

Advantages of green building design



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2018 Spring Term
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WHAT IS SUSTAINABILITY?

United Nations Brundtland Commission (1987):

- Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

International Union for Conservation of Nature (1997)

- Improving the quality of human life while living within the carrying capacity of the Earth's supporting eco-systems.

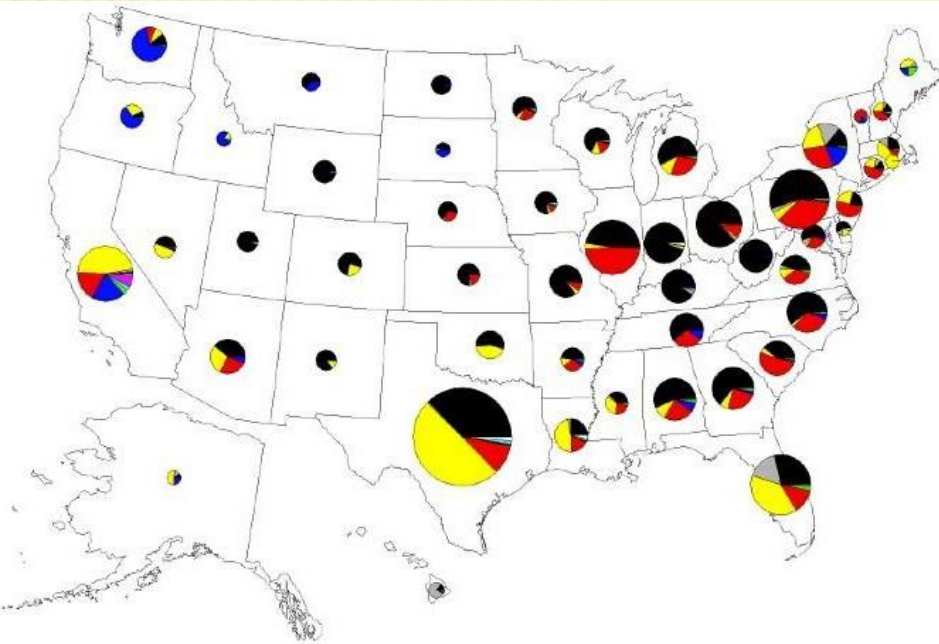
US Environmental Protection Agency (EPA):

- Simple principle: Everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment.
- Creates and maintains the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations.

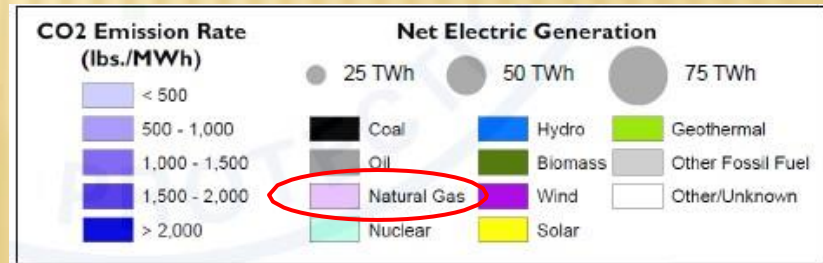
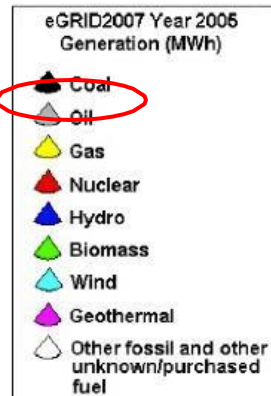
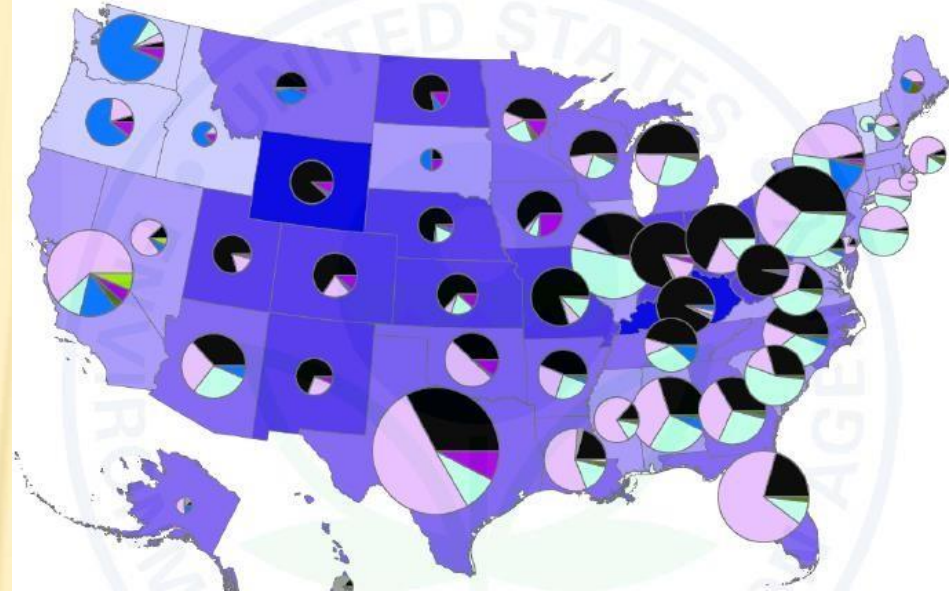
ENERGY: US SUPPLY BY REGION

Electricity Generation by Fuel Type & CO2 Emission Rates: 2005 vs. 2010

2005 Data



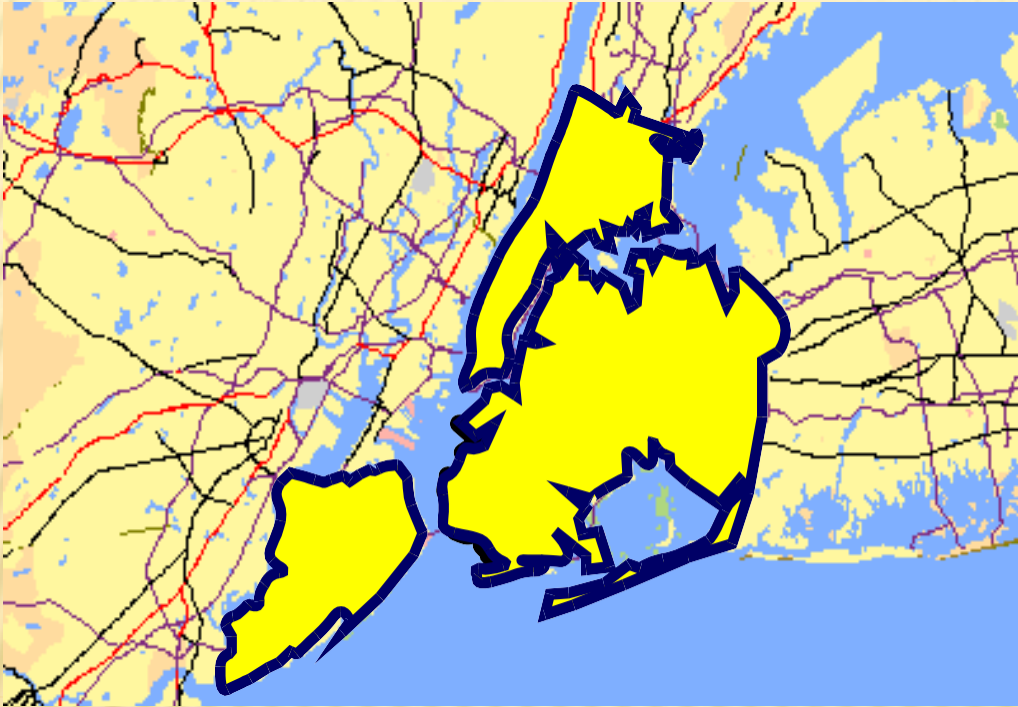
2010 Data



Energy: Solar

if we cover all of NYC with Solar Panels...

125 billion kWh per year

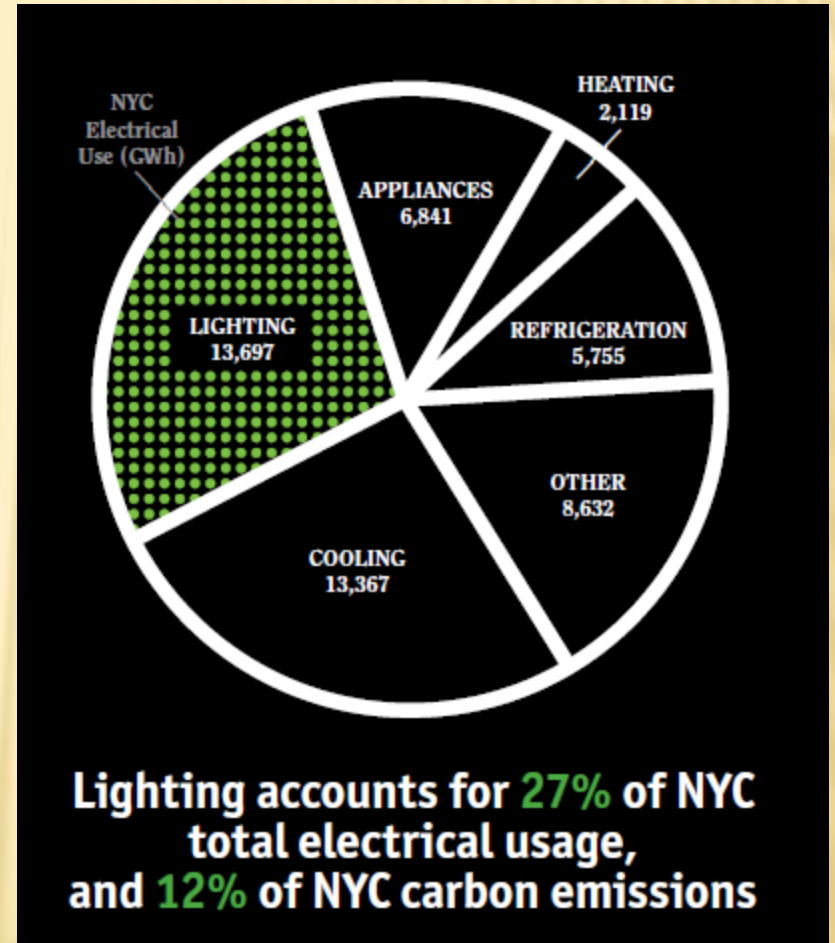
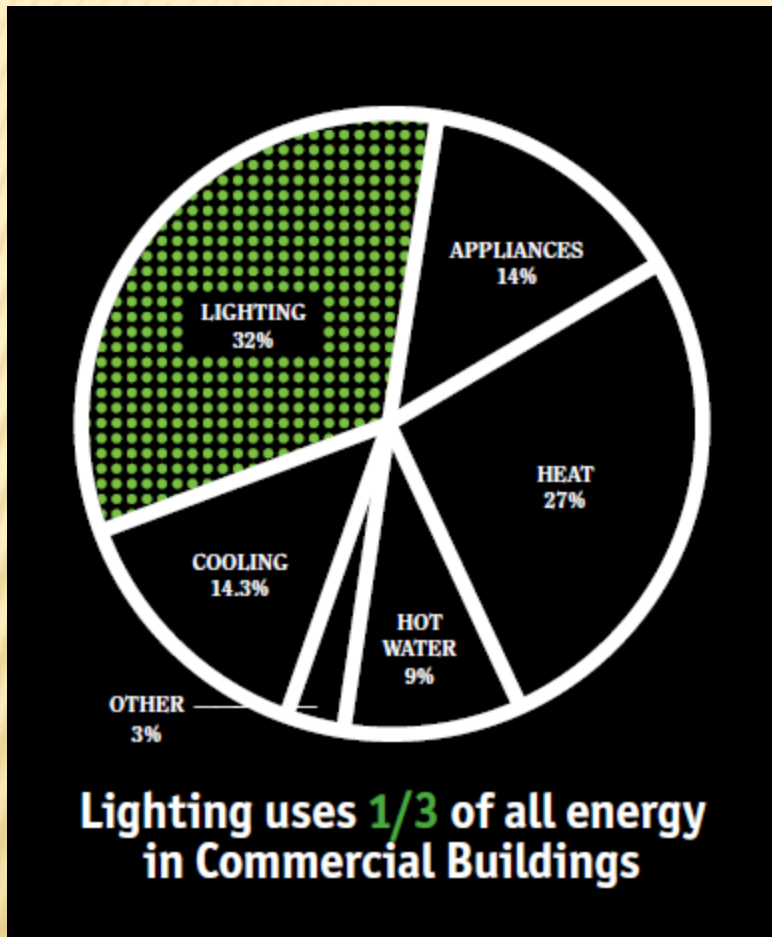


Perez et al., ASRC

2.5 CONED total generation



ENERGY: LIGHTING IN NEW YORK CITY



slide credit: Green Light New York, 2012

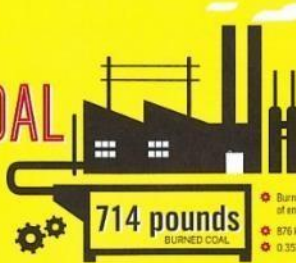
ENERGY: ELECTRICITY

HOW MUCH FUEL DOES IT TAKE TO POWER A LIGHTBULB FOR A YEAR?

HOW MUCH ENERGY—WHETHER ELECTRIC, COAL, NUCLEAR, OR OTHERWISE—IS REQUIRED FOR A 100-WATT LIGHTBULB TO RUN FOR A YEAR, 24 HOURS A DAY?

Kilowatt-hour (kWh) = unit of energy equal to 1,000 watt hours
 A 100-watt light uses 0.1 kilowatt-hours worth of energy in an hour
 How much energy does an electric 100-watt lightbulb use a year? $0.1 \text{ kW} \times 8,760 \text{ hours in a year} = 876 \text{ kWh}$

COAL



- Burning 1 ton of coal creates 2,460 kWh of energy
- $876 \text{ kWh} \div 2,460 \text{ kWh/ton} = 0.357 \text{ tons}$
- $0.357 \text{ tons} = 714 \text{ pounds}$

NUCLEAR

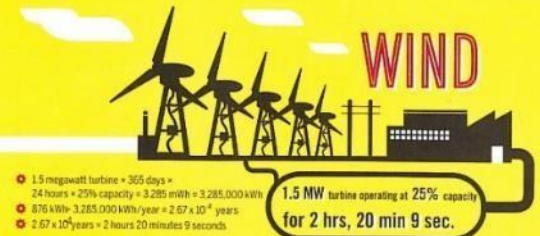


- 1 pound of the uranium 235 isotope can produce 10,246,469 kWh of energy
- $876 \text{ kWh} \div 10,246,469 \text{ kWh/pound} = 8.5 \times 10^{-6} \text{ pounds}$
- Divide this by .35 (the average thermal efficiency of uranium 235 is only 35%) = $2.4 \times 10^{-6} \text{ pounds}$
- Divide this by .007 (uranium 235 isotope needed for nuclear fission makes up only .7% of raw uranium) = 0.35pound of natural uranium.

NATURAL GAS

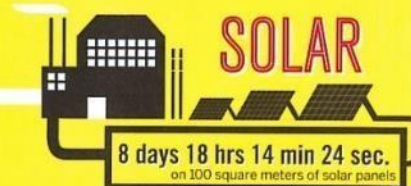


- 1 pound of natural gas can produce 6.12 kWh of energy
- $876 \text{ kWh} \div 6.12 \text{ kWh/pound} = 143 \text{ pounds of natural gas}$



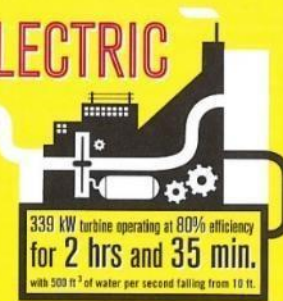
- 1.5 megawatt turbine = 365 days = 24 hours = 25% capacity = 3,285 kWh = 3,285,000 kWh
- $876 \text{ kWh} \div 3,285,000 \text{ kWh/year} = 2.67 \times 10^{-4} \text{ years}$
- $2.67 \times 10^{-4} \text{ years} = 2 \text{ hours } 20 \text{ minutes } 9 \text{ seconds}$

SOLAR



- Assuming a yield between 20-25% (average solar conversion efficiency), a one square meter solar panel can produce 1 kWh of energy in a day
- 100 one square meter panels producing 100 kWh would require 8 days 18 hours 14 minutes and 24 seconds.

HYDROELECTRIC



- The power of a hydro-electric turbine = (height of dam) x (river flow) x (efficiency) = 11.8 (converts units of feet and seconds into kilowatts)
- Assuming: dam height (10 feet) x river flow (500 ft³ per second) x (80% efficiency) = 11.8 = 339 kW turbine
- $876 \text{ kWh} \div 339 \text{ kW} = 2 \text{ hours and } 35 \text{ minutes}$

ENERGY: ELECTRICITY GRID

Scientific American 6/16/09

✘ What is the Power Grid?

US: 3 major interconnected regional grids

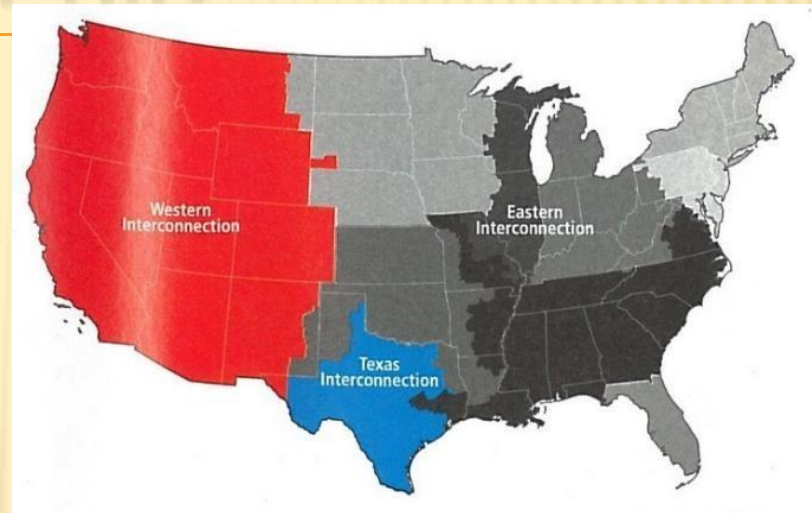
- Western
- Texas
- Eastern (comprised of smaller grids)

The grid is comprised of:

- Power generation plants (coal, natural gas, nuclear, renewables, etc.)
- Power distribution network (substations, transmission lines, feeders, etc)

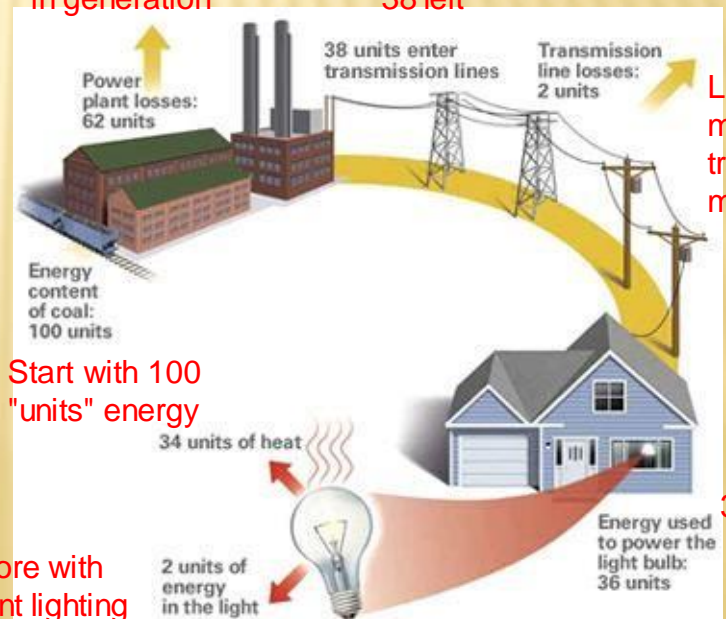
• System losses (inefficiencies):

- Transmission losses during distribution of electricity over long distances by cables.
- End result: Only around 1/3 of the original fuel burned is electricity converted into



Lose 62
in generation

38 left



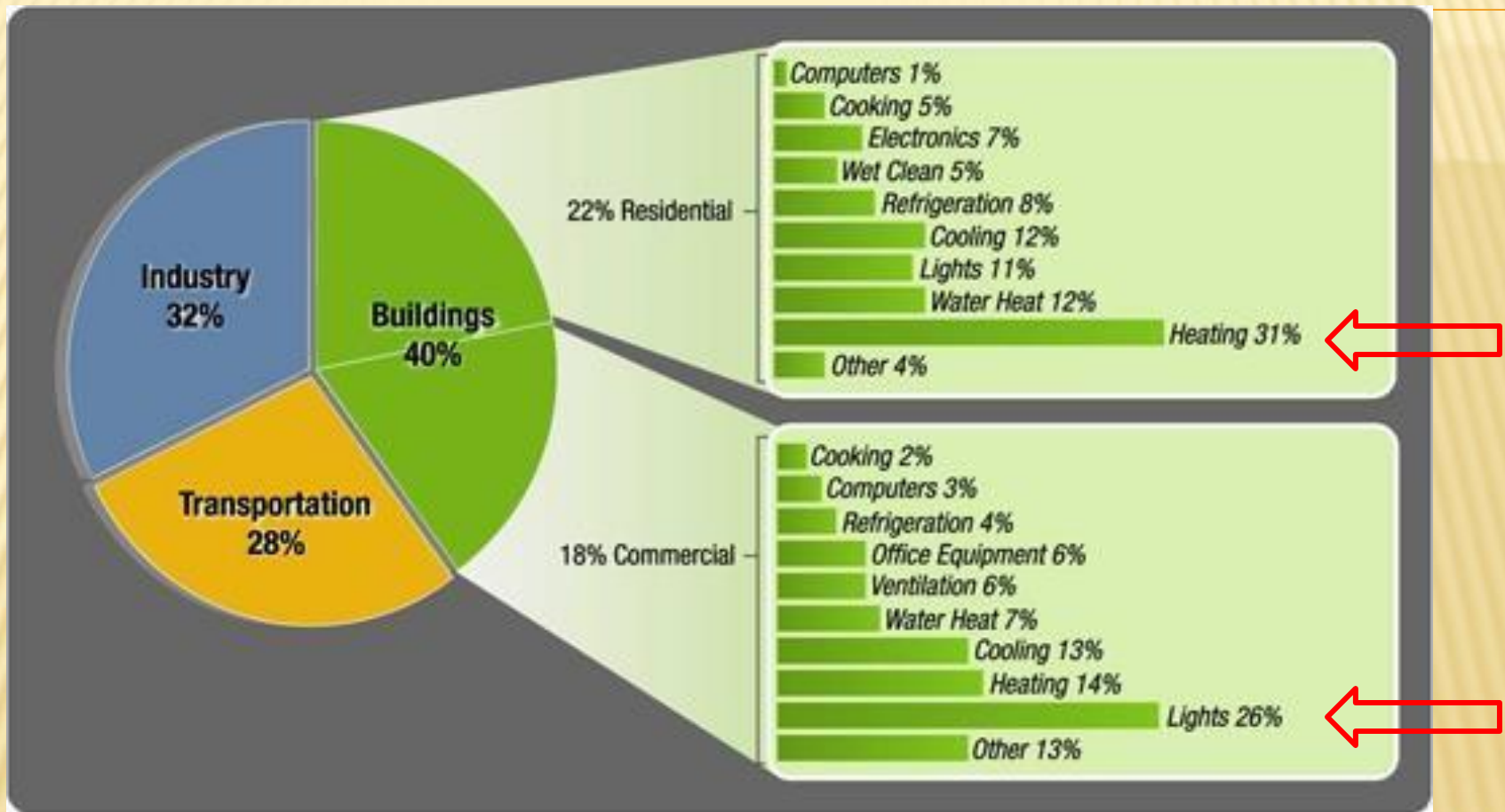
Lose 2
more in
trans-
mission

Start with 100
"units" energy

36 left

Lose more with
inefficient lighting

ENERGY: HOW IS IT USED IN BUILDINGS?

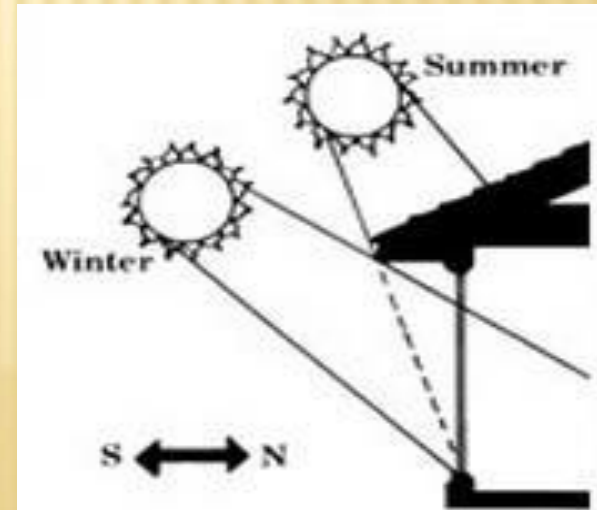
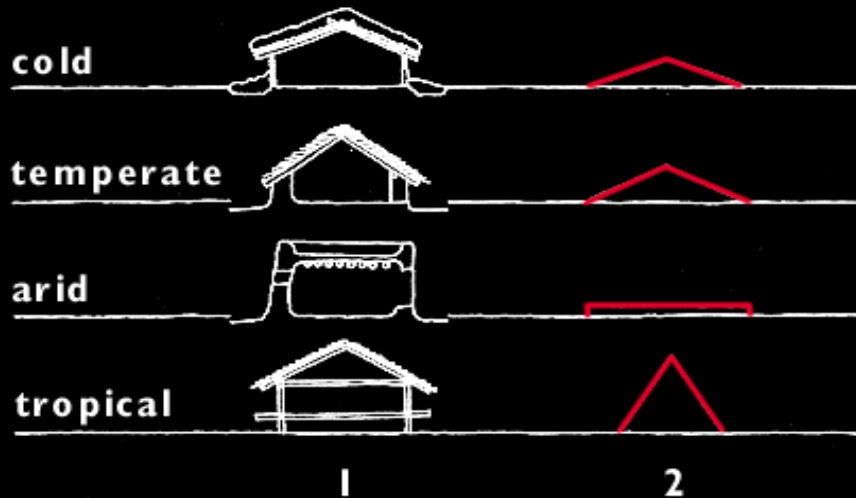


Building sector consumes 40% of the energy resources in the US.

GREEN BUILDING DESIGN:

How do we define “Green”?

- High performance
- LEED certified
- Net zero
- Healthy building



ENERGY: IMPORTANT METRICS (ENERGY STAR SCORE)

How Do We Compare Buildings?

Energy Star score

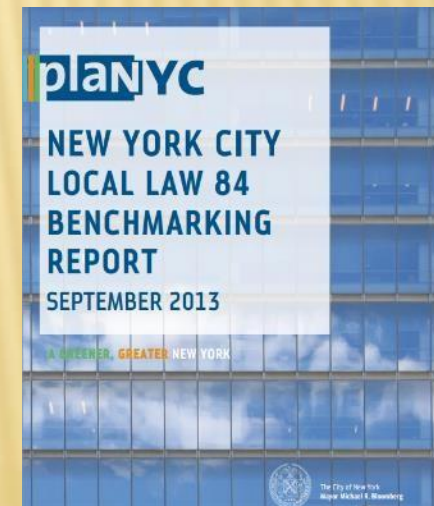
- Compares your building to national average for that particular building type
- 1 – 100 ENERGY STAR score
- Score 50 is median (average)
- Score 75 (75th percentile):
 - Means your building is better than 75% of similar buildings nationwide
 - Your building can be Energy Star certified
- 25 different building types
- "Benchmarking": compare your building's performance against similar buildings

New York City

- NYC Local Law 84
- Benchmarking data is public (city, large commercial, and large apt. buildings)



Image: EPA Energy Star



Introduction to LEED

LEED, or Leadership in Energy & Environmental Design, is a green building certification program that recognizes best-in-class building strategies and practices. To receive LEED certification, building projects satisfy prerequisites and earn points to achieve different levels of certification. Prerequisites and credits differ for each rating system, and teams choose the best fit for their project.

5 Rating systems

BD+C BUILDING DESIGN + CONSTRUCTION New Construction Core & Shell Schools Retail Healthcare Data Centres Hospitality Warehouses & Distribution	ID+C INTERIOR DESIGN + CONSTRUCTION Commercial Interiors Retail Hospitality	O+M OPERATION + MAINTENANCE Existing Buildings Data Centres Warehouses & Distribution Hospitality Schools Retail	ND NEIGHBOURHOOD DEVELOPMENT New land developments Land Redevelopment Residential Mixed Use Commercial Industrial	HOMES HOUSES + UNITS Single Homes Low Rise Multi Unit Mid Rise Multi Unit
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Credit Categories

Each rating system is made up of a combination of credit categories. Within each of the credit categories, there are specific prerequisites projects must satisfy and a variety of credits projects can pursue to earn points. The number of points the project earns determines its level of LEED certification.

INTEGRATIVE PROCESS Encouraging cross discipline collaboration	LOCATION & TRANSPORTATION Access to variety of transport and/or credit for constrained sites	MATERIALS & RESOURCES Using sustainable materials & reducing waste	WATER EFFICIENCY Smart use and reuse of water	ENERGY & ATMOSPHERE Energy Performance	SUSTAINABLE SITES Minimising impact on ecosystems & water resources	INDOOR ENVIRONMENT Indoor air quality & access to natural light & views	INNOVATION	REGIONAL PRIORITY Geographic environmental priorities



LEED is administered by the US Green Building Council. For information on the scheme go to www.usgbc.com

The Ratings



www.wtsustainability.com.au



LEED Credit Categories



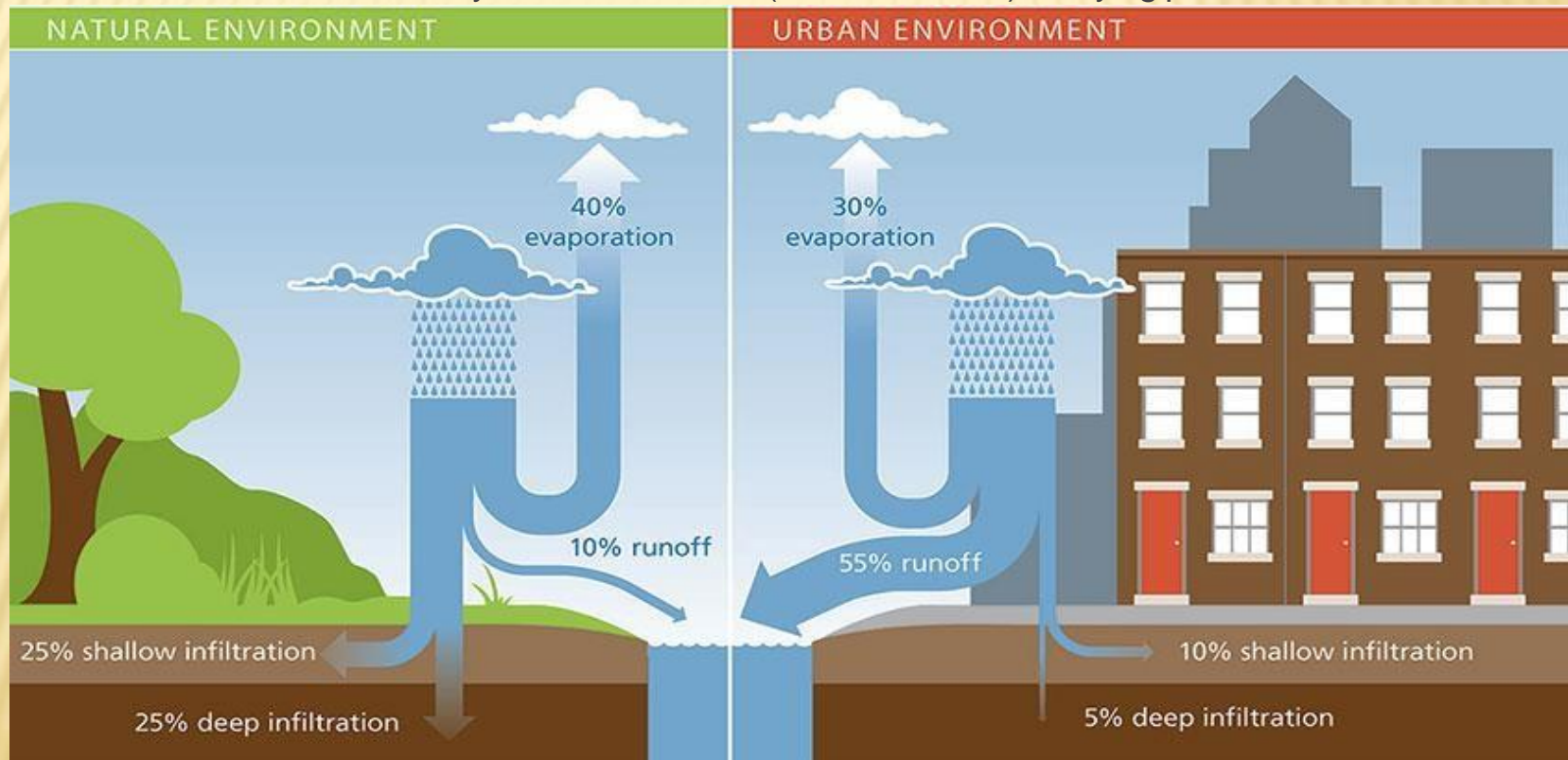
LEED is one of the best known green building rating program, and is used internationally, “certifying 1.5 million square feet of building space each day in 135 countries” with more than 54,000 projects currently participating.

The comprehensive green building certification program includes five separate rating “families”, each of which are further broken down into project types.

The LEED v4 system – released November 2013 – addresses 26 different types of construction situations.

The Hydrologic Cycle

- In “natural,” undeveloped conditions, most rainfall either infiltrates or evaporates back into the air.
- Land development (buildings, roads, driveways, parking lots) alters the Hydrologic Cycle.
 - Less infiltration due to more impervious surfaces
 - Less evaporation due to less vegetation.
 - More runoff directly into water bodies (rivers, streams), carrying pollutants with it.

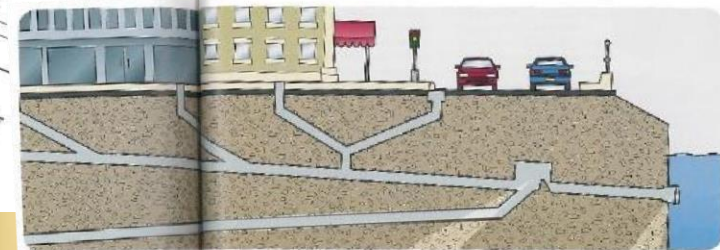
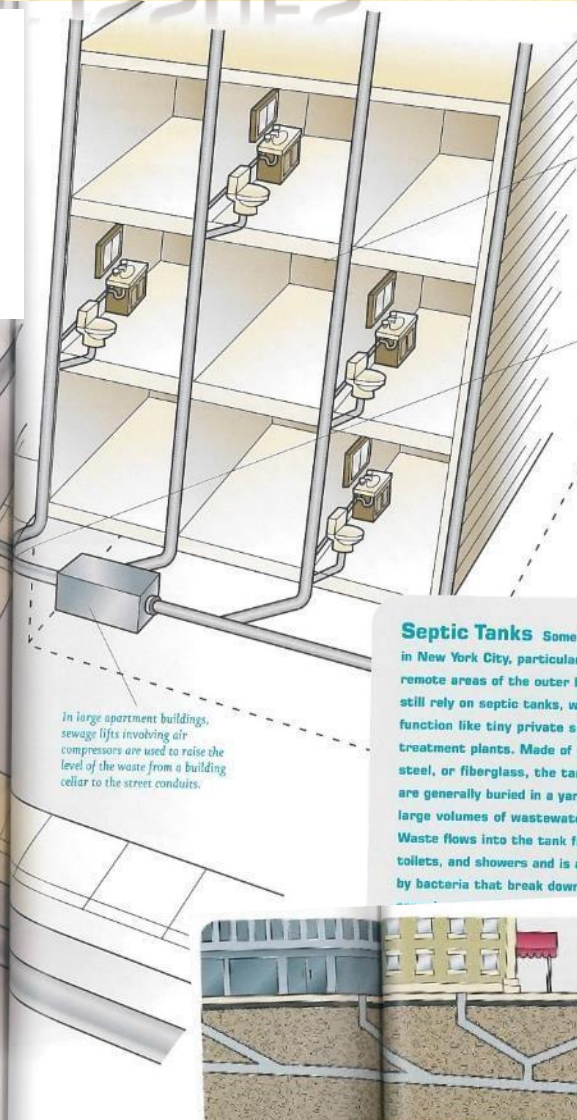
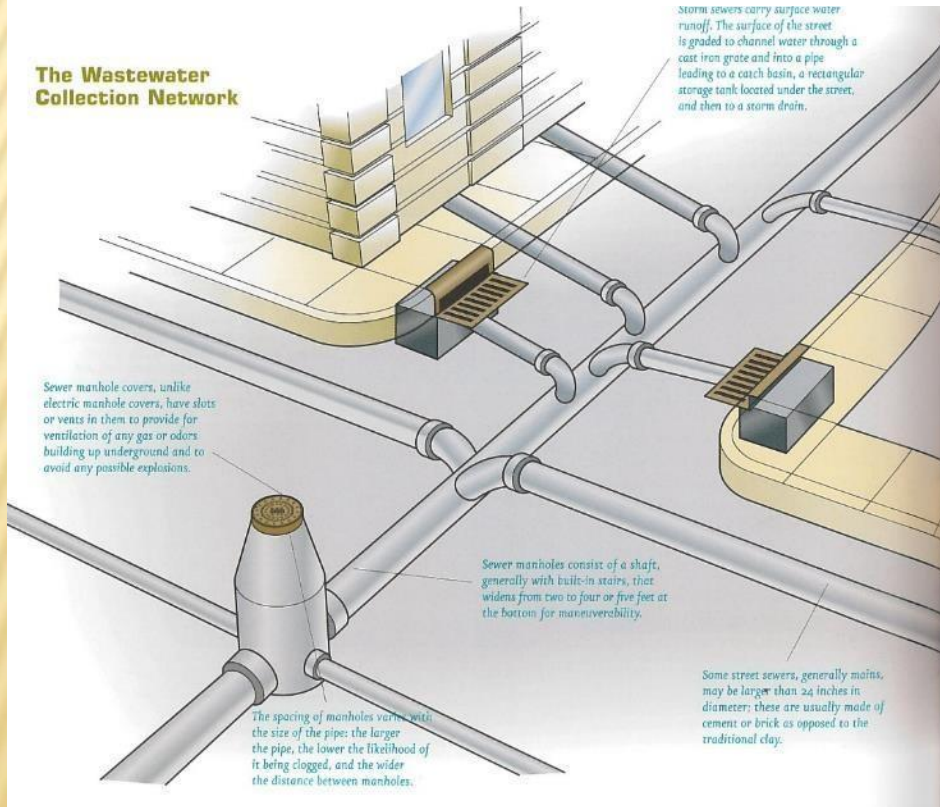


WATER: LOCAL NYC ISSUES

NYC Combined Sewers

- Stormwater + Wastewater both discharged into the same sewer pipes

The Wastewater Collection Network



WATER: LOCAL NYC ISSUES

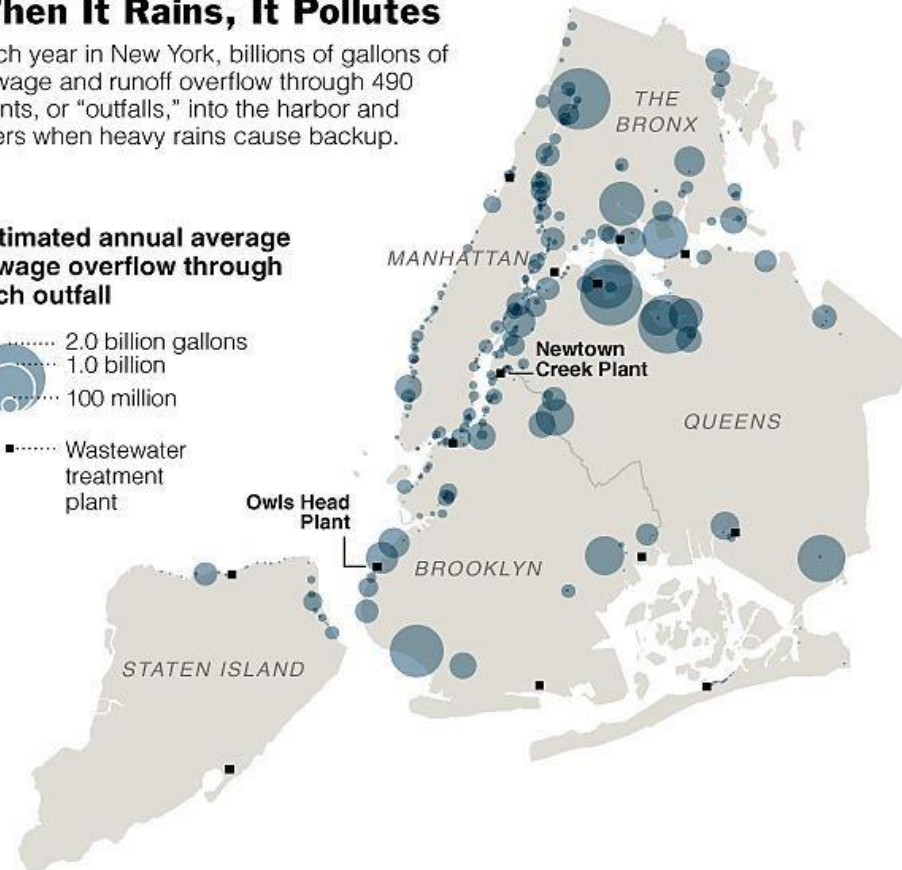
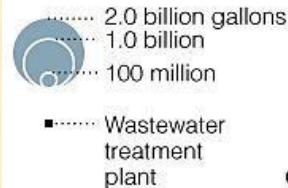
NYC Combined Sewers: CSOs

- During heavy rain and snow storms, combined sewers receive higher than normal flows.
- Treatment plants are unable to handle flows that are more than 2x design capacity
- When this occurs, a mix of excess stormwater + untreated wastewater discharges directly into the City's waterways at certain outfalls.
- CSO's are a concern due to their effect on water quality and recreational uses

When It Rains, It Pollutes

Each year in New York, billions of gallons of sewage and runoff overflow through 490 points, or "outfalls," into the harbor and rivers when heavy rains cause backup.

Estimated annual average sewage overflow through each outfall



TREATMENT PLANT

A mixture of wastewater and storm water is processed and expelled.



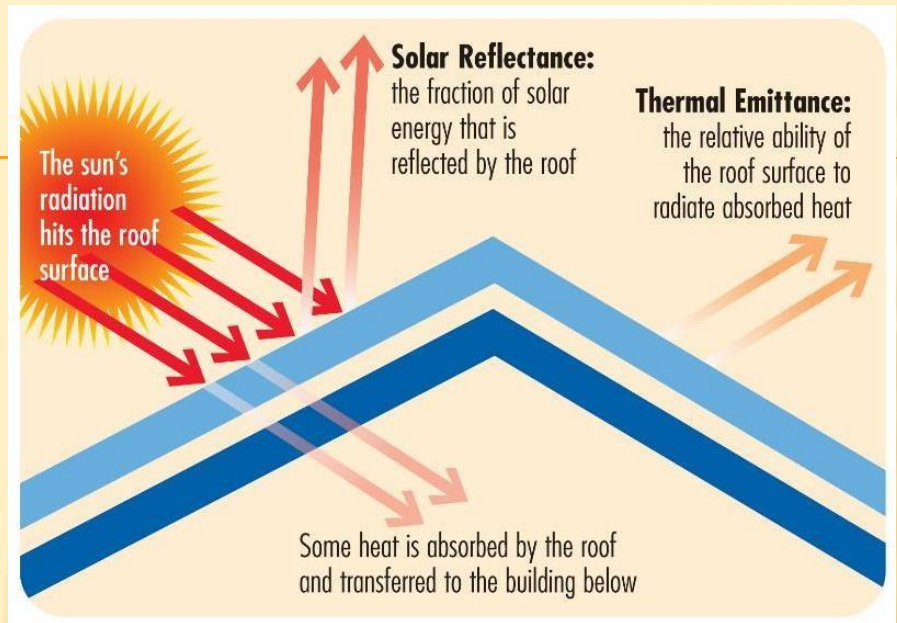
REGULATOR

When the flow of wastewater is too great, the regulator allows the overflow to pour into waterways.

ROOFS

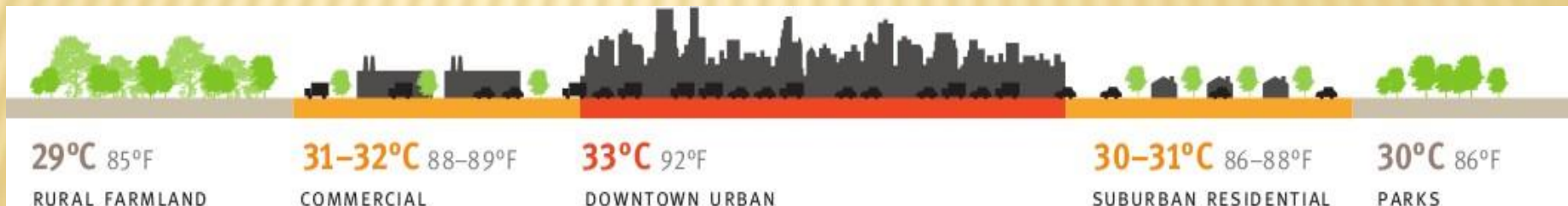
Solar Radiation on the Roof

- Reflected
- Absorbed
- Emitted



Urban Heat Island Effect

- Phenomenon in which cities and urban areas are several degrees hotter than surrounding areas
- Due to lack of vegetation and many dark colored surfaces (roofs, pavement) that absorb, hold, and slowly re-radiate heat



GREEN ROOFS

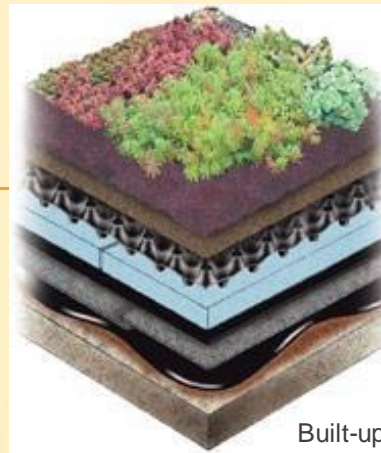
Green Roofs

Extensive Type

- Shallow soil (4" to 6")
- Typically low growing plants like sedums, which have shallow roots and do not require deep soil
- Can be built up in layers (membrane, protection layers, etc)
- OR, installed in modular, pre-planted containers or trays (easy installation and removal)

Intensive Type

- Deep soil (6" to 24" or more)
- Can accommodate trees, shrubs, larger plants, more variety
- Typically built up in layers (membranes, protection layers, etc)



Extensive Vegetation (Sedums, etc.)
Growing Media
Filter Fabric
Moisture Retention / Drainage Panel
Insulation
Root Barrier
Protection Course
Waterproofing Membrane (hot rubberized asphalt depicted)
Substrate (concrete deck depicted)

Built-up, layered system

Modular, container system



Yale Univ Smilow Cancer Hospital,
New Haven, CT (greenroofs.com)



Chicago City Hall

GREEN ROOFS

Green Roofs

- Benefits
 - Stormwater retention
 - Extends roof membrane life: protects against freeze/thaw, UV exposure
 - Reduces "Urban Heat Island Effect"
 - Creates habitat (birds, butterflies, bees)
 - Potential food production
 - Aesthetics, well being (e.g., hospital healing gardens)
 - Some insulating value
- Costs
 - Additional materials, labor
 - May need to reinforce building structure due to extra weight (load)
 - Maintenance
 - Irrigation (water the plants)



Extensive Vegetation (Sedums, etc.)
Growing Media
Filter Fabric
Moisture Retention / Drainage Panel
Insulation
Root Barrier
Protection Course
Waterproofing Membrane (hot rubberized asphalt depicted)
Substrate (concrete deck depicted)

Built-up, layered system

Modular, container system



Yale Univ Smilow Cancer Hospital,
New Haven, CT (greenroofs.com)



Chicago City Hall

BROOKLYN NAVY YARD, BLDG 92



Brooklyn Navy Yard, Building 92



Brooklyn Navy Yard, Bldg 92

LEED Scorecard

0010424382, Brooklyn, NY

Brooklyn Navy Yard Center at Building 92



LEED BD+C: Core and Shell (v2.0)

PLATINUM, AWARDED APR 2013



SUSTAINABLE SITES

AWARDED: 13 / 15

SSc1	Site selection	1 / 1
SSc2	Development density and community connectivity	1 / 1
SSc3	Brownfield redevelopment	1 / 1
SSc4.1	Alternative transportation - public transportation access	1 / 1
SSc4.2	Alternative transportation - bicycle storage and changing rooms	1 / 1
SSc4.3	Alternative transportation - low emitting and fuel efficient vehicles	1 / 1
SSc4.4	Alternative transportation - parking capacity	1 / 1
SSc5.1	Site development - protect or restore habitat	1 / 1
SSc5.2	Site development - maximize open space	1 / 1
SSc6.1	Stormwater design - quantity control	1 / 1
SSc6.2	Stormwater design - quality control	0 / 1
SSc7.1	Heat island effect - non-roof	1 / 1
SSc7.2	Heat island effect - roof	1 / 1
SSc8	Light pollution reduction	0 / 1
SSc9	Tenant design and construction guidelines	1 / 1



WATER EFFICIENCY

AWARDED: 5 / 5

WEc1.1	Water efficient landscaping - reduce by 50%	1 / 1
WEc1.2	Water efficient landscaping - no potable water use or no irrigation	1 / 1
WEc2	Innovative wastewater technologies	1 / 1
WEc3.1	Water use reduction - 20% reduction	1 / 1
WEc3.2	Water use reduction - 30% reduction	1 / 1



ENERGY & ATMOSPHERE

AWARDED: 13 / 14

EAc1	Optimize energy performance	8 / 8
EAc2	On-site renewable energy	0 / 1
EAc3	Enhanced commissioning	1 / 1
EAc4	Enhanced refrigerant Mgmt	1 / 1
EAc5.1	Measurement and verification - base building	2 / 1
EAc5.2	Measurement and verification - tenant submetering	0 / 1
EAc6	Green power	1 / 1



MATERIAL & RESOURCES

AWARDED: 10 / 11

MRc1.1	Building reuse - maintain 25% of existing walls, floors and roof	1 / 1
MRc1.2	Building reuse - maintain 50% of existing walls, floors and roof	1 / 1
MRc1.3	Building reuse - maintain 75% of existing walls, floors and roof	1 / 1



MATERIAL & RESOURCES

CONTINUED

MRc2.1	Construction waste Mgmt - divert 50% from disposal	1 / 1
MRc2.2	Construction waste Mgmt - divert 75% from disposal	1 / 1
MRc3	Materials reuse - 1%	1 / 1
MRc4.1	Recycled content - 10% (post-consumer + 1/2 pre-consumer)	1 / 1
MRc4.2	Recycled content - 20% (post-consumer + 1/2 pre-consumer)	1 / 1
MRc5.1	Regional materials - 10% extracted, processed and manufactured regionally	1 / 1
MRc5.2	Regional materials - 20% extracted, processed and manufactured regionally	1 / 1
MRc6	Certified wood	0 / 1



INDOOR ENVIRONMENTAL QUALITY

AWARDED: 7 / 12

EQc1	Outdoor air delivery monitoring	1 / 1
EQc2	Increased ventilation	1 / 1
EQc3	Construction IAQ Mgmt plan - during construction	1 / 1
EQc4.1	Low-emitting materials - adhesives and sealants	3 / 1
EQc4.2	Low-emitting materials - paints and coatings	0 / 1
EQc4.3	Low-emitting materials - carpet systems	0 / 1
EQc4.4	Low-emitting materials - composite wood and agrifiber products	0 / 1
EQc5	Indoor chemical and pollutant source control	1 / 1
EQc6	Controllability of systems - thermal comfort	0 / 1
EQc7	Thermal comfort - design	0 / 1
EQc8.1	Daylight and views - daylight 75% of spaces	0 / 1
EQc8.2	Daylight and views - views for 90% of spaces	0 / 1



INNOVATION

AWARDED: 4 / 5

IDc1	Innovation in design	3 / 4
IDc2	LEED Accredited Professional	1 / 1

TOTAL

52 / 62

SUSTAINABLE MATERIALS: WHAT IS THE TRUE COST?

Flooring Comparison (assume 50 yr. building): First Cost vs. Life Cycle Cost

Characteristic	VCT (vinyl composition tile)	Linoleum flooring
Composition	Binders, filler, pigments (some pigments contain heavy metals). Vinyl content 30% max.	Linseed oil, wood flour, pine rosin on jute backing, man-made. Environmentally friendly pigments
Disposal	Non-biodegradable	Biodegradable
Hygienic Properties	No antimicrobial properties	Inherently antimicrobial. Inhibits the growth of many micro-organisms
VOC Emissions	VOC's come from maintenance procedures	No harmful agents.
Availability	Produced in US Stocked in US	Produced in Europe. Shipped and stocked in US (Lower energy requirements in manufacturing offset shipping energy.)
Maintenance	Traditional waxing with periodic stripping and resealing	Wet method or dry method (preferred)
Initial Cost (Installed)	\$1.50 per sf (avg.)	\$3.50 per sf (avg.)
Maintenance Cost (per yr)	\$1.45/sf	\$.50/sf
Maintenance Cost (over 20 yrs)	\$29,000	\$10,000
System Service Life (yrs)	15 years	30 years
Number of replacement systems (in 50 yrs)	3 replacements	1 replacement

SOLAR

- One of the main advantages is that can either drastically reduce or totally eliminate your electric bills. This benefit of solar panels is pretty straightforward – when you install solar power for your home, you generate your own electricity, become less reliant on your electric utility and reduce your monthly electric bill.
- A solar panel system typically has a 25-30 year lifespan, which means that you can cut your electricity costs for decades to come by going solar. In addition it improves the value of your home.
- Solar panels are useful, especially at this location. Broad channel is prone to regular flooding which in turn causes blackouts form time to time. With the solar panels this will reduce the owners dependency of the grid and will keep the owner with electricity for some time while the respective authorities restore the electric service.

Your roof is great for solar!
1003 Cross Bay Boulevard, Far Rockaway, NY, United States

Save 30% or more
with Federal & State Incentives

Increased property value
Home values rise 3% or more

Congratulations!
Solar can save you up to \$9,800
Payback in about 4 years. \$0-down financing options available.

PAY CASH	\$0-DOWN LOAN	\$0-DOWN LEASE/PPA
Own the system; maximize savings	Own the system; no up-front cost	Rent the system; no up-front cost
\$9,800 20 Year Net Savings	\$8,700 20 Year Net Savings	\$2,300 20 Year Net Savings
\$1,800 Net Cost	\$0 Out-of-Pocket Cost	\$0 Out-of-Pocket Cost
3.5 Years Payback	Immediate Payback	Immediate Payback
3% or more Increase in Property Value	3% or more Increase in Property Value	0% Increase in Property Value
<p>Your Estimated Savings</p>	<p>Your Estimated Savings</p>	<p>Your Estimated Savings</p>

PASSIVE HOUSE/ GREEN DESIGN

- In theory can work with any building type not only houses, but most projects to date have been:
 - Residential (single family, multi family)
 - Schools
 - Some commercial
- Very popular in Europe
- Many projects in NYC, especially Brooklyn
- Like LEED, you can take a certification exam
 - Certified PH Designer or Consultant
 - Certified PH House Tradesperson (contractors)



Tighthouse, Brooklyn
Fabrica 718
completed 2013



174 Grand St, Brooklyn
Loadingdock5
completed 2011



INSULATION

Generally we want...

- Nice, thick layer of insulation
- Continuous insulation
- Avoid intermittent, interrupted insulation (e.g., in between metal stud framing)

Thermal images below:

- Yellow, orange, and red colors represent heat loss out through the envelope (i.e., the building is "leaking" heat and wasting energy and money).
- Purple and blue colors are cooler temperatures (i.e., heat is not escaping the building). This shows us where the insulation is located.



Insulation in between framing



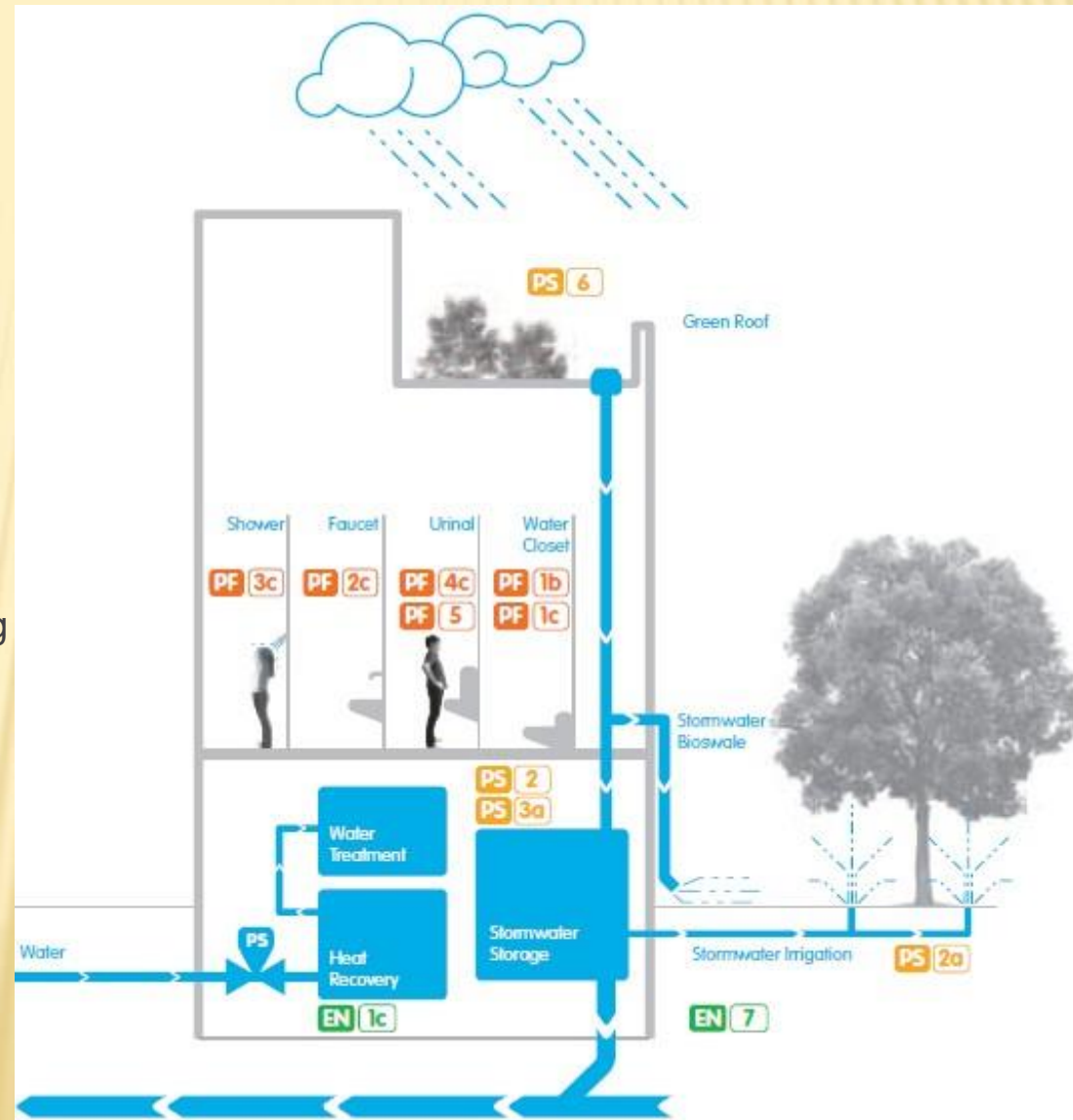
Continuous insulation

WATER: BUILDING SYSTEM STRATEGIES/DESIGN

NYC Dept. of Design & Construction:
Water Matters, June 2010

Water Harvesting & Reuse

- Potential water collection ("harvesting") from:
 - Stormwater
 - Greywater
 - Blackwater
 - HVAC cooling condensate
- Potential water reuse for:
 - Irrigation
 - Mechanical system (cooling towers)
 - Flushing fixtures (toilets, urinals)



WATER: BUILDING SYSTEM STRATEGIES

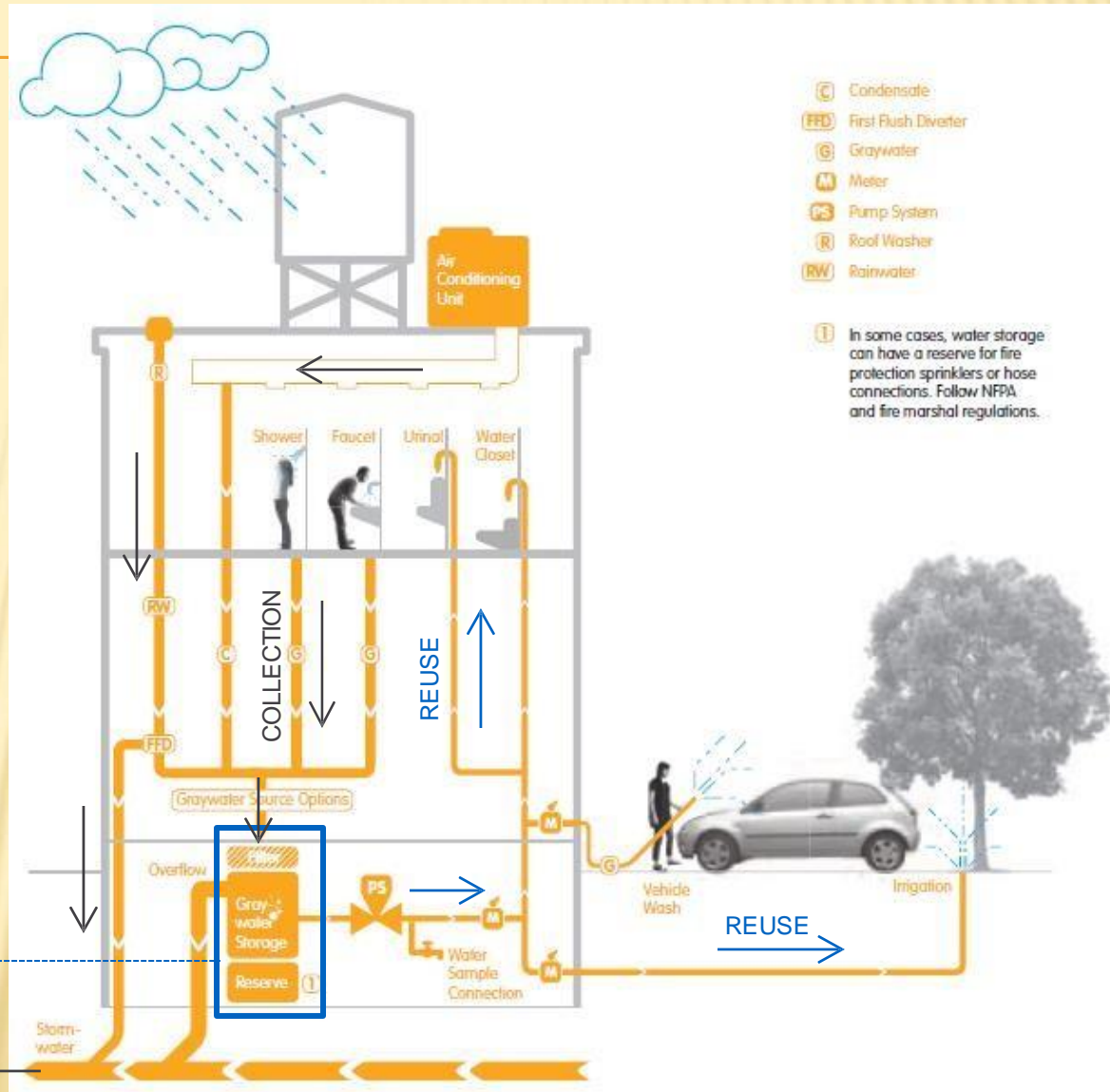
Storm & Greywater Harvesting

In this example scenario...

1. Collection from faucets, showers, roof rainwater, and air conditioning condensate
2. Initial "first flush" of each rainfall (which has most of the dirt and pollutants) is diverted to the sewer. The rest of rainwater goes to storage tank
3. Harvested water is filtered, treated, and stored in a tank
4. Treated non-potable water is reused for toilet and urinal flushing, irrigation, and vehicle washing

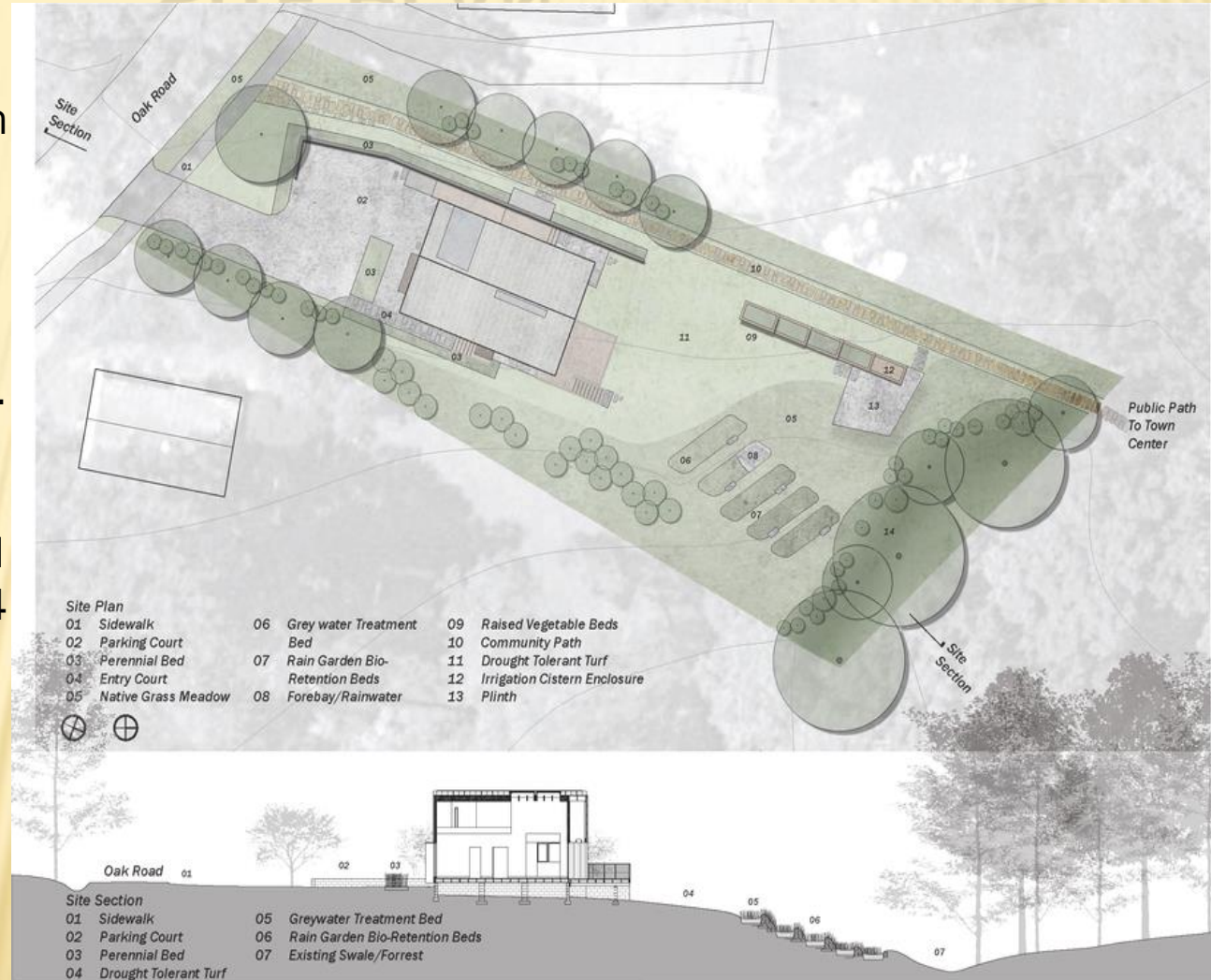
TREATMENT & STORAGE

TO COMBINED SEWER



SITE PLAN

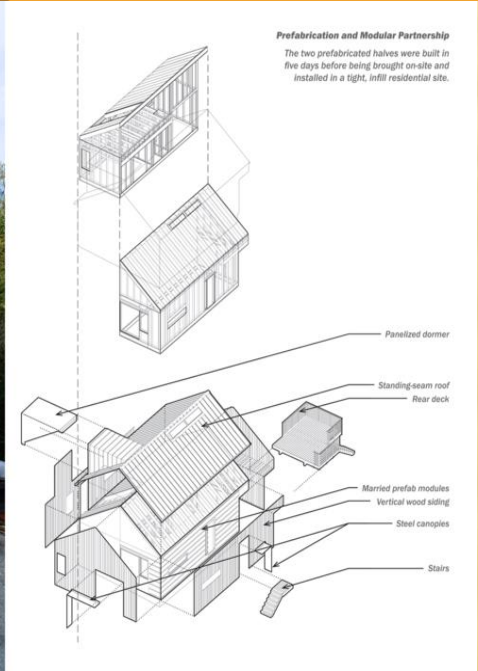
- The house is located on a previously developed lot in a previously developed community, minimizing the environmental impacts.
- The historic plan supports lifestyles that emphasize walking and cycling a half-mile to 14 basic amenities.
- Estimated percent of occupants using public transit, cycling or walking: 100%



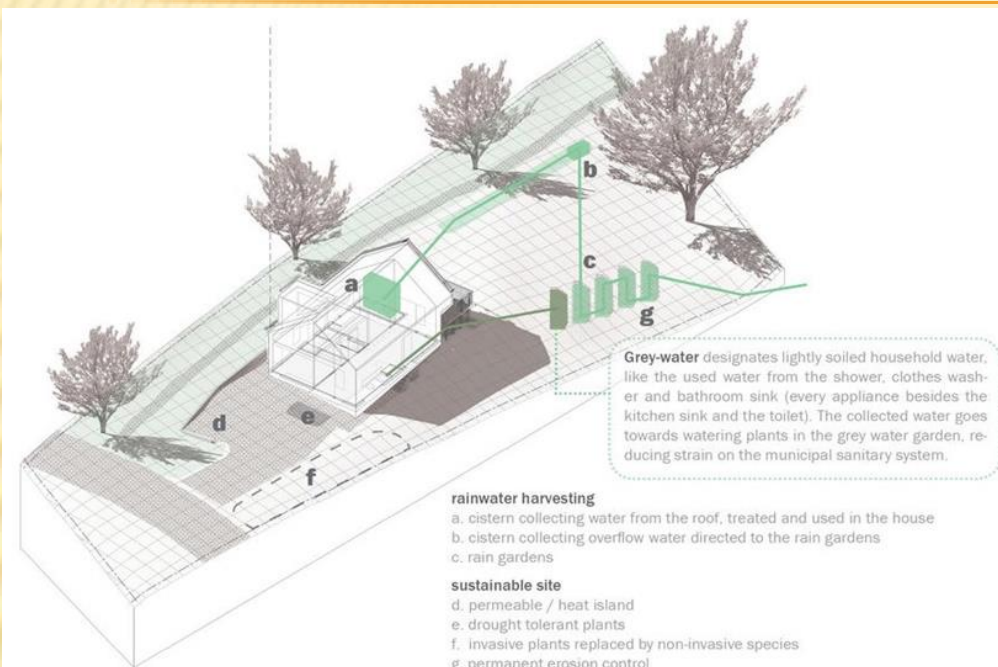
BUILDING OVERVIEW

At 1008 sf, A New Norris House is less than half the size of the median house, and it is sited on a 0.3 acre lot. “Right-sizing” reduced material and operational loads and costs, and shifted funds to quality design and construction, passive strategies and high-efficiency systems.

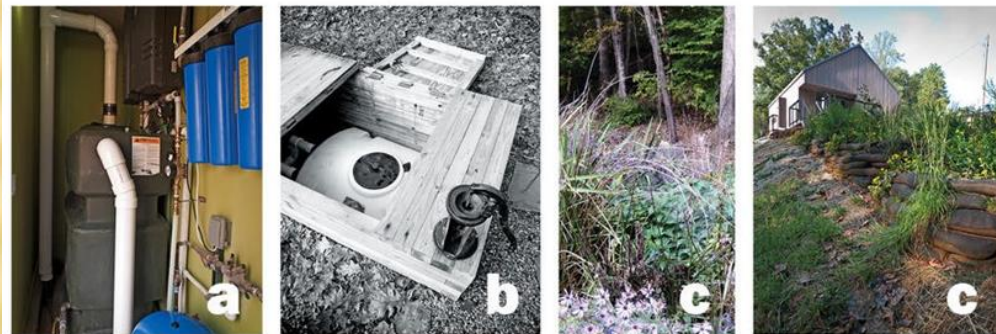
- The compact house was designed for off-site manufacture.
- Advanced framing techniques resulted in a 17.5% reduction in lumber, increased insulation, and decreased thermal bridging.
- 70% diversion of construction waste.
- Low- and no-VOC glues, paints and finishes were carefully controlled, critical to air quality given the tight envelope and immediate occupancy inherent in manufactured housing.



GREEN DESIGN FEATURES



- LEED for Homes Rating Date:2012. Platinum (26 points over Platinum threshold)
- One year of post-occupancy evaluation has revealed that the home is able to collect and treat rainwater that is safe for human contact by EPA. In the first year of study, 39,388 gallons of water has been passively returned to the landscape through greywater and rainwater overflow systems.
- Over 73% of waste water has been reused on-site.



REFERENCES

- ✘ Zhang, Fangzhu, and Philip Cooke. “Green Buildings and Energy Efficiency.” Green Buildings and Energy Efficiency, Centre for Advanced Studies, Cardiff University, UK, 2010, www.dimeeu.org/files/active/0/Cooke-2010-Fang-Green-building-review.pdf.
- ✘ Stutz, Bruce. “Green Roofs Are Starting To Sprout in American Cities.” Yale E360, 2 Dec. 2010, [e360.yale.edu/features/green roofs are starting to sprout in American cities](http://e360.yale.edu/features/green_roofs_are_starting_to_sprout_in_American_cities).
- ✘ Foroudastan, Saeed D, and Olivia Dees. “Solar Power and Sustainability in Developing Countries.” Engineering Technology and Industrial Studies College of Basic and Applied Sciences Middle Tennessee State University, 2006, pp. 1–13., [www.udc.edu/docs/cere/Solar Power and Sustainability in Developing Countries.pdf](http://www.udc.edu/docs/cere/Solar_Power_and_Sustainability_in_Developing_Countries.pdf).
- ✘ Biswas, Tajin, and Ramesh Krishnamurti. “FRAMEWORK FOR SUSTAINABLE BUILDING DESIGN.” FRAMEWORK FOR SUSTAINABLE BUILDING DESIGN, Carnegie Mellon University, 1 Jan. 2009, repository.cmu.edu/cgi/viewcontent.cgi?article=1046&context=architecture
- ✘ Circo, Carl J. “Using Mandates and Incentives to Promote Sustainable Construction and Green Building Projects in the Private Sector: A Call for More State Land Use Policy Initiatives.” Using Mandates and Incentives to Promote Sustainable Construction and Green Building Projects in the Private Sector, [Http://Www.pennstatelawreview.org](http://www.pennstatelawreview.org), 16 Apr. 2008, 11:33AM, [www.pennstatelawreview.org/articles/112 Penn St. L. Rev. 731.pdf](http://www.pennstatelawreview.org/articles/112_Penn_St._L._Rev._731.pdf).
- ✘ ARCH 3551: Sustainability History & Practice, Spring 2018 class
- ✘ AIA COTE (Committee on the Environment) Top Ten Projects, <http://www.aiatopten.org/node/280>