Building Science: Your Home and How It Works (and Doesn't)

LLC Spring, 2019

Do you own or rent a house, condo, or apartment? Are you thinking of remodeling, improving the comfort of your house, or making it safer or more energy efficient? Or do you just want to understand how it all works? Then this course is for you.

Learn what makes your home tick and view it anew. Most of us know little about the science, engineering, building materials and practices used to design, build and maintain a home. Specific course topics may include structural integrity, heat loss, solar heat gain, water and water vapor management, resistance to hurricanes, earthquakes and fires, indoor air quality, soundproofing, plumbing and electrical hazards, pest control, and sustainable materials and practices. Understand better cold winter drafts, why some wood rots, how mold can accumulate, and how to improve your indoor air quality.

Format: Participants will be encouraged to give a presentation on a topic of interest, design a home improvement project, or address a problem in their own home which incorporates course material.

Coordinator: Bob Opaluch, opiehere@gmail.com, (978) 808-6869
Bob designed and built a passive solar home in Boulder, Colorado, and renovated two homes in MA; and has done a lifetime of various home repairs and improvements for friends and family. He led LLC courses including Sustainable Architecture, and published articles on building topics in Green Building Advisor. His employment includes twenty years of engineering work at Bell Labs, Verizon, CSC/Caltech and a Silicon Valley startup. Bob has bachelor degrees in Applied Mathematics and in Philosophy from Brown, and a PhD and MA in psychology from UCLA. Bob taught for five years at UCLA, Cal State, U. Northern Colorado, and U. Maryland-European Division.

Course Goals

1. Gain a more sophisticated understanding of your home, based upon scientific principles or data, engineering or design considerations, or building codes, building practices or materials.
2. Perceive some aspects of your home differently, based upon topics discussed in class, or a specific project to address some issue.
3. Gain some insight on how scientific knowledge, engineering and design, building code requirements, building materials, and construction practices are interrelated.
4. Enable participants to explore some home improvement ideas with greater understanding and confidence.
5. Enjoy class presentations, project reviews and class discussions.

Since this is a Collaborative Learning course, we are all jointly responsible for educating each other (and ourselves). What are your own goals in taking this course? Consider both specific content that interests or benefits you, as well as other benefits of taking a seminar (e.g., practice at communication or technology skills, staying intellectually and socially active)

Presentations

- Presentations will focus on some key concepts in the field of Building Science, and specific topics of interest to class members.
- Each of the ten class sessions can be divided into two approximately 45 minute presentations (with a short break between them).
- You are encouraged to give a presentation, or work on an applied project. Applied design projects can be summarized in a shorter presentation, or by distributing a written document or slideshow to course participants.
- Pick a topic and/or design project, and pick a session date (course week 3 thru week 9), and please email or discuss with the course coordinator as soon as you can.
- Update the course coordinator on your plans.
- If needed, please feel free to seek help from classmates or the coordinator. They can help you start work on your topic of interest if you need some help.
- You are encouraged to work jointly, especially if you are less comfortable speaking to a group or creating slide shows or other materials.
- For presentations, it may help to identify specific scientific principles and data, related engineering and design work, and (if applicable) building codes, materials and practices.
- Consider raising one or more discussion questions during your presentation. Discussion questions take time to craft to be thoughtful and interesting, and encourage fruitful discussions among class participants.
- You are encouraged to work jointly, especially if you are less comfortable speaking to a group, or creating slide shows or other materials.
- The course coordinator (or other course participants) can help you start work on your topic of interest if you need some help.
- Copies of the slides from presentations typically will be distributed to class members

Class Sessions: Rules of the Road

1. Respect your elders! (See footnote for longer explanation)
2. NO FOOD in classrooms (use the break room), but drinks ***in covered containers*** are permitted. Please clean up after ourselves!
3. FOOD RESTRICTIONS: No pork, pork products, or shellfish! Do not mix meat and dairy products!
4. Please turn off phones or put on vibrate mode to avoid disruptions. Feel free to step out of the room for any reason, without disruption the class. Bathrooms are located xxx. If you are late for class, or need to leave early, please quietly have a seat or leave quietly, we understand these things happen due to traffic, parking, weather, conflicting schedules, and many other good reasons.
5. Session leaders are responsible for providing a presentation with visuals or props, testing any slideshows, videos or Internet-based materials BEFORE the session. Bring a flash thumb drive with your presentation (or your laptop) if you are presenting. (Please bring your flash drive the previous week to test it out.)
6. Microphones are available if you cannot speak loud enough for everyone to be heard. Those who need to sit near the speaker can reserve a seat.

7. Encourage quiet people to contribute if you notice they seem to have something to say. Please do not dominate the discussions if you find you tend to take more than your share of the group's time.
8. Please do not engage in side conversations during someone's presentation; either attend to the presentation or bring your side discussion up for all the class to discuss.
9. Classes may be moved or canceled due to weather conditions or Temple events. If the Temple closes for inclement weather, LLC classes for that day will be cancelled. The course coordinator will notify class participants by email. (Let me know if you prefer to receive a phone call (or voice mail if you don't answer).
10. If you need to cancel or change the date of your presentation, please contact the course coordinator as soon as possible.
11. Access to the Temple for LLC classes will be through the rear entrance from the parking lot. Since access to the Temple is restricted, LLC members should push the button to signal the office and will be buzzed in.
12. The assigned parking spaces in the Temple parking lot belong to the Rabbi and staff of Temple Beth-El. Please do NOT park in these assigned spaces. Any vehicles parked in assigned spaces will be subject to towing at owner's expense. There is usually ample parking on Orchard Street, so if the lot is full, please park on Orchard Street.
13. In the unlikely event of genuine emergencies, call 911 and then call the Temple office 401–331–6070 Ext 105. Any concerns or complaints about the conditions in the classrooms, which are not deemed emergencies, should be reported to the course coordinator only.

Meetings

- **Two hours Tuesdays March 12 to May 14th**
- **Two 45 minute, three 30 minute or some 20 minute sessions per day, plus announcements, discussions and breaks**
- Please turn off phones or put on vibrate mode
- Feel free to drift in and out of the room quietly without disrupting, if necessary

Preparing for presentations:

- You are strongly encouraged to either do a presentation or a project. Doing more than one is okay (time permitting).
- You are entitled to a **45 minute time slot**, or can take less time if preferred (e.g., 30 minutes, 20 minutes), or can take more if available that day
- Projects could be a presentation, or you can a distribute a project report (paper, PDF or Word doc) or both.
- You are encouraged to work together with another participant or a small group, especially if you have concerns about public speaking, concerns about creating or running slideshows, want to work on the same topic as others, or prefer to split a topic with others.
- You are encouraged to practice your presentation beforehand by going through your slides while reading aloud. Time the length of the presentation.

- Please spend some time thinking up some good discussion questions in addition to your presentation. Suggesting related projects, distributing or providing links to additional information,
- The course coordinator Bob and probably others in the course are willing to help out if you have questions or difficulty finding information, creating or running slide shows, etc.
- Best to bring slideshows or presentation materials on a **USB flash drive** to plug into the classroom's Mac Mini for slides, videos, Internet links, etc.
- You can connect **your own laptop** to the Mac Mini for your presentation
- You can **connect to the Internet** as part of your presentation, but occasionally may not available
- **Test out your slideshow or Internet links in class** the week before your presentation (which doesn't have to be complete for the test). Sometimes we experience technical difficulties, so better to experience them in advance, not the day of your presentation.
- Let me know ASAP if you need to reschedule a presentation.
- Presentation problems: Bad sources for information, technical difficulties with slide shows or Internet availability, presentation takes much more or less time than estimated, speak to the audience to be heard well and note audience reactions, …
- Optional: Simple mathematics with a conceptual explanation (derivation) is okay. Spreadsheets are okay. Please avoid complex formulas that may intimidate or confuse those who are allergic to math. Or make the math a separate part that is optional to understanding the presentation.

Summary of LLC Building Science Course (Spring, 2019)

Recent Building Science research, analysis and construction recommendations have focused on four key components of the building envelope, to optimize a building's performance:

1. **Bulk Water Barrier**: "Water is the enemy of wood", the common material used in small buildings. Roofing and cladding sheds rain and snow from roofs and walls. Underlayments, flashing, drip edges, and rain screens behind wall cladding, stop water that gets beyond roofing and wall cladding.
2. **Air Barrier**: The building envelope needs to be sealed from uncontrolled air infiltration and air leaks to reduce drafts, increase comfort, and reduce utility costs for heating and cooling the building's interior. The tighter the building envelope, the better. Heat losses are minimized during winter, and heat gains and humidity are minimized during hot humid summers.
    - Many new products and materials are available to reduce air leakage.
    - During construction of buildings, *blower door tests* can pressurize or depressurize the interior, to detect and seal leaks before interior finishes make those leaks inaccessible to seal.
    - *Heat Recovery Ventilators (HRVs)* can provide fresh air using minimal energy by warming the incoming cold air in winter, using heat from the exhaust air. (Similarly, HRVs can *cool* incoming air in *hot summer* weather.)

- *Energy Recovery Ventilators (ERVs)* not only transfer heat between incoming and outgoing air streams, they also transfer humidity. So interior air can stay dryer during hot humid weather, and not too dry during cold dry winter weather.
- HRVs and ERVs also can improve *indoor air quality*. Options include filters to rid incoming air of various undesirable particulates, and to run automatically if indoor CO2, temps, humidity or pollution becomes excessive.

3. **Thermal Barrier**: Many types of insulation are available to reduce wintertime heat loss (and summertime heat gain). Common choices include fiberglass and mineral wool batts and loose fill; mineral wool semi-rigid panels; cellulose loose fill; EPS, GPS and XPS rigid foam panels; and site-applied closed or open cell foam. Canned spray foam can seal cracks and small holes.
    - R-value indicates the resistance of a material or assembly to reduce heat transmission. R-value varies from R-1 (e.g., single pane of glass) to R-100 or higher (e.g., attic insulation in some high performance homes).
    - Doubling the amount of insulation will cut the heat loss in half (e.g., R-5 will allow twice as much heat transmitted per area as R-10).
    - You can use spreadsheets to model conductive heat loss accurately, although it can be tedious to model all the different building components to add up the heat losses for the whole building or a room.
    - Usually it is cheapest to insulate attics, where space is usually not a constraint, so attics tend to have more insulation installed. Typically R-38 is the minimum required in new attics or roofs, and R-100 may be found in certified Passive House buildings.
    - Walls can have insulation installed between wood studs, or a continuous layer of insulation, typically installed on the exterior of the wall, or between parallel double walls. Typically R-19 or R-20 is the new minimum requirement, although most localities probably still accept typical R-13 2x4 walls with fiberglass batts. High performance homebuilders typically are R-35 or above.
    - Foundations and basements that are included in the building envelope need to be insulated, typically on the inside of foundation walls, and rigid foam installed below a concrete slab floor. R-10 is the minimum sub-slab insulation now required in more recent building codes (but I doubt enforced).
    - Doors and windows tend to have minimal insulation value, but high performance windows and doors often reduce heat loss by 50% to 80% vs. cheaper common products. Insulated window treatments (e.g., cellular shades, insulated shutters) can reduce heat loss through windows appreciably, since windows tend to be covered about two-thirds of each day during the longer night-times of mid-winter. Typical double-pane windows are R-2 (U=0.5), and R-4 to R-5 windows aren't that much more expensive and worth the added expense!
4. **Water Vapor Management**: Water ends up in building materials not only from bulk water, but also from condensing water vapor. As air escapes from a building through smaller cracks and holes, the air is cooled by cold building materials, and water vapor condenses inside walls and attics. Similarly, water vapor can move through many solid

materials (e.g., wood). Wood rot and mold can result from excessive water vapor migrating into the building envelope. It is important to allow walls to dry towards the interior, exterior, or both directions. It is risky if low permeability materials (e.g., glass, foil facers, most roof shingles, closed cell foam) traps moisture inside a wall or other building assembly. Significant interior water vapor sources include humidifiers, cooking, showers, plants, laundry hung to dry indoors, and wood stored inside for for fireplaces or wood stoves.

During winter, heat is lost from homes by conduction (objects that touch), convection (air movement bringing heat and cold in the air), and by radiation (heat jumping across air or vacuums).

- **Conductive heat loss** is managed by *insulation*, slowing the movement of heat through the building envelope.
- **Convective heat loss** is managed by air barriers, which stop the flow of air through the building envelope.
- **Radiant heat loss** tends to be minimal, and is typically ignored in computing a home's heat loss during cold winter weather.

Windows and glazing are a source of *radiant heat gain*, especially when the sun beats directly through window glass. In the northeastern US, the sun is almost directly overhead at noon in June, but quite low on the southern horizon at noon in December. Therefore, unshaded south-facing windows get substantial solar heat gain (and daylighting) in December and January, but almost none in June (and early summer). Those solar gains add some warmth to a typical home during a sunny winter day. In a well-insulated solar-oriented home with more substantial areas of south-facing windows, solar heat gain could almost eliminate the need for a heating system, other than minor electric heating. West and East-facing windows get less than a third of the wintertime solar gains of unshaded south-facing windows, and North-facing windows get no direct solar gain and only about one-fifteenth as much solar gain vs. south. West-facing windows can get a lot of solar gain during hot summer afternoons, so should be shaded by a porch, overhang, tree, solar-blocking screen or treatment, or some other shading to avoid unwanted summertime heat gain.

Window upgrades to reduce heat loss (or gain) includes:

- Storm windows (adds R-1)
- Double-pane (R-2) or triple pane windows (R-3), which have sealed *Insulating Glass Units* (IGUs), trapping air or a gas inside the window panes
- Filling the spaces inside IGUs with argon (cheap) or krypton (expensive) adds R-1
- Treating one or more glass surfaces with invisible Low E coatings, to reflect infrared heat (back into the home in winter, and reject the heat in summer)
- Adding a pane of glass, a gas inside the IGU, or each Low E coating, adds about R-1 to the window's insulating value. So windows typically are R-2 (cheaper doublepanes) to R-7 (expensive triple panes, with argon or krypon fill, and multiple Low E coatings).

- IGUs with a vacuum between panes (instead of air, argon or krypton) would have a very high insulating value (perhaps R-50?), but are not yet available
- Note that window coverings (e.g., cellular/honeycomb shades, window quilts, insulated shutters) can add R-1 to R-5, if the coverings are fairly airtight to stop interior convection currents along the window glass.
- Window stickers show the U-value (inverse of R-value, typically from U=0.5 mediocre to U=0.15 excellent), Solar Heat Gain Coefficient (SHGC, from low solar gain 35% to high solar gain 70%), and the Visible Light Transmittance (VT, best to be at least 0.4 or 40%).
- Most leaky window types are sliding or double-hung windows. Least leaky are fixed (picture windows), Tilt and Turn, casement, and awning windows.

The USA can be divided into climate zones that vary from benevolent climates (Key West, San Diego, Honolulu) to harsh winter climates (Alaska, N Dakota). Providence is Zone 5A, with moderately cold winters and mild summers, about 5,500 Heating Degree Days, 29^{o}F average January temperature, and 9^{o}F winter "design temperature" (assumed average daily temperature on the coldest day of a typical winter) and moderately sunny.

The BTUs of heat loss from a home can be calculated using a spreadsheet, knowing the R-value of each of the various parts of the building envelope (attic, walls, floor or concrete basement, windows, doors, …), the square feet of area of each assembly, the temperature difference between the outdoor and indoor temperature (9^{o}F or 29^{o}F vs. 68^{o}F), and the time the heat loss occurs (hour, 24 hour day, month, season). Knowing the heat loss allow you to calculate the size of a heating system (or solar heat gain) is needed to keep each room of the home at a comfortable temperature during the coldest day of winter. Supplementary heat can be provided by a gas, oil, propane or electric central heating system, a wood stove, electrical resistance or radiant heaters in various rooms, by electrical heat pumps, or some combination.

Mini-split heat pumps can be used to take heat from cold outdoor air, and transfer that heat to the indoors. Most minisplits provide both heating and air conditioning, but some have only one mode.

- Minisplits are 2-3 times more efficient than electrical resistance or electrical radiant heating, less expensive than oil or propane heating, and comparable to the cost of heating with a natural gas central heating system.
- Minisplits are not very expensive (over $1,000). Gas or oil central heating systems cost far more to install.
- Typically mini-splits are used to heat an open floor plan, or rooms on the same floor when doors are typically left open.
- Each story of a multi-level building can have a separate minisplit. (Heat rises to an upper floor during winter, but not a lower floor. Cool air falls to a lower floor during summer, but not an upper floor.) Multi-head or ducted heat pumps can be used to heat separate areas.
- Newer minisplits work effectively down to minus 15^{o}F, but are less efficient at below zero temps.

Hybrid Heat Pump Water Heaters take heat from the surrounding room to heat water in the tank. They also can operate in typical electrical element heating mode. They are 3-4 times as efficient as traditional electric hot water tanks, but are more than double the purchase price (before energy efficiency tax rebates). They are especially sensible to use in hot, humid climates, as they would cool and dehumidify the surrounding air in the home. They also can be noisy, so are best located in a basement or utility area, especially in cold winter climates when they could cool the surrounding area.

Universal Design attempts to create homes for a wider range of people and abilities (children, elderly, disabled, wheelchair users, blind or low vision, deaf, tall/short, various cultural backgrounds).

- Most Universal Design features are easier and less expensive to provide if included in the original construction, not added later.
- Many Universal Design recommendations cost little (porch or roof over entries, eliminating stairs for entries, lowering door and shower thresholds, 36" wide doors, lever door and faucet handles, high contrast colors, open floor plans, single story units, side-by-side refrigerators, drawers instead of doors on refrigerators or kitchen base cabinets, more reachable or visible levels for electrical outlets, switches and thermostats.
- Bathrooms for wheelchair users require a 5' turning circle, outswing or pocket 36" door, space both beside and in front of toilet, roll-in 5'x3' shower, preferably wall-hung sink, and grab bars for at least toilet and shower areas.

The Home Repair Checklist was distributed to the class. The Home Repair Checklist has many specific items to improve the homebuyers attention to details of the condition of the home being inspected. While inspecting a home to purchase, the detailed checklist of the home's features, potential problems and needed repairs, provides an objective and detailed assessment of the condition and value of a home. The Home Repair Checklist has been used successfully by prospective homebuyers while making home inspections and purchase decisions, and was rated positively by those homebuyers.

Understanding criminal behavior patterns leads police to recommend specific physical changes to a home's yard, windows, entry doors (selection, locking and reinforcement), lighting, and simulating occupancy when away.

Smart Homes and electrical upgrades were reviewed only briefly due to time constraints.

The building renovation process, cost estimating, and hiring contractors was discussed, and contacts for contractors are being shared among class members. A list will be compiled and distributed.

This course included home improvement project presentations and illustrations, including:

- Site applied spray foam insulation

- Subsidized RISE program insulation, air-sealing, lightbulbs and refrigerators
- Passive solar home with substantial south-facing glazing that has almost no winter heating bill
- Plumbing upgrades and preserving historic plumbing fixtures
- Electrical system upgrades
- Roofing leaks, damage, and ice dams
- Insurance complications in repairs
- Home improvement projects to accommodate wheelchair users and occupants using crutches,
- Finding, selecting, managing and terminating contractors

Books and Internet Resources

There is no required book or articles for this course overall. However, specific presentations may have a reading assignment, or suggestions for optional reading before or after the presentation. Most of this reading material is likely to be available on the Internet. If you do not have access to the Internet, please discuss with the coordinator. Here's some good examples of general Building Science references.

https://buildingscience.com

https://www.greenbuildingadvisor.com/blog/building-science

Paul, Jens, *Building Science - concepts and application*. West Sussex, UK: Wiley-Blackwell, 2011, $61. https://www.amazon.com/Building-Science-Application-Jens-Pohl/dp/0470655739

Racusin, Jacob, *Essential Building Science: Understanding Energy and Moisture in High Performance House Design*. https://www.amazon.com/Essential-Building-Science-Understanding-Performance/dp/0865718342/ref=sr_1_1?ie=UTF8&qid=1542929671&sr=8-1&keywords=building+science

Gifford, Henry, *Buildings Don't Lie*, $75.
https://smile.amazon.com/Buildings-Dont-Lie-Henry-Gifford/dp/0999011006/ref=pd_rhf_ee_s_vtp_ses_clicks_0_1?_encoding=UTF8&pd_rd_i=0999011006&pd_rd_r=5948b8f1-bf88-4362-9723-166841051c80&pd_rd_w=jKkGN&pd_rd_wg=ApcGs&pf_rd_i=desktop-rhf&pf_rd_m=ATVPDKIKX0DE
"A simple, clear, thorough and complete explanation of basic building science applicable to any building…"

National Institute of Building Sciences
https://www.nibs.org

Climate zones (not plant hardiness zones):
https://www.greenbuildingadvisor.com/article/all-about-climate-zones

Resilient Design (overview on buildings weathering storms and outages)
https://www.finehomebuilding.com/2012/04/26/a-case-for-resilient-design

Winterizing Tips
https://www.greenbuildingadvisor.com/article/winterizing-tips-that-work

Energy-efficient dehumidification:
https://www.greenbuildingadvisor.com/article/high-performance-dehumidification

mold, humidity levels:
https://www.greenbuildingadvisor.com/article/coping-high-humidity-mold
https://www.greenbuildingadvisor.com/article/moisture-sources-relative-humidity-and-mold
https://www.greenbuildingadvisor.com/article/common-sense-mold

Poisonous Home Cleaning Chemicals and Food-Medication Interactions:
https://missouripoisoncenter.org/some-things-just-dont-mix/

Ventilation:
https://www.greenbuildingadvisor.com/article/two-main-flaws-kitchen-ventilation

Lead Poisoning
https://www.youtube.com/watch?v=GUizvEjR-0U
John Oliver covers data and costs of lead poisoning in children

https://www.greenbuildingadvisor.com/article/managing-lead-paint-hazards
Lead paint hazards and abatement procedures

Lstiburek video
https://www.youtube.com/watch?v=9Hm9ALhyTHo
1:45 of 10 mins done

Building science summer camp
https://www.energyvanguard.com/blog/76438/Matt-Risinger-s-Building-Science-Summer-Camp-Interviews

https://www.wbdg.org/resources/building-science-concepts

https://www.wbdg.org/resources/building-enclosure-design-principles-and-strategies

https://www.amazon.com/Building-Science-Application-Jens-Pohl/dp/0470655739

https://www.energyvanguard.com/blog/44254/The-Best-Books-I-ve-Ever-Read-On-Building-Science-and-Beyond

https://www.wiley.com/en-us/Water+in+Buildings%3A+An+Architect%27s+Guide+to+Moisture+and+Mold-p-9780471468509

https://www.newsociety.com/Books/E/Essential-Building-Science
Pressure diagnostics, air movement tied to air temp within building envelope

https://www.greenbuildingadvisor.com/article/an-introduction-to-pressure-diagnostics
holes in partitions and walls can lead to air flow up and down the structure, and may cause condensation or humidity problems as well as heat loss or heat gain.

Architects Need Training in Building Science
https://s3.amazonaws.com/greenbuildingadvisor.s3.tauntoncloud.com/app/uploads/2019/01/04073550/EDU-June-2005-final.pdf

Fortified Home Program
https://disastersafety.org/fortified/fortified-home/

Budget-Friendly Energy Efficient Construction
https://www.greenbuildingadvisor.com/article/efficient-walls-budget

Poor Indoor Air Quality and Health
https://www.greenbuildingadvisor.com/article/the-trouble-with-homes-asthma-and-poor-indoor-air-quality

NY Times article on "How Your Gas Stove is Bad for You and the Planet"
https://www.nytimes.com/2019/05/01/opinion/climate-change-gas-electricity.html

Asbestos
https://www.greenbuildingadvisor.com/article/how-worried-should-you-be-about-asbestos-in-older-homes

Ventilation Requirements and HRVs for Bathrooms
https://www.greenbuildingadvisor.com/article/does-a-home-with-an-hrv-also-need-bath-fans

Ontario Canada Imposes Tougher Ventilation Requirements
https://www.greenbuildingadvisor.com/article/ontario-imposes-tougher-ventilation-requirements

Air Leakage and Air Sealing
https://www.greenbuildingadvisor.com/article/an-introduction-to-pressure-diagnostics

Holes in partitions and walls can lead to air flow up and down the structure, and may cause condensation or humidity problems as well as heat loss or heat gain.

FEMA Building Code Resources for Natural Hazards (Quake, Wind, Flood, Wildfires)
https://www.fema.gov/building-code-resources

Interesting article about affordable Panama City Habitat homes that survived the hurricane
https://www.jlconline.com/projects/disaster-resistant-building/surviving-hurricane-habitat-houses-offer-lessons_o?utm_source=newsletter&utm_content=Brief&utm_medium=email&utm_campaign=JLC_120218%20(1)&he=56c8cc46cd5d14365291bacef5cb6b3966b22d3e

Summer interior humidity control, nighttime cooling, dehumidifiers, ERVs, AC:
https://www.greenbuildingadvisor.com/article/coping-high-humidity-mold

Air Filters
https://www.greenbuildingadvisor.com/article/seven-reasons-filter-isnt-cleaning-air

Floods
http://www.bbc.com/future/story/20181129-the-underground-cathedral-protecting-tokyo-from-floods

Climate Zones
https://www.greenbuildingadvisor.com/article/all-about-climate-zones

Energy-efficient "Pretty Good" House Concept
https://www.greenbuildingadvisor.com/article/ten-essential-steps-to-a-pretty-good-house

Radiation
https://io9.gizmodo.com/how-does-radiation-travel-and-what-kinds-of-damage-can-5782367

Wintertime Solar Heat Gain, Passive Solar Heating, and Climate
https://www.greenbuildingadvisor.com/article/a-quantitative-look-at-solar-heat-gain
This article is loaded with data, and may be difficult to read in some sections, but gives a lot of useful information about solar heat gain.

https://www.greenbuildingadvisor.com/green-homes/a-passive-solar-home-from-the-1980s
This article describes how passive solar works, and describes the house I built in Colorado.

https://www.greenbuildingadvisor.com/article/resilient-design-passive-solar-heat
Excellent description of passive solar design and resilience. Alex Wilson is a good person to follow for well thought out and well written descriptions of high performance building design concepts and sustainable materials.

"Passive Solar Architecture: Heating, Cooling, Ventilation, Daylighting, and more Using Natural Flows"

https://buildingscience.com/documents/insights/bsi-021-thermodynamics-its-not-rocket-science?searchterm=space%2520shuttle

Drying Green Lumber, Solar Kiln for Drying Wood, Moisture Meters
https://www.wagnermeters.com/forest-products/industry-info/kiln-drying-your-own-wood/

Hiring a Contractor
https://www.homeadvisor.com/r/guide-to-hiring-a-contractor/

Older Adults Trained How to Fall Safely
https://www.nytimes.com/2018/01/02/world/europe/netherlands-falling-elderly.html

Amazon Alexa intelligent assistant device sends voice recordings of its user to random stranger by mistake:
https://www.theverge.com/2018/12/20/18150531/amazon-alexa-voice-recordings-wrong-user-gdpr-privacy-ai

Nostalgia for buildings and places:
https://www.npr.org/sections/thesalt/2019/03/31/702530169/closing-time-the-science-behind-nostalgia-for-our-favorite-bars

partially read
https://www.greenbuildingadvisor.com/article/how-to-become-a-building-enclosure-control-freak

https://www.greenbuildingadvisor.com/article/what-is-the-ideal-relative-humidity-in-winter

http://www.greenbuildercoalition.org

https://www.greenbuildingadvisor.com/article/is-cold-sheathing-in-double-wall-construction-at-risk

https://www.greenbuildingadvisor.com/article/winterizing-tips-that-work

https://www.greenbuildingadvisor.com/article/ten-essential-steps-to-a-pretty-good-house

https://www.greenbuildingadvisor.com/article/a-brief-introduction-to-wufi-in-5-easy-pieces

https://www.greenbuildingadvisor.com/article/does-a-composting-toilet-stink-up-your-house

https://www.greenbuildingadvisor.com/article/all-about-climate-zones

https://www.greenbuildingadvisor.com/article/the-trouble-with-homes-asthma-and-poor-indoor-air-quality

https://www.greenbuildingadvisor.com/article/is-the-pretty-good-house-the-next-big-thing-part-2

https://www.resnet.us/hers-index-score-card

Videos:

Matt Risinger is a high-end builder in Austin, and has a big presence on social media, often touting specific products (endorsements). Google Risinger and a high performance homebuilding topic to see other videos.
Matt Risinger building timber frame luxury home with Bensonwood components (2 min):
https://www.youtube.com/watch?v=Ab51ZkNY1R8

Ted Benson started out building timber frame homes, moving to high end clients. Benson saw the promise of manufacturing walls and other building assemblies in controlled factory conditions. The following videos show Benson's state of the art factory.
Ted Benson, Bensonwood and Unity Homes, custom manufactured, energy efficient homes (4 min):
https://www.youtube.com/watch?v=GICs5i_MvJ4
Factory tour (22 min) uses construction vocabulary (lots more detail):
https://www.youtube.com/watch?v=JpznB7uiZrw

Norman Foster, "My Green Agenda for Architecture", computers in architecture and factory-based construction, green architecture history, homes imbedded in car-centric cities (32 min):
https://www.ted.com/talks/norman_foster_s_green_agenda#t-1096317
Focuses architecture and on larger buildings

Four 26 minute "Aging in Place" TV show videos from 2012. Overview of Universal Design ideas, home design and construction upgrades, and specific equipment available in hardware stores. Includes interviews with elderly and disabled users of homes that are upgraded with Universal Design features.
https://video.wcny.org/search/?q=design+for+a+lifetime