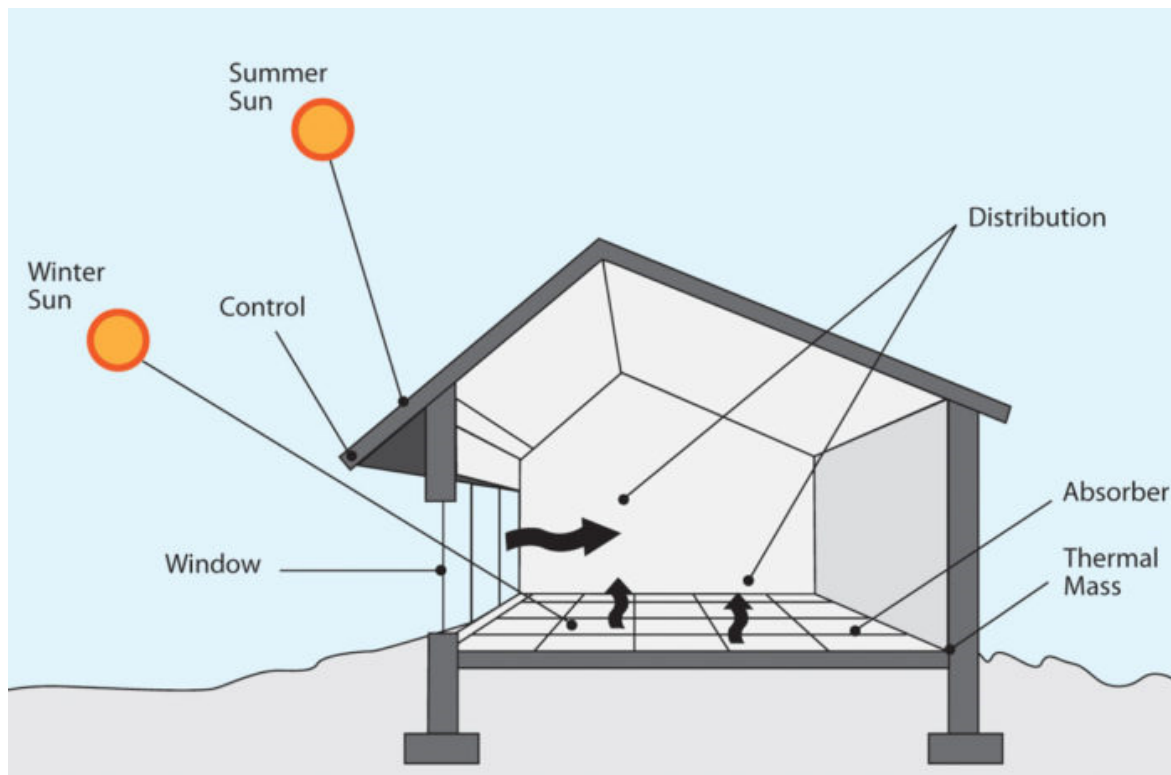
Project Design Principles

- Set project goals and minimum efficiency targets early
- Integrated design process
- Leverage energy modeling early and often
- Consider life cycle cost impacts



Net Zero Design – Building Design for Net Zero

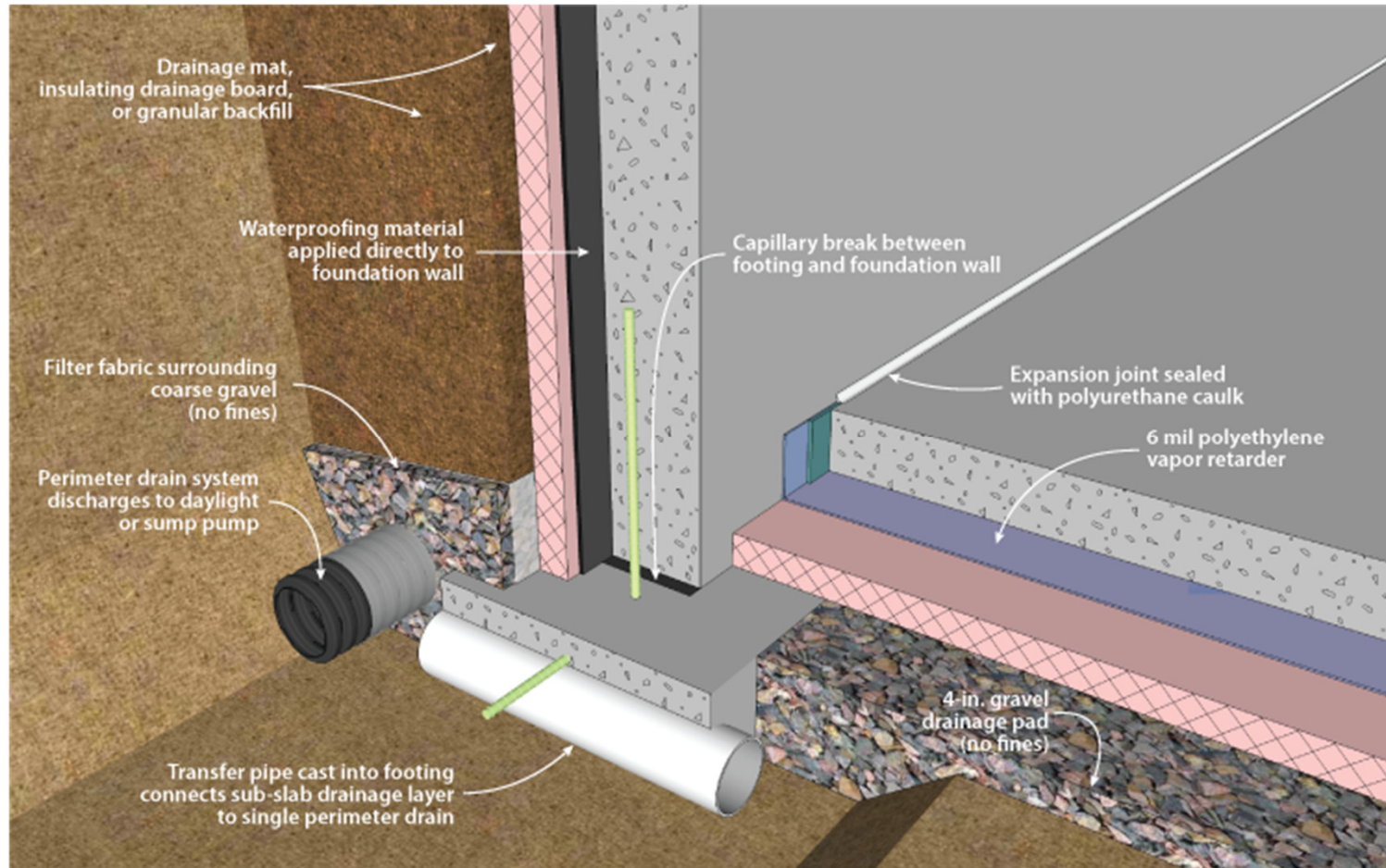
Passive (Solar) Design



- Heating
- Cooling
- Ventilation
- Lighting

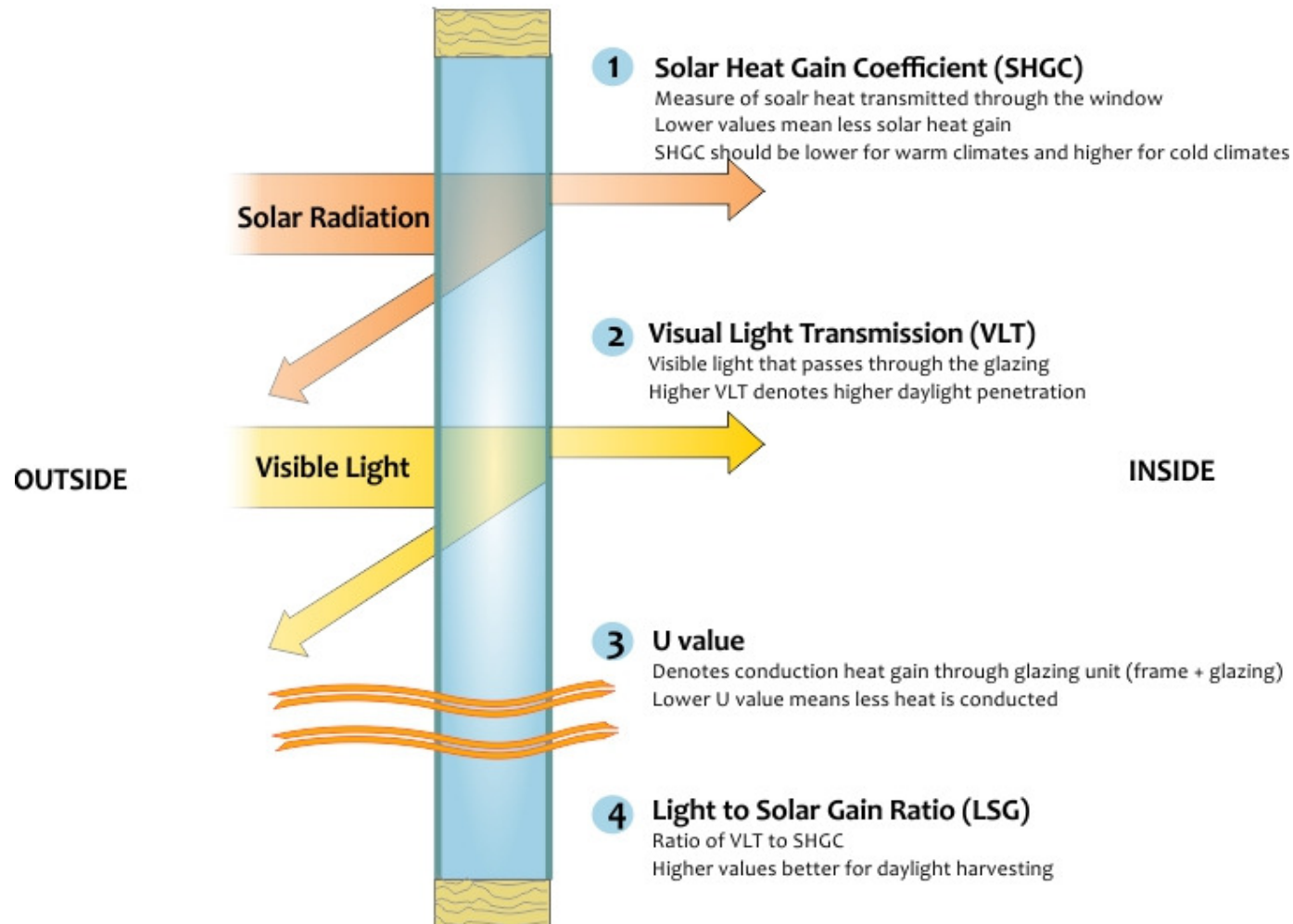
Designing a building to take maximum advantage of sunlight and the local climate, and to minimize the penalties, before using mechanical and electrical systems.

Net Zero Design – Structural and Building Envelope



- Continuous insulating envelope
- Continuous airtight layer
- Moisture barrier/resistance
- GWP and embodied energy of materials
- Increased costs and diminishing returns

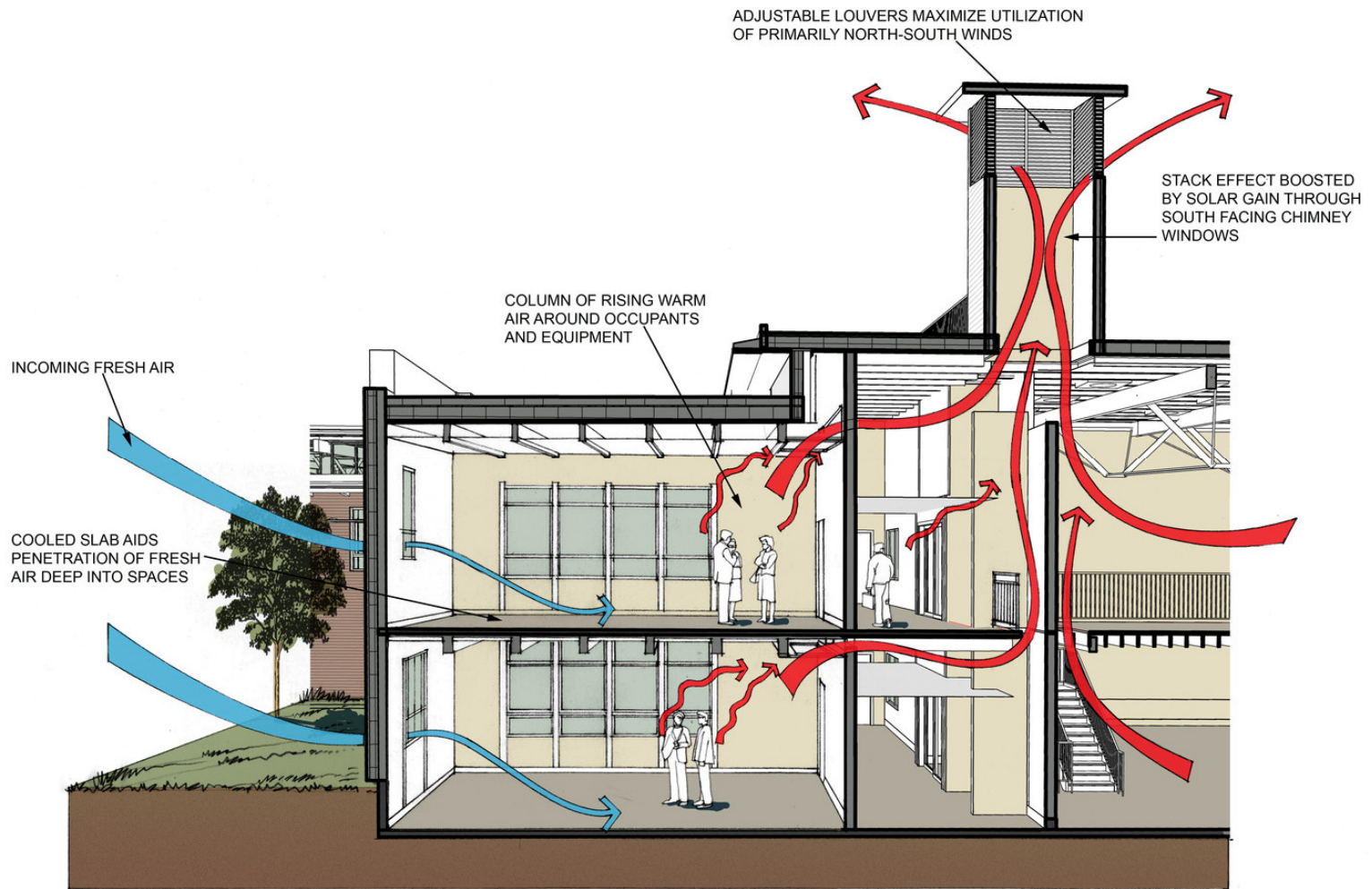
Net Zero Design – Windows



- Minimize glazing area (WWR) to reduce thermal losses
- Increase glazing area for daylighting
- Use lower U-values and include framing effects; thermal breaks
- Low-emissivity (Low-E) coatings and argon-fills
- Fixed shades and blinds

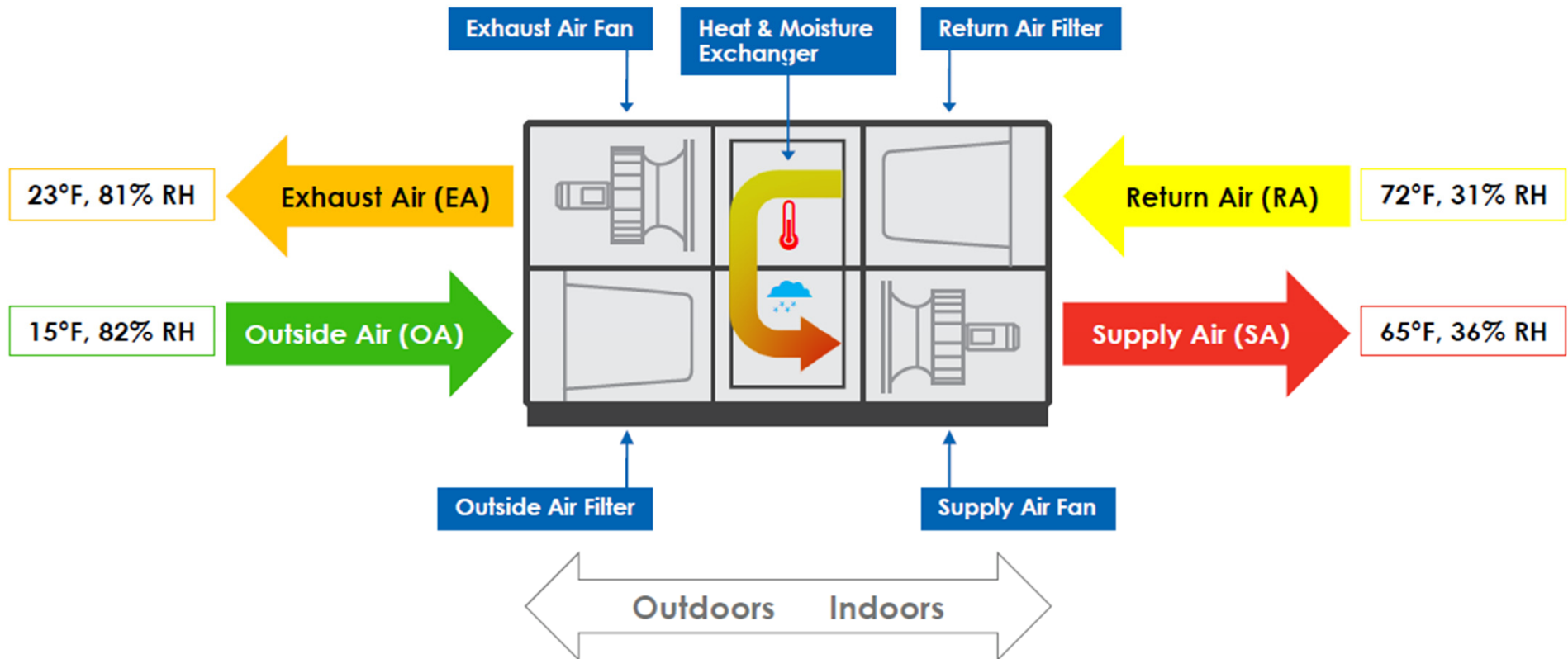
Net Zero Design – Ventilation

Natural Ventilation



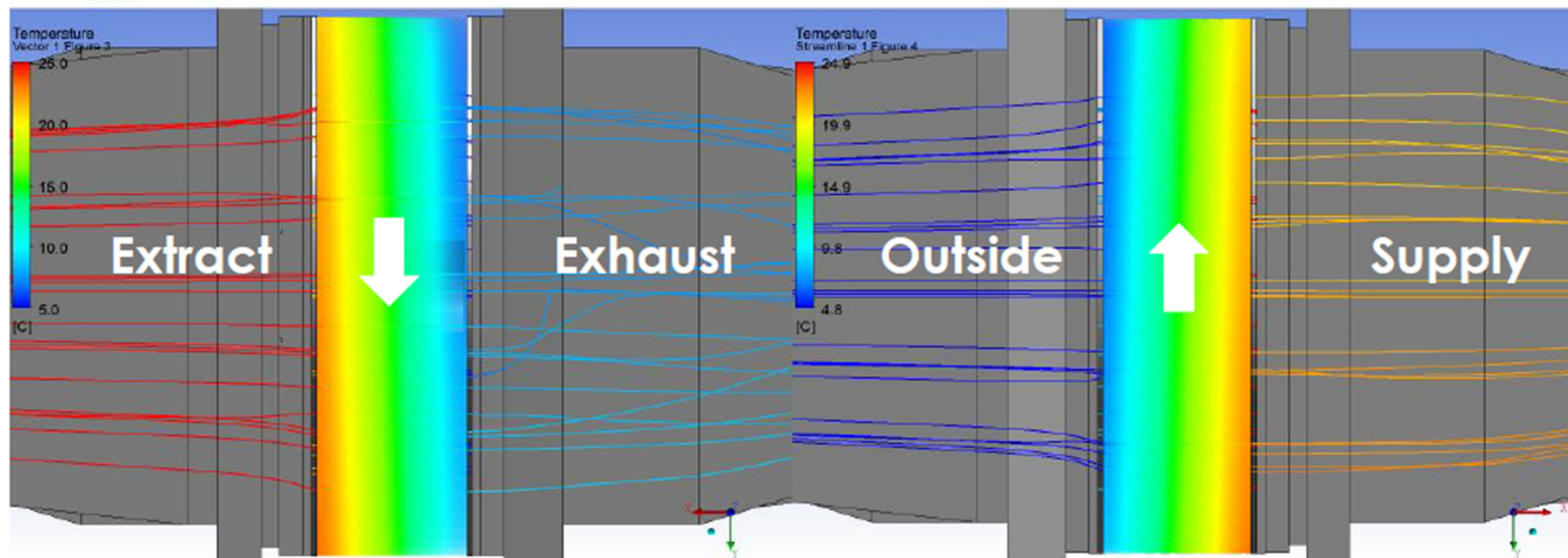
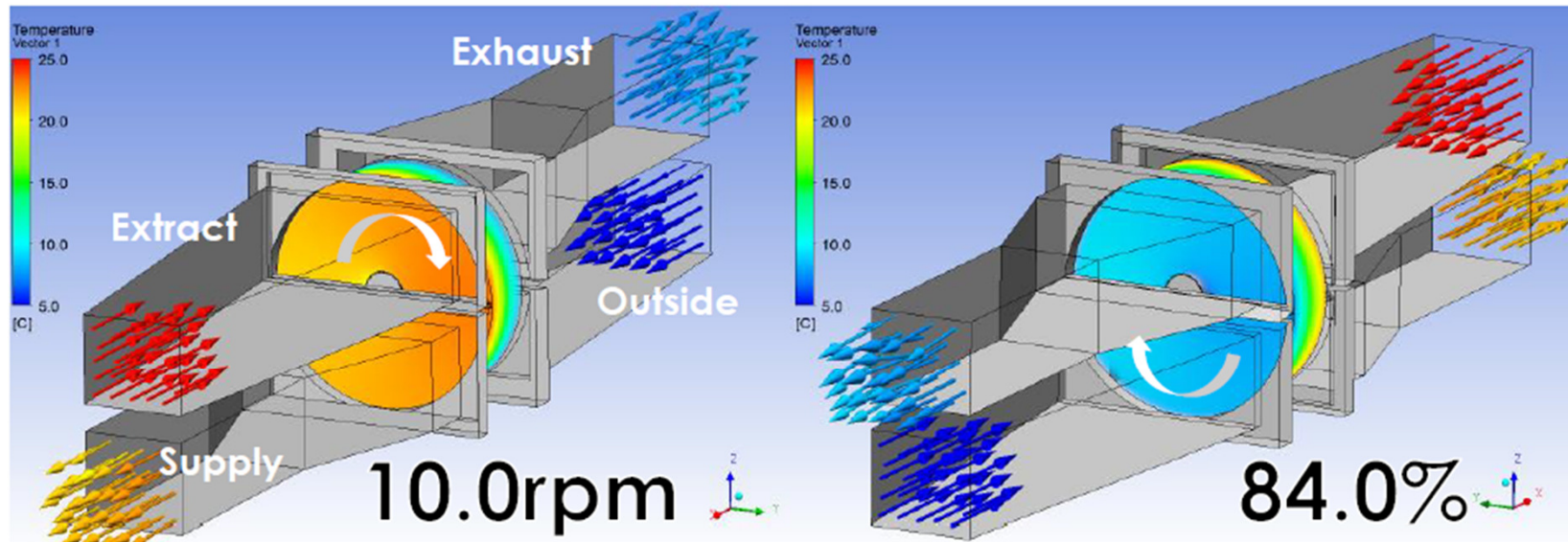
Net Zero Design – Ventilation

Energy Recovery Ventilator (ERV)



Net Zero Design – Ventilation

Energy Recovery Ventilator (ERV)



Net Zero Design – HVAC & Heat Pumps

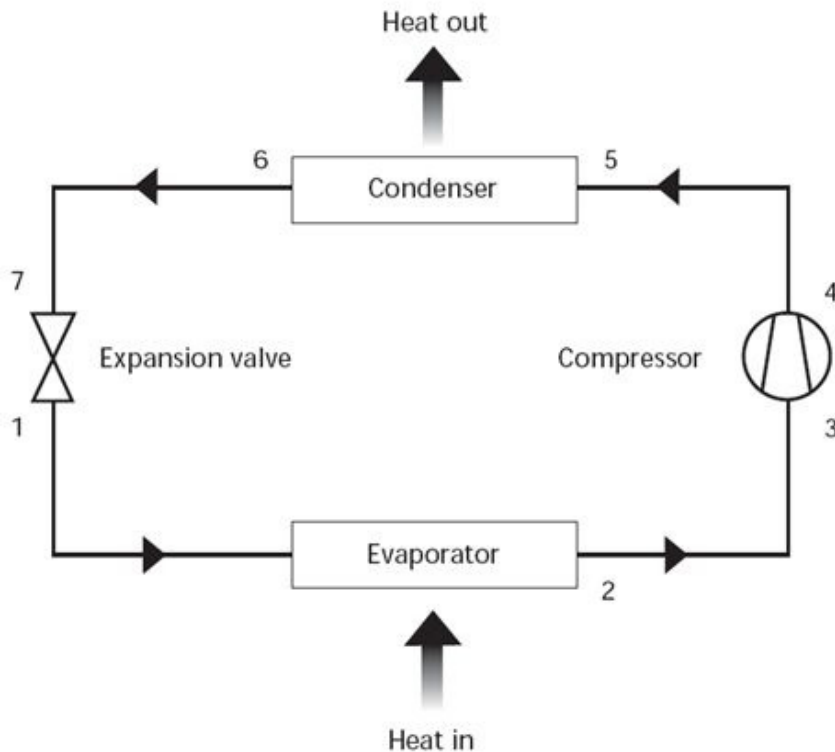
Electric Heating?



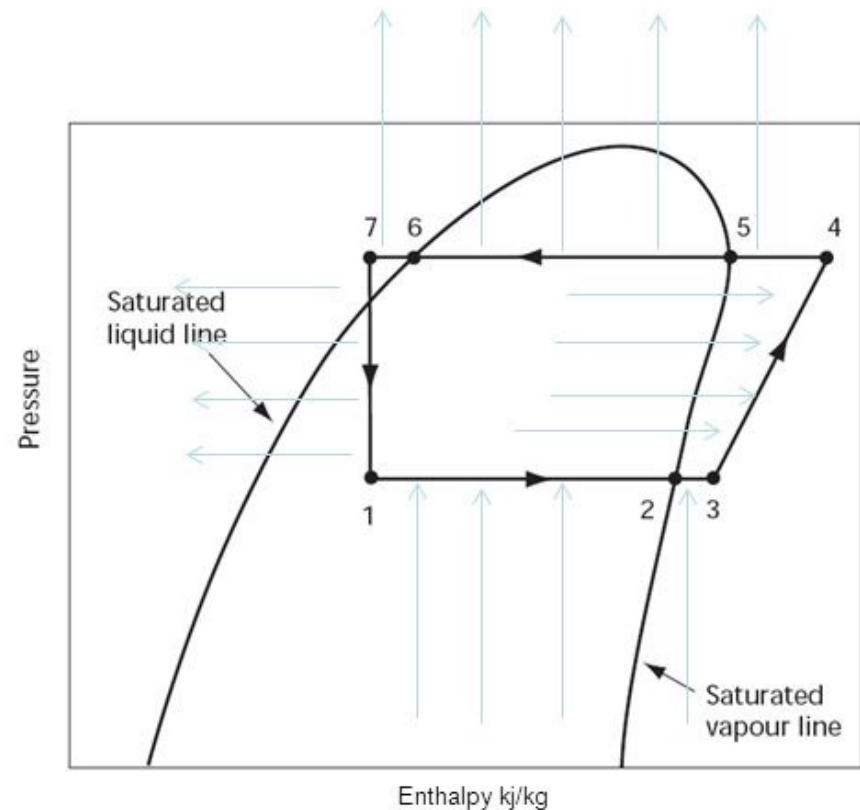
Net Zero Design – HVAC & Heat Pumps

Mechanical Refrigeration

The Vapour Compression Cycle



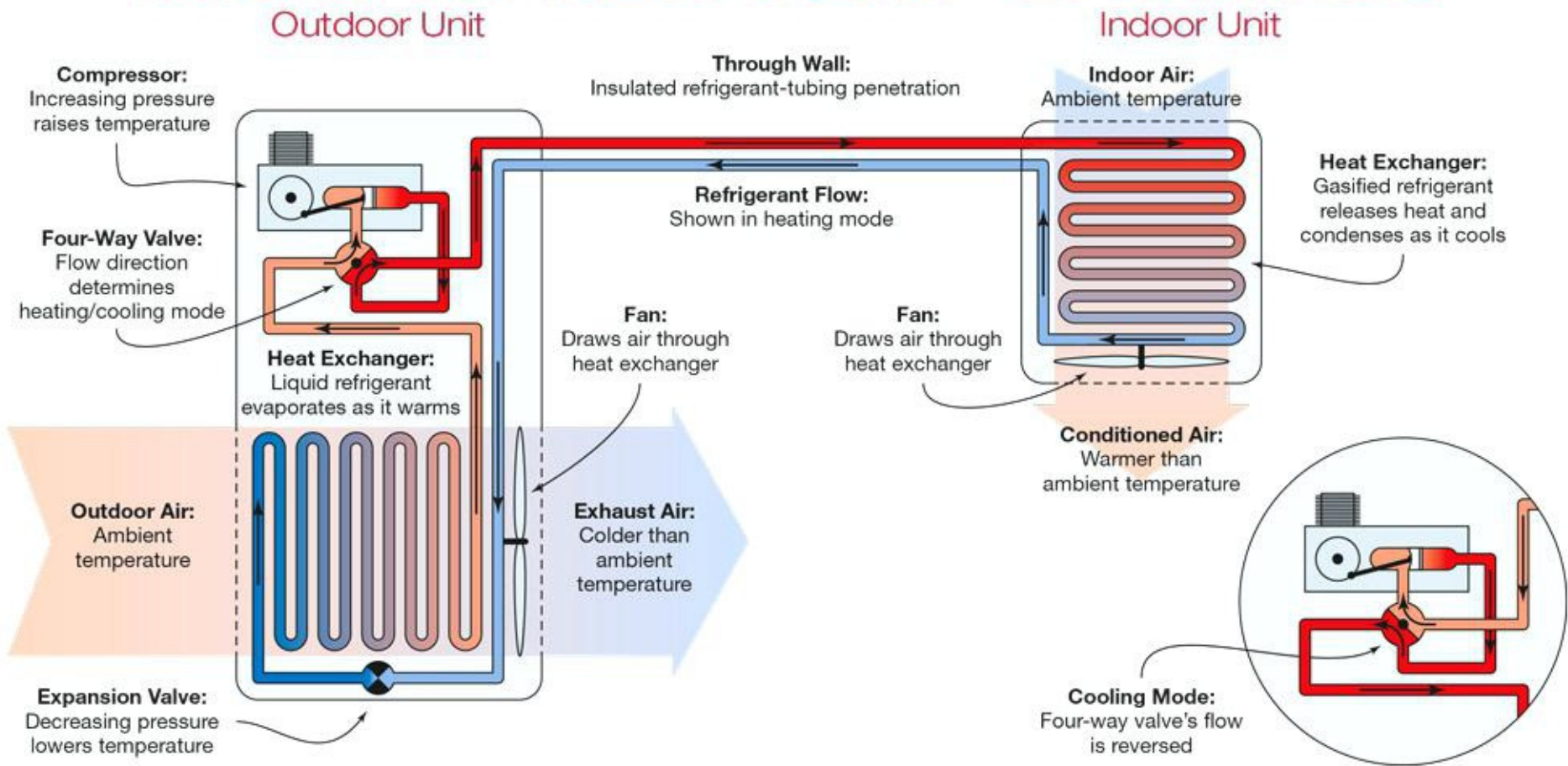
Principle Components of Vapour Compression Cycle



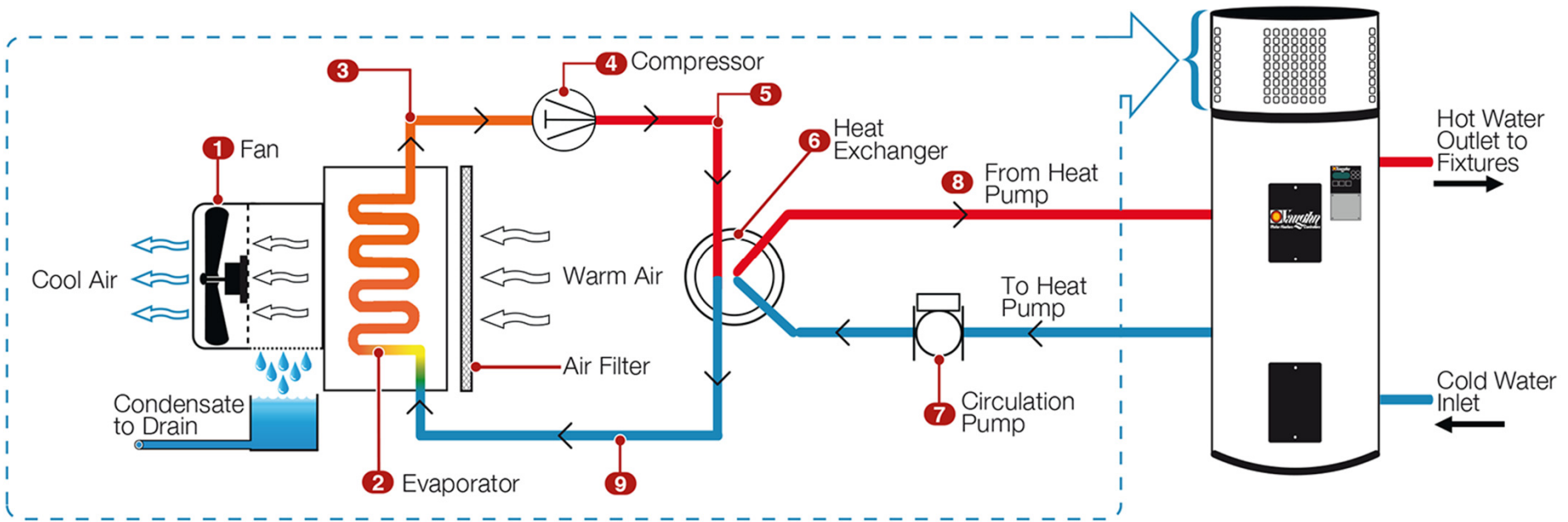
Pressure-Enthalpy Chart

Net Zero Design – HVAC & Heat Pumps

MINISPLIT HEAT-PUMP OPERATION

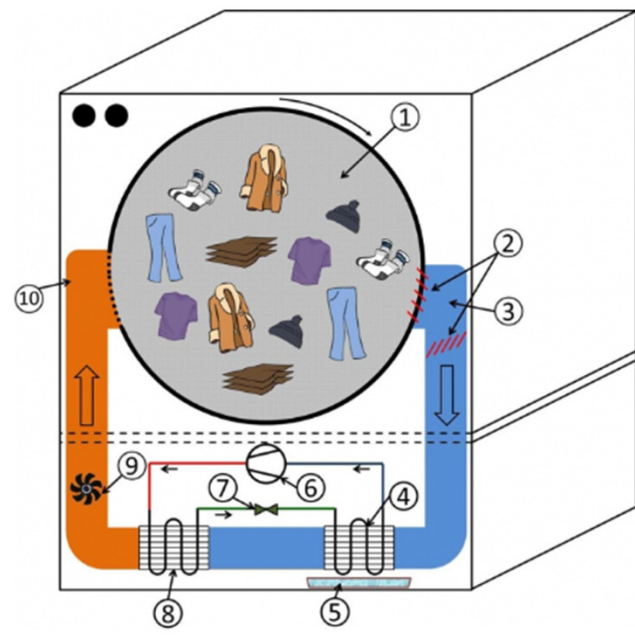


Net Zero Design – HVAC & Heat Pumps



Heat Pump Water Heater (HPWH)

Heat Pump Clothes Dryer



1. Drum
2. Filter
3. Warm Humid Air
4. Evaporator
5. Condensate
6. Compressor
7. Expansion Device
8. Condenser
9. Blower
10. Hot Dry Air

Net Zero Design – Service Hot Water

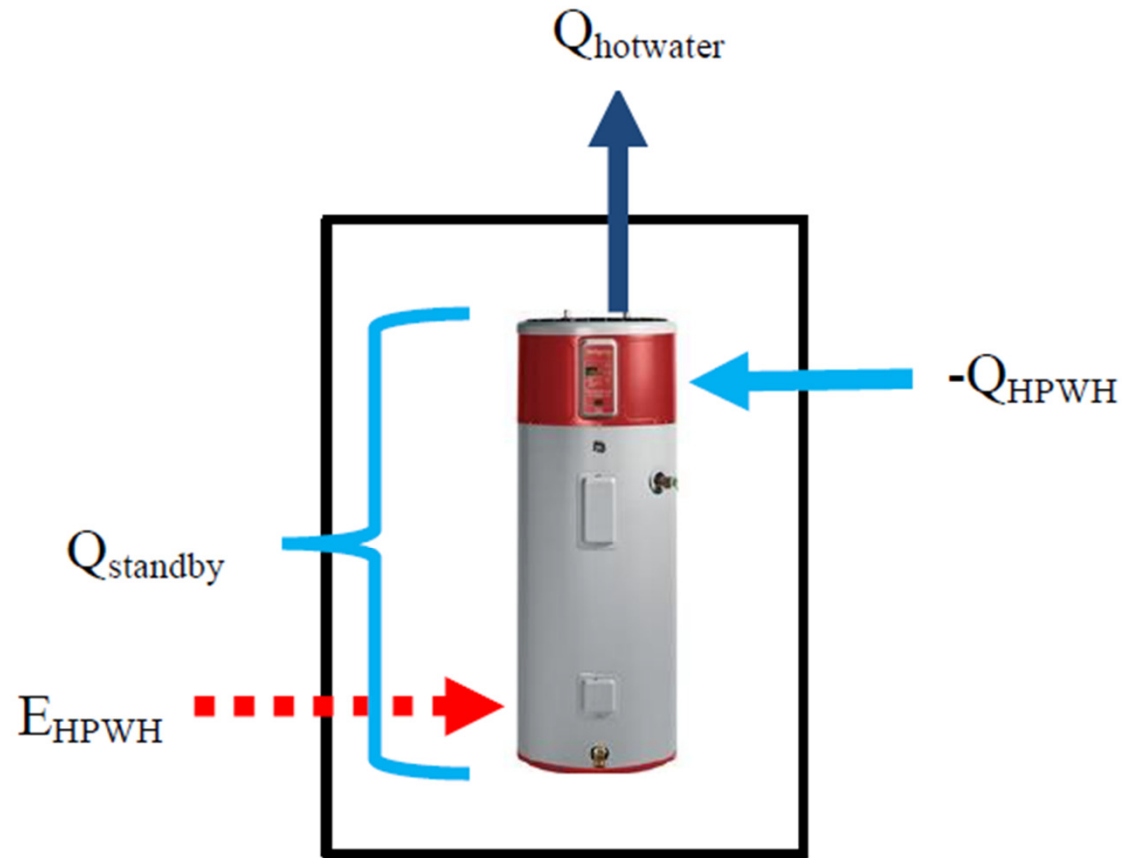


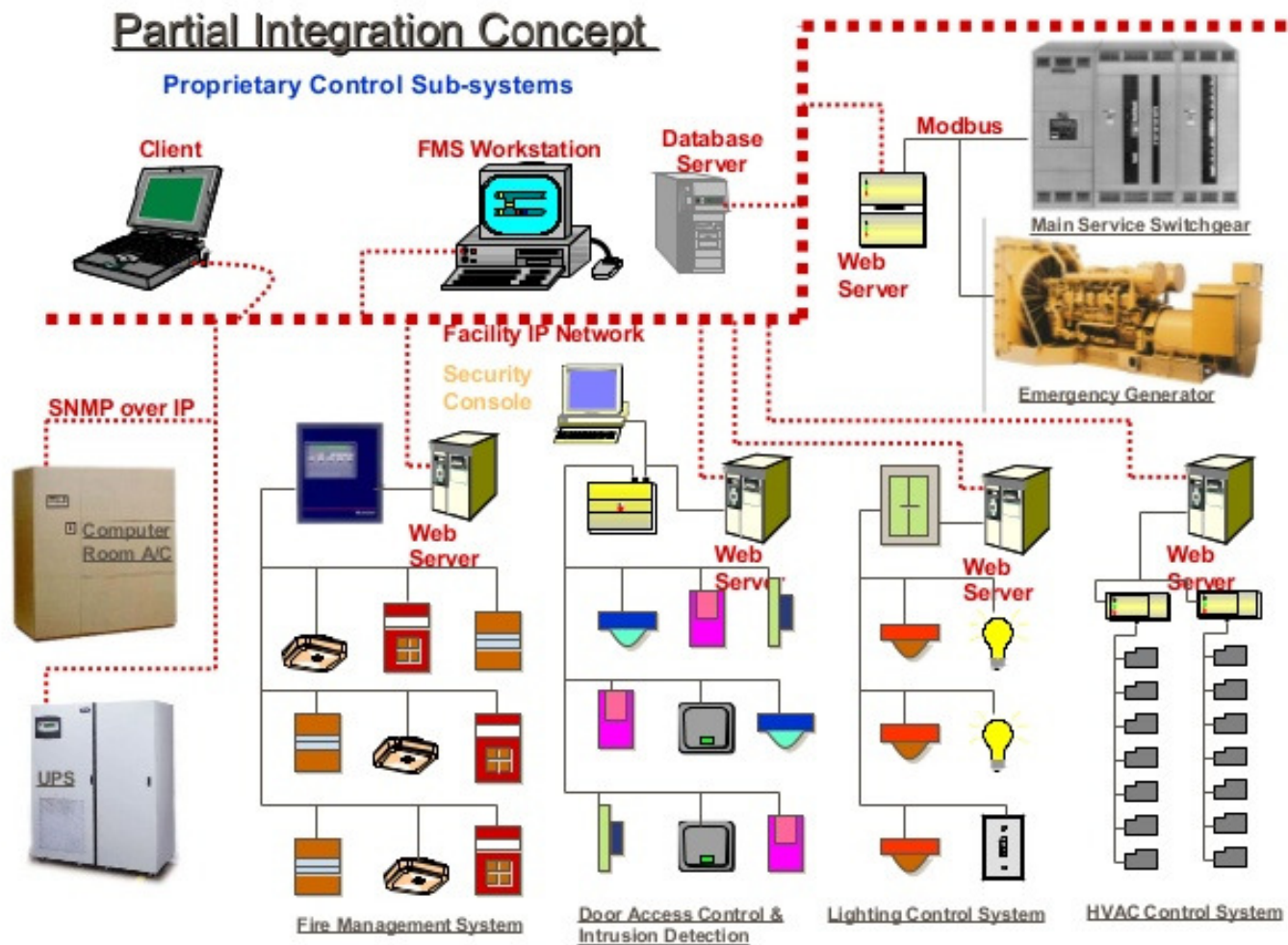
Figure 3.1. Diagram of Energy Balance around a HPWH

$$E_{\text{HPWH}} + Q_{\text{HPWH}} = Q_{\text{hotwater}} + Q_{\text{standby}}$$

Additional space conditioning load decreases COP by 13%

- From COP = 1.90 down to 1.66
- Still better than 0.95!

Net Zero Design – Controls & Smart Buildings



Learning Assessment Time!



Which building load would not be served by a heat pump?

- A. Heating
- B. Pumping
- C. Cooling
- D. Service hot water
- E. Clothes drying

Learning Assessment Time!



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Learning Assessment Time!



Which building load is influenced by total window area?

- A. Heating
- B. Pumping and fan energy
- C. Cooling
- D. Lighting
- E. All of the above

Learning Assessment Time!



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New York State Entities, Programs, Policies

- Energy consumption in New York
- Electricity consumption and the electric grid
- NYISO
- PSC
- Governor
- NYSERDA
- Affected state entities including SUNY, DASNY
- Net Zero certifications

Entities, Programs, Policies – NYS Energy Mix

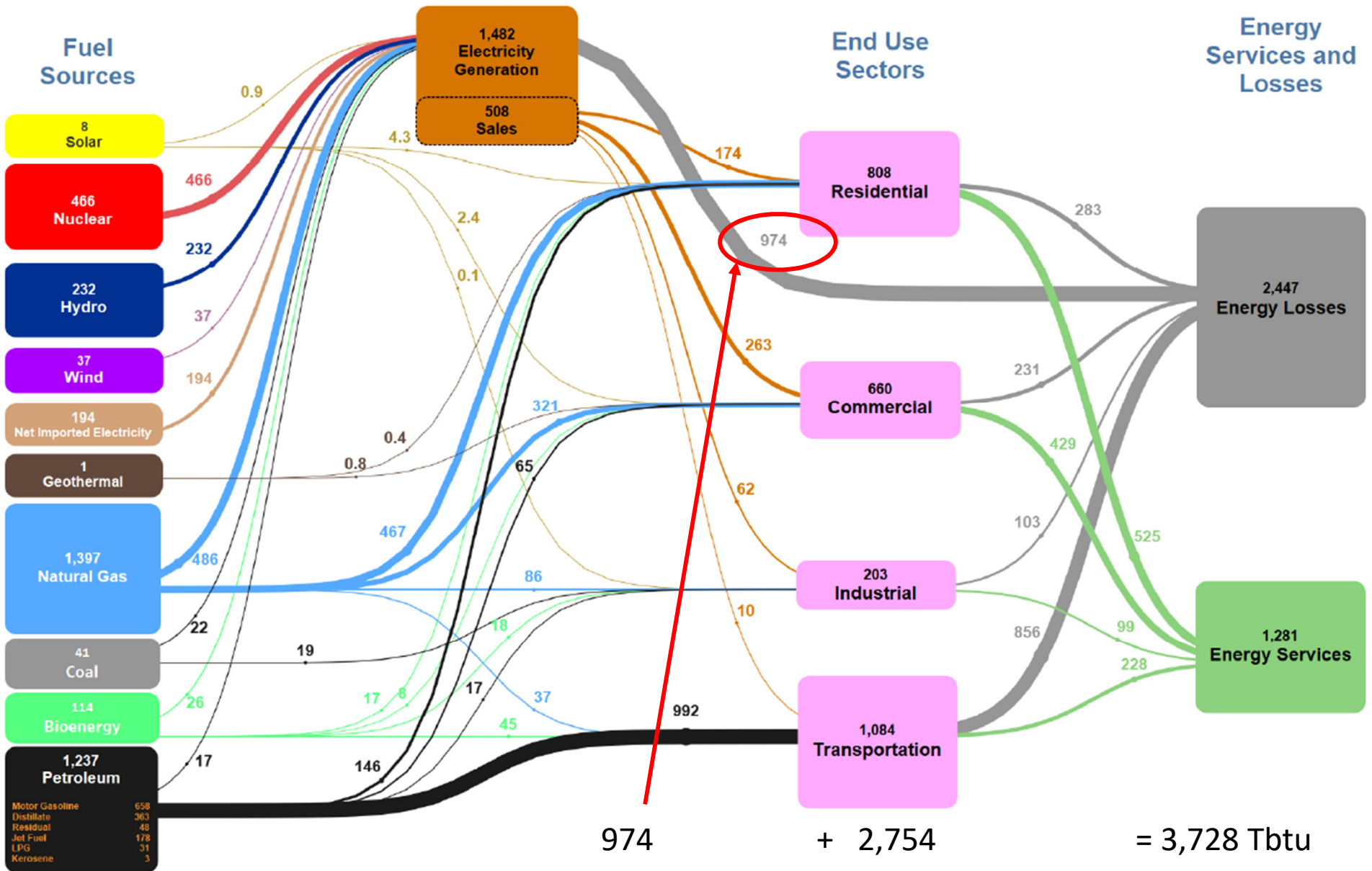
New York State rankings – Fun Facts

- Ranked 50th in energy consumption per capita (RI is less; LA is worst)
- Ranked 51st in energy cost per capita (\$2,524; WY is worst - \$6813)
- Produced more hydroelectric power than any other state east of the Rocky Mountains; 4th in the U.S.
- Ranked 5th in petroleum consumption
- ...but has the lowest petroleum consumption per capita
- Ranked 9th in energy-related CO₂ emissions
- ... but has the lowest emissions per capita (except District of Columbia)

Sources: eia.gov (2016 & 2017 data);

Entities, Programs, Policies – NYS Energy Mix

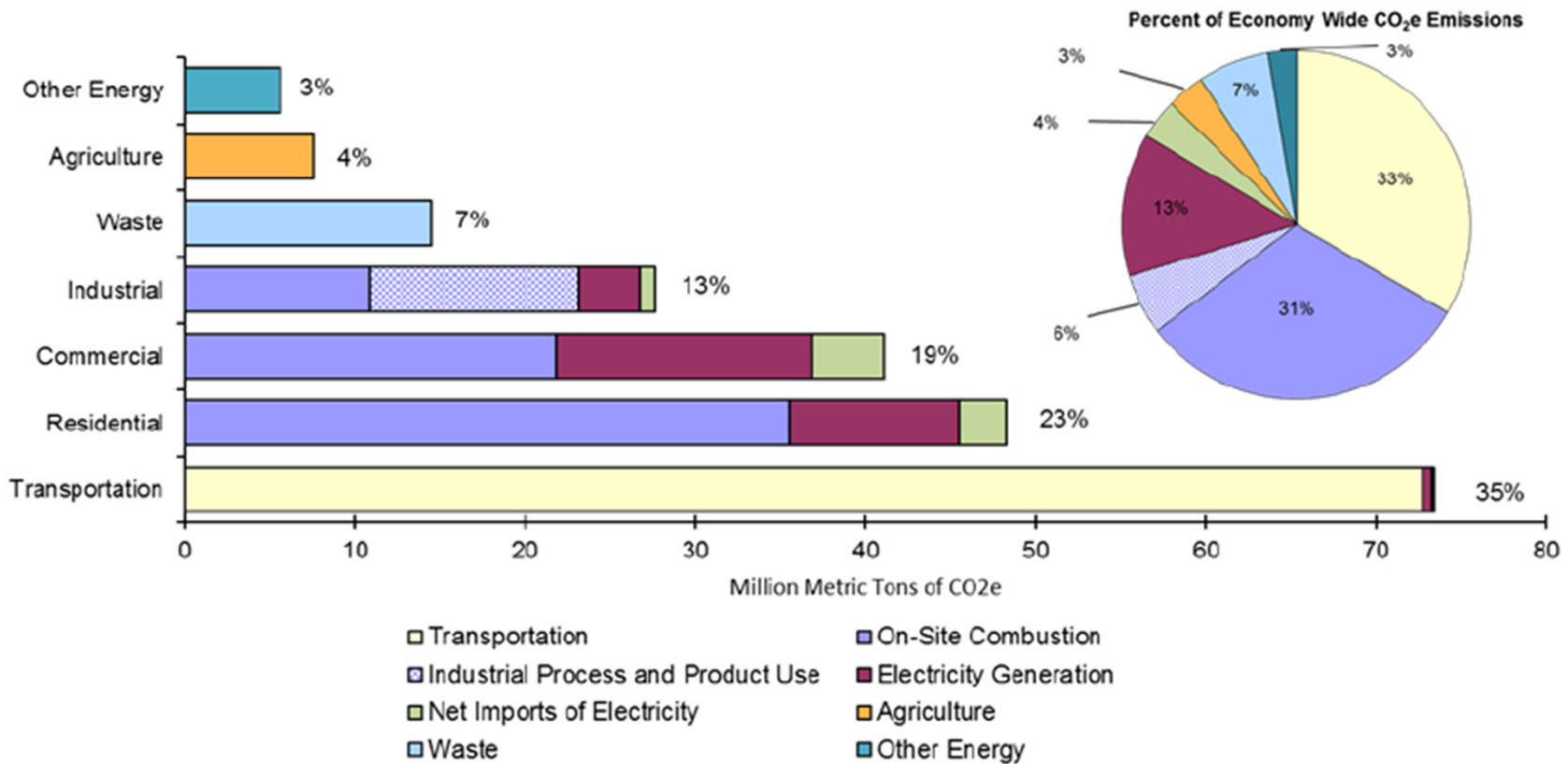
2015 New York State Energy Flow (Tbtu)
 Estimated New York Energy Consumption in 2015: 3,728 Tbtu



Entities, Programs, Policies – NYS Energy Mix

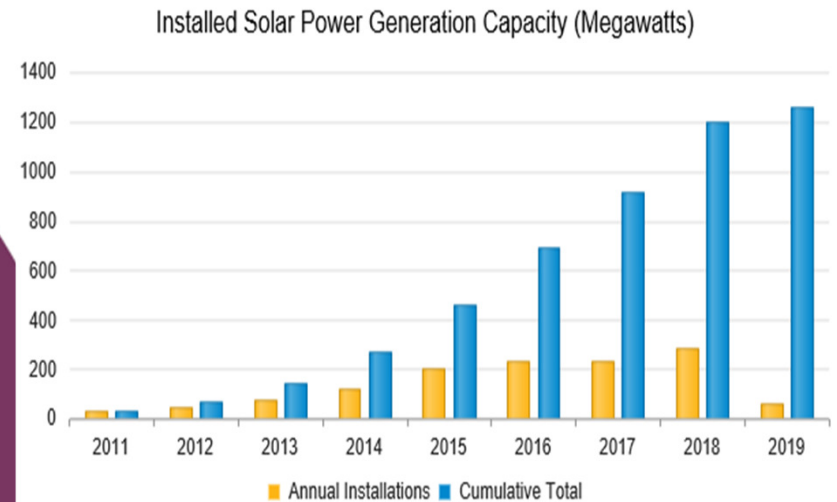
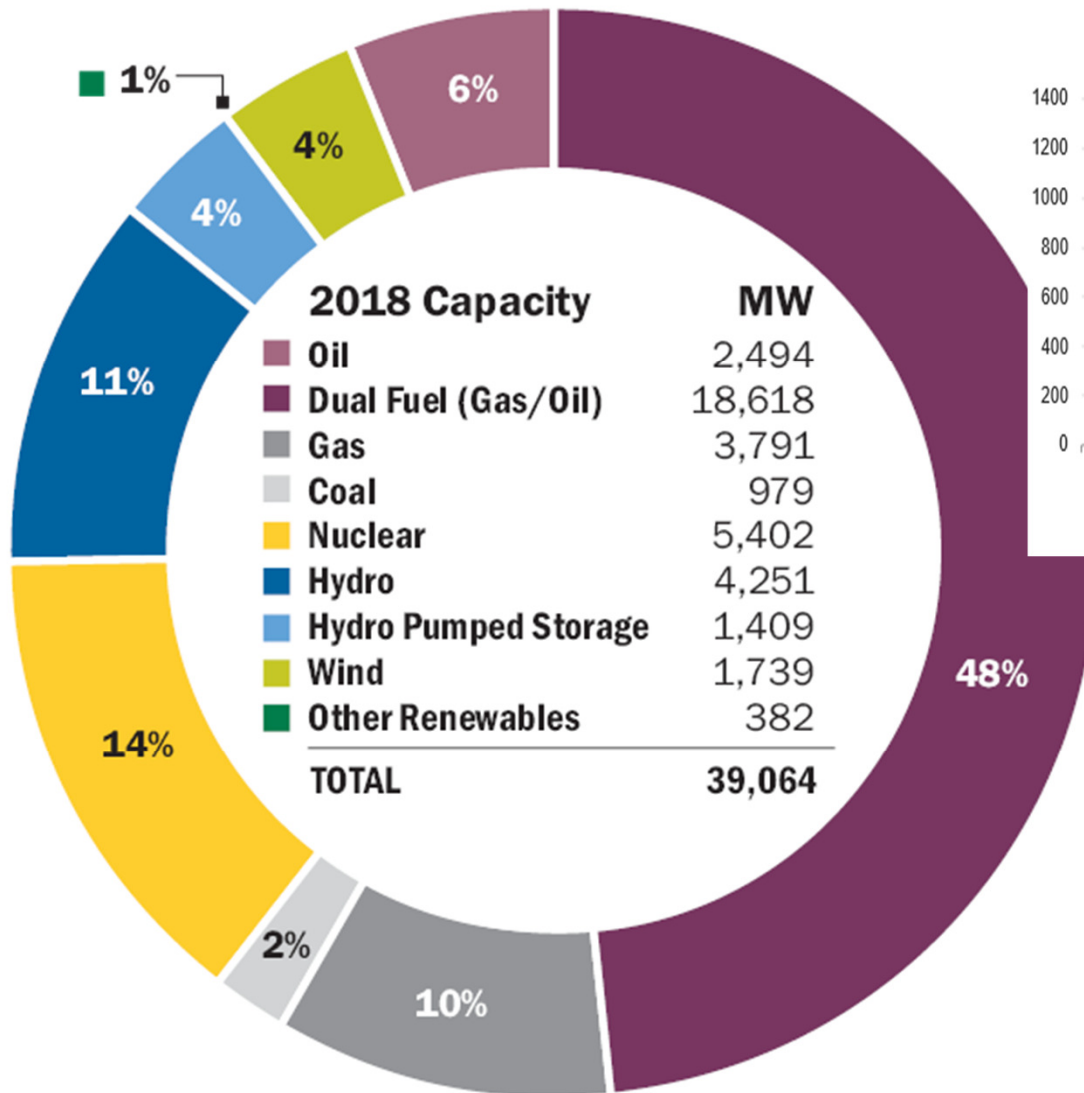
New York State GHG Emissions by Sector - 2015

Total Economy Wide CO₂e: 218 Million Metric Tons



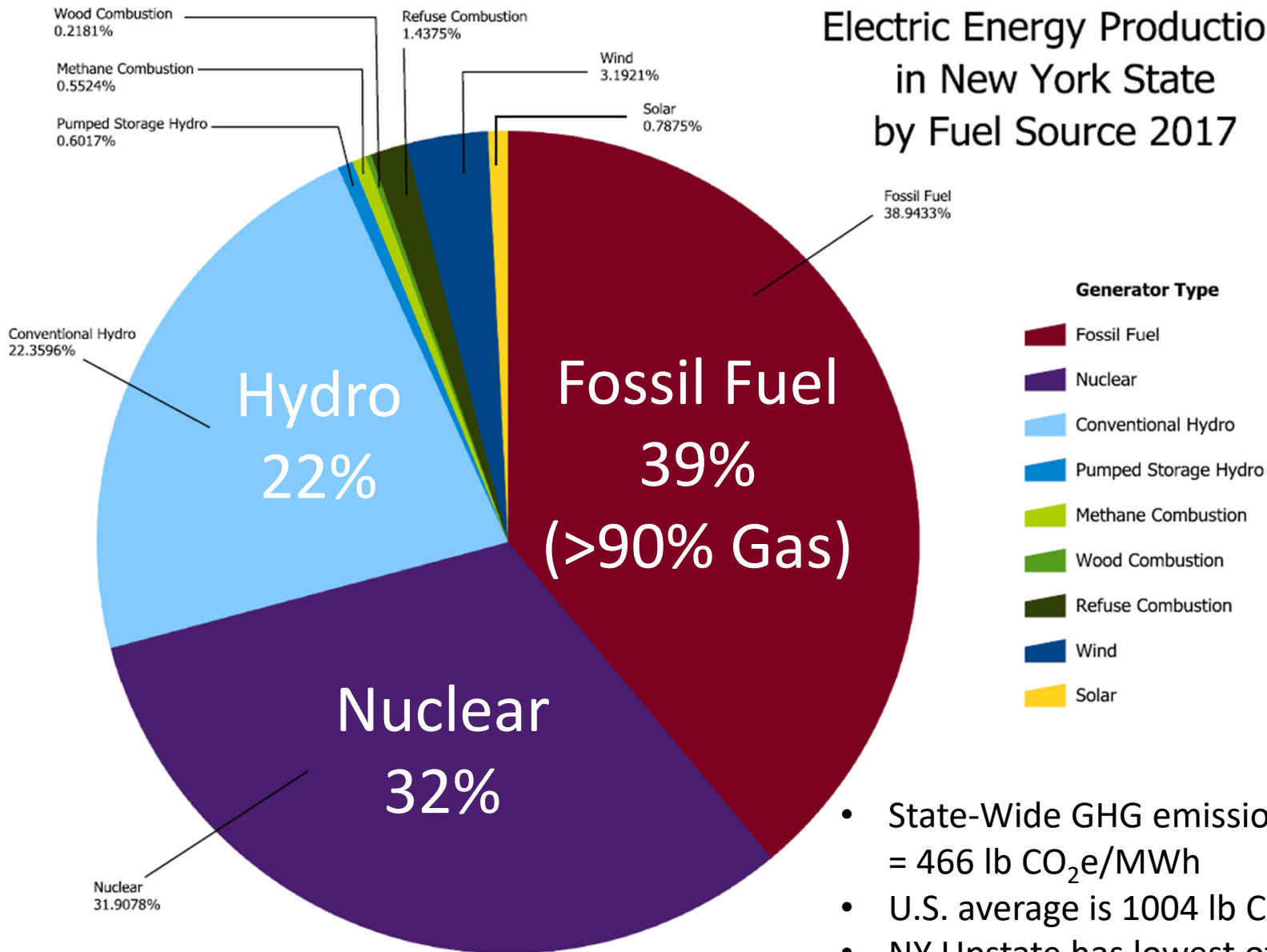
Entities, Programs, Policies – NYS Electric Grid

New York State Electric Power Capacity



Entities, Programs, Policies – NYS Electric Grid

Electric Energy Production
in New York State
by Fuel Source 2017

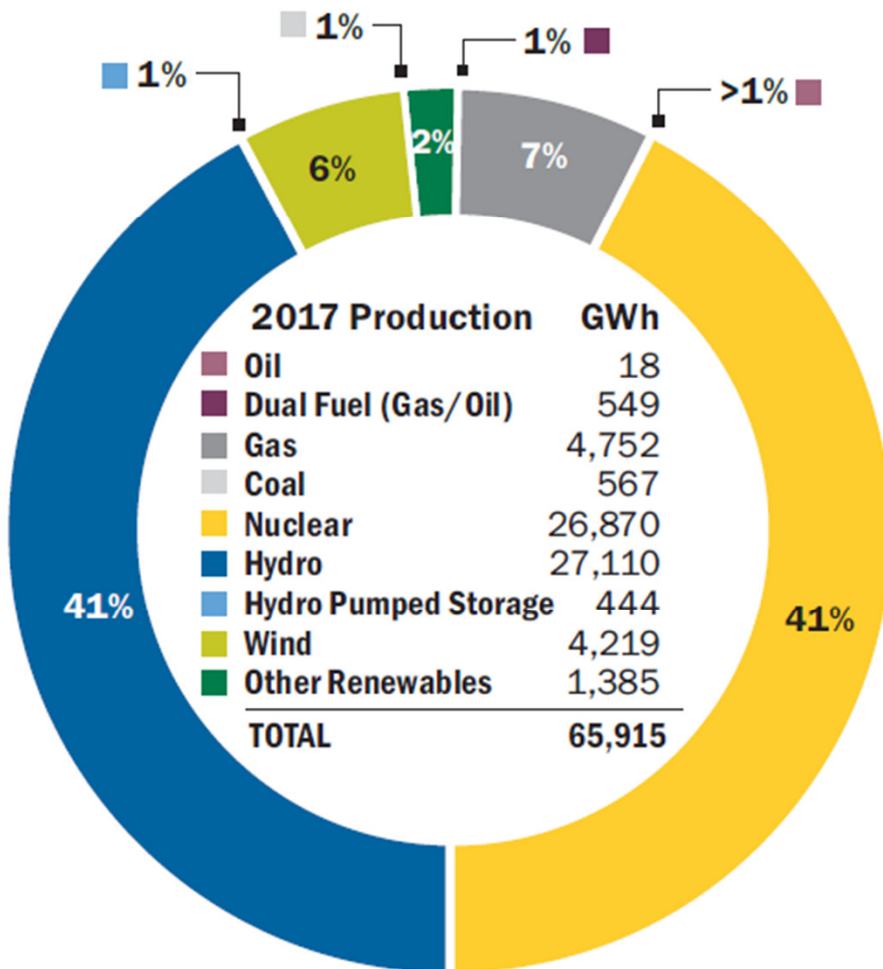


- State-Wide GHG emissions factor = 466 lb CO₂e/MWh
- U.S. average is 1004 lb CO₂e/MWh
- NY Upstate has lowest of 26 eGRID subregions – 296 lb CO₂e/MWh

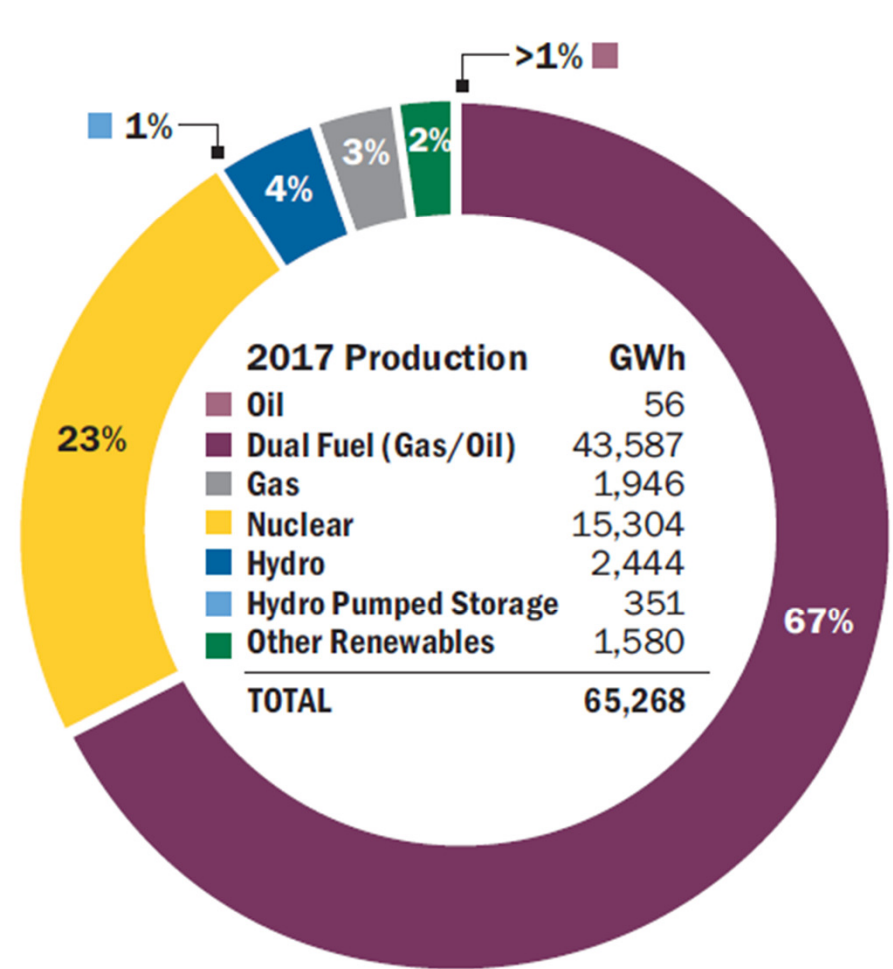
Sources:
2018 Load and Capacity Data Report, NYISO.
Solar Electric Programs Reported by NYSERDA.

Entities, Programs, Policies – NYS Electric Grid

**UPSTATE ENERGY
(Zones A-E)**



**DOWNSTATE ENERGY
(Zones F-K)**

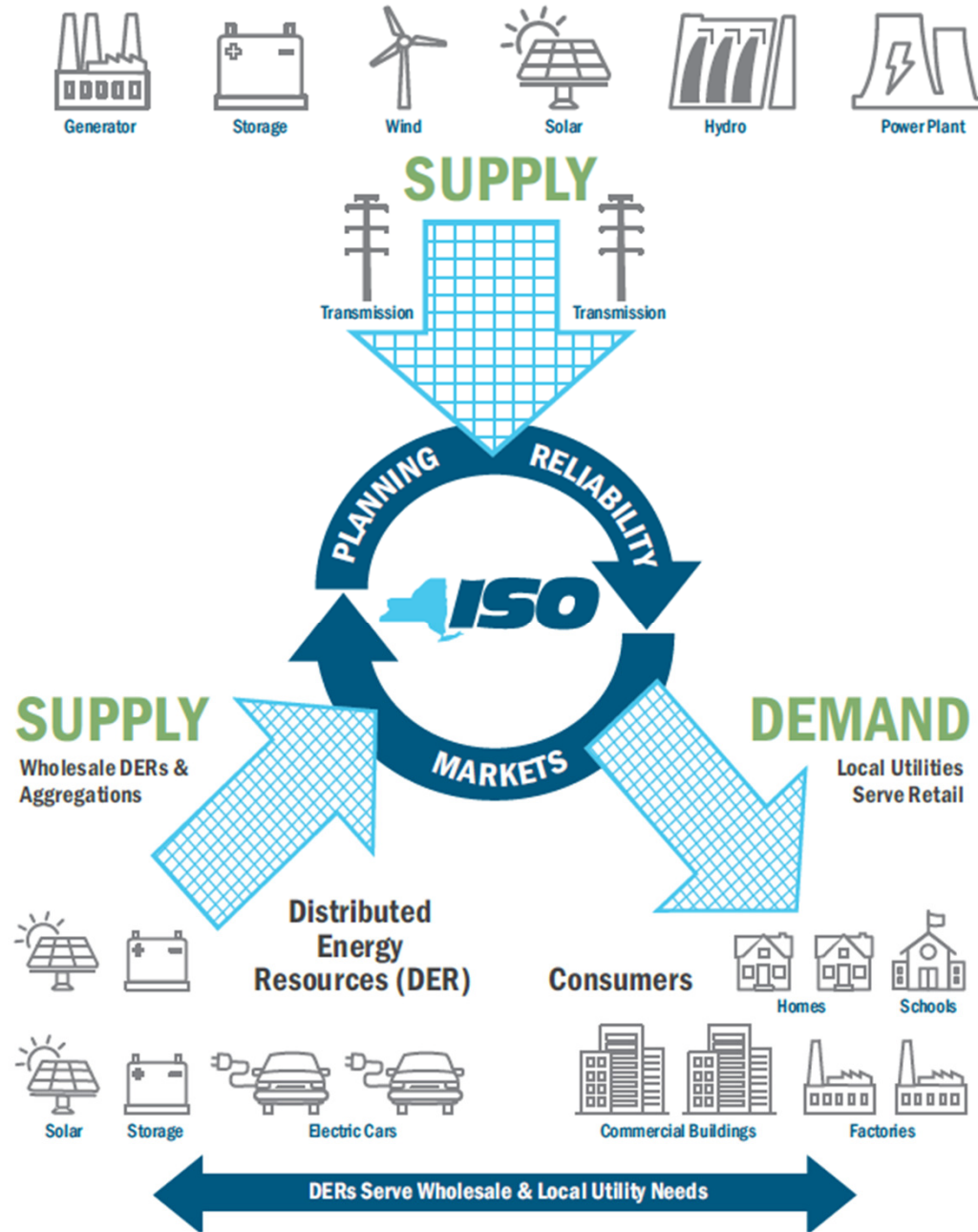


Entities, Programs, Policies – NYS Electric Grid

New York Independent System Operator (NYISO)

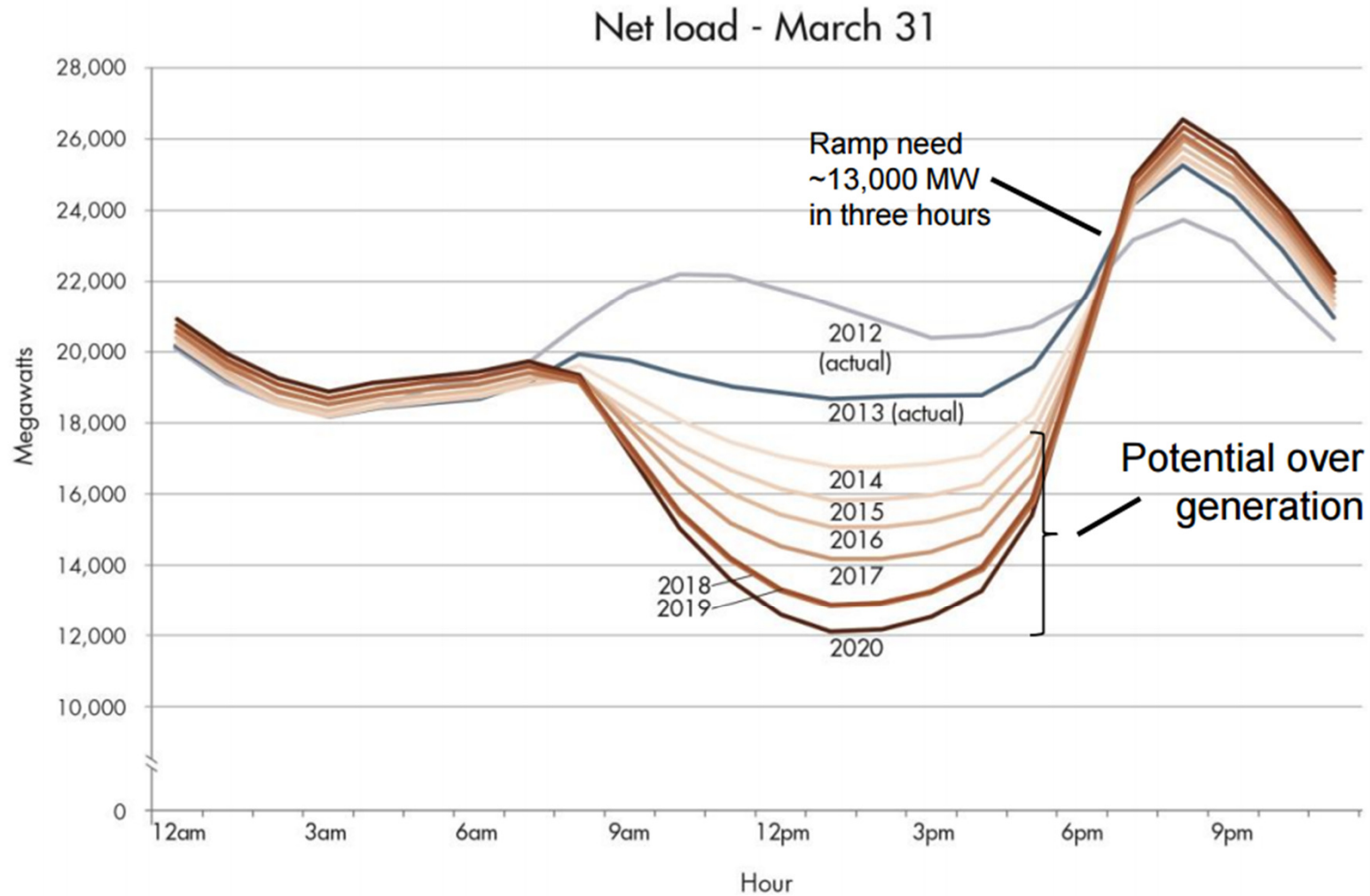
- NY electric grid is managed by a single **independent system operator** called the **NYISO**.
- Independent, non-partisan, not-for-profit organization
- Regulated under the Federal Energy Regulatory Commission (FERC)
- Three critical functions:
 - operating the New York State bulk electric system
 - administering competitive wholesale energy markets
 - planning for future system needs
- Priority is maintaining grid reliability

Entities, Programs, Policies – NYS Electric Grid



Entities, Programs, Policies – NYS Electric Grid

The “Duck Curve” – adding renewables to the grid



Public Service Commission (PSC)

- Regulates and oversees the electric, gas, water and telecommunication industries in New York
- Approves (or denies) utility rate requests
- Allows and facilitates public comments
- Part of the Department of Public Service (DPS)
- Five members appointed by the Governor; 6-year terms

Entities, Programs, Policies – Governor & PSC

Reforming the Energy Vision (REV, Apr. 2014)

- Policy framework announced after Hurricane Sandy
- PSC Track One order Feb. 2015
- PSC Track Two order May 2016
- 2015 New York State Energy Plan is the “comprehensive roadmap”
- Ongoing and regularly updated by the governor

40% Reduction in GHG emissions from 1990 levels

Reducing greenhouse gas (GHG) emissions from the energy sector—power generation, industry, buildings, and transportation—is critical to protecting the health and welfare of New Yorkers and reaching the longer term goal of decreasing total carbon emissions 80% by 2050.

50% Generation of electricity must come from renewable energy sources

Renewable energy sources, including solar, wind, hydropower, and biomass, will play a vital role in reducing electricity price volatility and curbing carbon emissions.

600 Increase in statewide energy efficiency from 2012 levels trillion Btu

Energy efficiency results in lower energy bills and is the single most cost-effective tool in achieving energy objectives.

Entities, Programs, Policies – Governor & PSC

Clean Energy Standard (CES – Aug. 2016)

- Includes a renewable energy standard (RES)
- Also a zero-emissions credit (ZEC) requirement
- Utilities must acquire 50% of electricity from clean energy resources by 2030
- Existing nuclear power plants are zero emission resources
- Subsidizes old nuclear plants:
 - Ginna (guh-NAY; now the oldest nuclear plant in the U.S.)
 - James A. Fitzpatrick
 - Nine Mile Point



Entities, Programs, Policies – Governor & PSC

“Green New Deal” (Jan. 2019)

- 100% carbon-neutral electricity by 2040
- Boosts Clean Energy Standard from 50% to 70% renewables by 2030, by
- Nearly quadrupling New York’s offshore wind target to 9,000 megawatts by 2035, up from 2,400 megawatts by 2030
- Doubling distributed solar deployment to 6,000 megawatts by 2025, up from 3,000 megawatts by 2023
- More than doubling new large-scale, land-based wind and solar resources through the Clean Energy Standard
- Maximizing the contributions and potential of New York's existing renewable resources
- Deploying 3,000 megawatts of energy storage by 2030

Entities, Programs, Policies – New York City

New York City Climate Mobilization Act (Apr. 18th 2019)

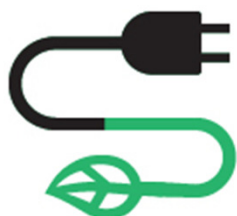
- Includes set of 10 bills
- A study will look at closing 24 gas- and oil-fueled power plants
- Green roofs
- Calls on DEC to deny water permit for Williams Pipeline (fracked gas from PA)
- “Dirty Buildings Bill” requires 50,000 buildings to cut emissions by installing new windows, insulation and other retrofits; \$millions in fines for non-compliance



Entities, Programs, Policies – Governor & PSC

Other Orders, Initiatives and Legislation

- Climate and Community Protection Act (S2992 and A3876; current)



50% Electricity from clean renewable energy by 2030



40% Clean energy funds invested in disadvantaged communities



100% Human-caused climate pollution eliminated by 2050

- New Efficiency New York filing Dec-2018
- Westchester County Gas Moratorium Mar-2019

Other Orders, Initiatives and Legislation

- Executive Orders 88 & 166
- Clean Energy Fund
- NY Green Bank
- Methane Reduction Plan
- Regional Greenhouse Gas Initiative (RGGI)
- Transportation and Climate Initiative (TCI)
- Hydraulic fracturing (fracking) ban
- Coal power phase-out by 2020

Entities, Programs, Policies – Governor & NYSERDA

NYSERDA 2018 Clean Energy Industry Report

CLEAN ENERGY EMPLOYMENT BY TECHNOLOGY (number of jobs, December 2017)



117k

Energy Efficiency

Energy efficiency technologies are commercially available throughout the State. Includes lighting, ENERGY STAR® appliances (including HVAC), insulation, advanced building materials, renewable heating and cooling, and other efficient technologies.



22k

Renewable Electric Power Generation

Includes solar, wind, geothermal, low-impact hydropower, and other renewable generation technologies.



7.8k

Alternative Transportation

Includes electric, hybrid, plug-in hybrid, and fuel cell/hydrogen vehicles, natural gas and other alternative fuel buses, and transportation storage.



2.6k

Renewable Fuels

Includes biofuels such as wood pellets and ethanol.



1.6k

Grid Modernization and Storage

Includes smart grid, microgrid, demand response management, and grid storage.

Entities, Programs, Policies – NYSERDA Programs

Programs for Buildings

- New Construction Program (Commercial; Low-Rise Residential; Multifamily)
- FlexTech
- NY-SUN
- GSHP Rebate Program
- RetrofitNY - Buildings of Excellence – Zero Energy for Economic Development
- Real Time Energy Management
- Net Zero Portfolio Support

Entities, Programs, Policies – NYSERDA Programs

Programs for Electric Grid & EV

- PON 4074 – Electric Power Transmission and Distribution (EPTD) High Performing Grid
- FlexTech
- NY-SUN
- RetrofitNY - Buildings of Excellence – Zero Energy for Economic Development
- Real Time Energy Management

Entities, Programs, Policies – NYSERDA Programs

Sponsorship of Conferences



When: April 24 | 8:30 a.m. - 5:00 p.m. ET

Where: DoubleTree | 455 S. Broadway, Tarrytown, NY 10591

Who Should Attend: Developers, architects, contractors, energy consultants, bankers and others involved in the commercial building trade

Entities, Programs, Policies – DASNY, SUNY

“Affected State Entities” – NYS Universities & State Agencies

- Over four dozen state entities that comply with Executive Orders
- Entities that influence the most buildings:

SUNY

DOCCS

CUNY

OMH

OGS

MTA

DASNY

SUNY Overview

Chancellor Johnson's
Sustainability Goals:

- 100% Renewable Grid Sourced Electricity
- Deep Energy Retrofits
- New Buildings Net Zero Energy
- Clean Energy Workforce Development



DASNY Overview

DASNY's construction pipeline is more than **\$6 billion**. We are actively managing over **900 projects** with annual construction expenditures totaling approximately **\$900 million**.

DASNY is partnering with NYSERDA and SUNY to develop high performance retrofit solutions as part of the overall gut renovation of an existing residence hall at a SUNY College.

This project is intended as a proof-of-concept pilot for possible development throughout the entire SUNY system's **64 campuses** and **500 residence halls**, supporting SUNY residence hall improvement goals and New York State goals for energy efficiency.

The SUNY System: A Large Market Opportunity

Almost 500 Residence Halls and over 70,000 beds

Many built circa 1970s

Revenue-funded projects

Similar building types → similar retrofit solution will be applicable to most halls

Entities, Programs, Policies – DASNY, SUNY

Aligned with Governor Cuomo, Chancellor Johnson has outlined eight ambitious goals to enable SUNY's clean energy vision:

- 1 **ACHIEVE ENVIRONMENTAL SUSTAINABILITY**
- 2 **DEVELOP CLEAN ENERGY MASTER PLANS**
- 3 **ESTABLISH A NETWORK OF COMMUNITY RESILIENCE**
- 4 **LEAD WITH NET ZERO BUILDINGS**
- 5 **RETROFIT EXISTING BUILDINGS**
- 6 **ESTABLISH A CLEAN ENERGY NETWORK CONSISTING OF RESEARCH, INNOVATION, PARTNERSHIPS AND EDUCATION.**
- 7 **ATTRACT START-UP ACTIVITIES IN NY**
- 8 **ENHANCE WORKFORCE DEVELOPMENT**

Entities, Programs, Policies – Certifications

- ILFI: Zero Carbon -> Zero Energy -> Energy “Petal”
- USGBC: LEED Zero Energy -> LEED Zero Carbon
- PHIUS: PHIUS+ Source Zero
- Residential Zero Energy and/or Zero Energy “Ready” programs
 - DOE
 - Earth Advantage
 - Canadian Home Builders Association
 - Built Green
 - Green Home Institute

Learning Assessment Time!



Which fossil fuel is most heavily used in New York state?

- A. Coal
- B. Fuel oil
- C. Gasoline
- D. Natural gas

Learning Assessment Time!



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Learning Assessment Time!



SUNY will meet 100% of this need from renewable sources:

- A. Building materials for new construction
- B. Transportation fuels
- C. Grid-sourced electricity
- D. All of the above

Learning Assessment Time!



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Questions?



Thank You!

Net Zero – Reducing Energy and Carbon in New York State Building Stock

Next up at 9:45 a.m.:

- **INCORPORATING INNOVATIVE BUILDING CONSTRUCTION PRODUCTS & PERFORMANCE-BASED DESIGN ALTERNATIVES**

BY BRIAN SCOT TOLLISEN, PE



Bill Bishop, PE, LEED AP, CEM

bbishop@pathfinder-ea.com

585-698-1956