Energy Standards, Codes, Incentives, and Efficiency Designations:

ASHRAE 90.1
IECC
Tax & Utility Incentives
Energy Efficiency Certifications

I. What are "energy standards, codes, and efficiency designations"?

A. The US Department of Energy (DoE) Office of Energy Efficiency & Renewable Energy says 'codes' are...

1. Building codes are state laws. The U.S. does not have a national building code or energy code; instead, states or local governments can choose to adopt one of the national model energy codes, a modified version of the model code, or their own state-specific code.
   a And per the 10th Amendment to the Constitution, powers not delegated to the Federal Government by the Constitution, nor prohibited by the Constitution to the States, are reserved to the States, or to the people. So States have the right (obligation) to establish and enforce laws that protect the welfare, health, and safety of the public.
   b Energy codes are just one of many building codes, such as fire, electrical, structural, or plumbing.
   c Energy codes are different than appliance and equipment standards. Energy codes cover the building itself—for example, the walls/floors/ceiling insulation, windows, air leakage, and duct leakage. Appliance and equipment standards cover the things that go into the buildings. However, there is some overlap, particularly in lighting.
   d National model energy codes are developed by two private organizations, American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) and the International Codes Council (ICC). ASHRAE develops the model commercial energy code, known as 90.1. The ICC develops the International Energy Conservation Code (IECC), which contains chapters for both residential and commercial buildings. Any interested party can participate in the development processes by submitting proposals to change the code and commenting on others' proposals. The codes cycle is continuous, with new codes being developed every three years. Final versions of each new edition are determined by a vote of the 90.1 committee members for ASHRAE and by the ICC membership for the IECC.
   e Most codes are adopted at the state level, though, in about 10 states they are adopted by cities. State adoption can occur directly by legislative action, or through regulatory agencies authorized by the legislature. Cities adopt codes

through their mayors, councils, or committees depending on their form of government. Once adopted, the code becomes law within the particular state or local jurisdiction.

B. And what's the difference between 'codes' and 'standards'? The National Institute of Standards and Technology (NIST) says...
    1. A standard is the definition of terms; classification of components; delineation of procedures; specification of dimensions, materials, performance, designs, or operations; measurement of quality and quantity in describing materials, processes, products, systems, services, or practices; test methods and sampling procedures; or descriptions of fit and measurements of size or strength.
    ...whereas...
    2. A code is a standard that has been enacted into law by a local, regional, or national authority having jurisdiction so that the engineer or contractor [or architect or other design professional such as a passive house consultant] is legally obligated to comply with the code. [insert, my words]
C. And 'efficiency designations'?
    1. Here, we can look to the Federal Energy Management Program (FEMP) and Environmental Protection Agency (EPA) for some specific input, but I figure we're talking about a broader set of designations also.
        a FEMP and EPA have established four programs that specify products as energy- or water-efficient: Energy Star, EPEAT, FEMP Designated, FEMP Low Standby Power, and WaterSense.
        b But I'd also group efficiency designations such as AFUE (based on ASHRAE 103), SEER (AHRI 210/240), PHIUS+, Declare, ICC-ESR and others here. Labels – evidencing some portion of a broad range of qualitative qualities found attached to manufacturing, product, equipment, installation, project, operations, and possibly other scales.
            - As an example, the EPA says that through its WaterSense Product Certification System, that the EPA requires all products bearing the WaterSense label to be independently certified. The WaterSense Product Certification System outlines the process and procedures for the product certification to ensure that all WaterSense labeled products meet EPA's criteria for efficiency and performance.
            - FEMP sums it up nicely...such labels help buyers in their acquisition phase meet their purchasing requirements.
            - But possibly my favorite: The ICC-ES Report...a document that presents the findings, conclusions, and recommendations from a particular evaluation. ICC-ES Reports verify that new and innovative building products comply with code requirements. ICC-ES Reports provide information about what code requirements or acceptance criteria were used to evaluate a product, and how the product should be identified, installed and much more.
D. And lastly, what are 'incentives'?
    1. As in tax and utility incentives...

a Programs like:
- 26 USC 25C (and 25D also) – the US Internal Revenue Code Nonbusiness Energy Property Tax Credit 2005 – 2017, in part extended for 2018 – 2021 at varying levels
- Or the Regional Greenhouse Gas Initiative, NYSERDA's RetrofitNY, Orange & Rockland Utility My ORU Store, DoE grants
- Or public finance instruments possibly found here...https://www.energy.gov/savings/search

b In a way these are all sort of the same thing...
- According to a Congressional Research Service (Report R42089, Residential Energy Tax Credits, 2018)...[my paraphasing]...Public financial stimulus designed to either A) provide certain things to the public or B) influence the public to do (buy) certain things themselves for certain benefits to the public – addressing things like market failures, unrealized efficiency, etc.
- And something like cap and trade intending to realize its emissions goals through a marketplace whereas best-available-technology-based / command-and-control regulation intended to realize its emissions goals through a tax - a somewhat complicated but direct carrot-and-stick approach versus an indirect but somewhat simpler approach.

2. Or as in private-side funding...
   a Programs like:
   - Green Financing – purpose-specific loans at advantaged rates, mortgage-backed
   - Property Assessed Clean Energy Financing (PACE) – purpose-specific funding repaid through addition to property tax, with first lien priority, building not owner is guarantor
   - Efficiency Services Agreements (ESA) – energy agreement with 3rd party to provide energy and maintain software and hardware, repaid through utility bill, 3rd party owns equipment
   - Other private finance instruments...PPA, MESA...

II. **So, now that we know what energy standards, codes, and efficiency designations are, and possibly how to fund portions of entireties of our projects, what does it mean?**
   A. What does it all add up to?
   B. Are we surviving or thriving?
   C. Stephen Covey says begin with the end in mind.
   D. So, what's the end?
   E. Are we building a sustainable, equitable, inspiring world?
      1. A glide path to zero based on IPCC research and reporting?
         a Limiting warming to no more than 1.5°C requires decreasing carbon pollution by 45 percent from 2010 levels by 2030. That's a little over a decade from now. The world would need to reach net zero emissions by 2050…The IPCC

report ultimately offers four mitigation scenarios—four ways to limit global warming—all with trade-offs. The differences among the four pathways hinge largely on how quickly we can move away from fossil fuels. There is no scenario in which our fossil fuel use can continue unabated if we are to meet the 1.5°C goal; coal power will have to be essentially eliminated by mid-century. And all scenarios are more ambitious than what would be achieved by the existing Paris Agreement targets. – NRDC on IPCC CC Report, https://www.nrdc.org/stories/ipcc-climate-change-report-why-it-matters-everyone-planet#sec-actions

b Even limiting warming to 1.5°C comes with higher risks from extreme heat, drought, and heavy precipitation. This harms agriculture, food and water supplies, human health, and the oceans. Optimum agricultural belts will shift, water supplies will be at additional risk, and disease-carrying insects will move into new areas. Additionally, an extra half-degree Celsius (about 1°F) from 1.5°C to 2°C would magnify impacts:
   - Doubling the number of people affected by water scarcity.
   - Doubling the losses of corn yields in the tropics.
   - Increasing by 10 times the frequency of ice-free summers in the Arctic Ocean.
   - Losing 30 percent more coral reefs (meaning a total of 99 percent of coral reefs will disappear).
   - Losing an additional 50 percent of global fisheries.
   - Adding 10 million people to those affected by sea level rise.

     https://www.climatecentral.org/gallery/graphics/limiting-global-warming-require-deep-emissions-cuts

2. Architecture 2030 sets the goals in the building context:
   a The Roadmap to Zero Emissions is a flexible plan that sets out the emissions reduction targets necessary in the building sector worldwide to avert dangerous and irreversible climate change, including the actions and financing instruments needed to reach the targets. At our present rate of fossil fuel consumption, it is estimated that we will have emitted one trillion tons of industrial era carbon by about 2040. We're already over half way there. If we surpass this one-trillion-ton threshold, the planet will pass a tipping point and continue to warm, leaving future generations with a deteriorating and dangerous climate system. To keep carbon emissions under the one-trillion-ton threshold, global CO2 emissions from fossil fuels must peak around 2016 and reach zero by about 2050.
   b Building Sector CO2 Emissions Schedule Guidelines: Achieve a total annual Building Sector (residential, commercial, and institutional building operations) CO2 emissions level, relative to Building Sector CO2 emissions in 2015, within the following range:
      - 0% to -15% in 2020
      - 15% to -30% in 2025
      - 30% to -45% in 2030

- 45% to -60% in 2035
- 60% to -75% in 2040
- 75% to -90% in 2045
- 90% to Zero CO2 emissions in 2050

  Architecture 2030 https://architecture2030.org/publications-2/roadmap-to-zero/

3. Others might slice it differently: Net-zero buildings may be attained by 2050 if a 5% energy efficiency gain is achieved when the IECC is updated every three years. - Christopher Chwedyk, Burnham
   ...however...
4. Global greenhouse gas emissions show no signs of peaking. Global CO2emissions from energy and industry increased in 2017, following a three-year period of stabilization. In 2017 greenhouse gas emissions (GHG) - excluding emissions from land-use change - reached a record 49.2 GtCO2e. This is an increase of 1.1 percent on the previous year. - United Nations Environment Programme, Emissions Gap Report 2018
5. A key problem with current energy code practice is the difficulty in determining what level of performance the codes are delivering…A number of recent studies have demonstrated that various components of new buildings do not perform as well as intended…The solution to many of these problems is to calibrate energy codes to actual building performance…At a national level, there should be direction and funding to comprehensively address the lack of energy performance data for our nation's building infrastructure. Without this information, we will never answer the question: Are we on track to meeting ambitious building energy performance goals? – New Building Institute, https://newbuildings.org/wp-content/uploads/2015/11/Code_Calibration_July-20101.pdf
   a Pacific Northwest National Laboratory (PNNL) says there was about a 1% efficiency gain in the 2012-2015 IECC Revision. - PNNL-23977
   b And according to Congress, there are a variety of reasons why consumers may not make optimal investments in residential energy efficiency.
      - If electricity prices do not reflect any potential negative environmental consequences of electricity production, consumers do not pay the full cost associated with consuming electricity. These lower prices lead consumers to consume more electricity than is optimal, and to underinvest in energy efficiency.
      - The principal-agent problem can occur when there is a disconnect between the incentives for those making energy-efficient property purchasing decisions (the agent) and the ultimate energy consumer (the principal).
      - Capital market imperfections may also lead households to underinvest in energy-efficiency property. Oftentimes, investments in energy efficiency involve high initial costs, followed by a flow of savings.

Congressional Research Service Report R42089, Residential Energy Tax Credits

III. So it seems like this our global population occupancy sustainability safety health condition is a difficult balance to assess and maintain...

A. A few quotes...
   1. It's not whether we change our environment but how. - John Muir [paraphrased]
   2. There are no passengers on spaceship earth. We are all crew. We become what we behold. - Marshall McLuhan
   3. Well, I don't know what will happen now. We've got some difficult days ahead. But it really doesn't matter with me now, because I've been to the mountaintop. And I don't mind. Like anybody, I would like to live - a long life; longevity has its place. But I'm not concerned about that now. [I've gone] up to the mountain. And I've looked over. And I've seen the Promised Land. - Martin Luther King Jr. [my paraphrase]

B. To steer a ship, we need lighthouses (or GPS) – to guide the way toward a sustainable, equitable, inspiring future. Let's visit a few lighthouse...
   1. *The 'Policy' Lighthouse:*
      a If last year's trend continues, 2019 will see growth in the number of states and cities that leapfrog the national energy code model and advance local regulations well beyond the minimum standards. - Ralph DiNola, https://www.greenbuildingadvisor.com/article/2019-year-energy-codes?source=W20005EN&tp=i-H43-BC-EKb-gobWy-1o-Rur1-1c-goZ62-18teeo&sourcekey=W20005EN&utm_campaign=green-building-advisor-eletter&utm_source=eletter&utm_medium=eletter&utm_content=gba_eletter&cid=55093&mid=632666784
         - Stretch Codes - a voluntary appendix to a mandatory statewide minimum energy code that allows municipalities to adopt a uniform beyond code option to achieve greater levels of energy efficiency – 20%+ better efficiency than current national building energy codes. - New Buildings Institute
         - Reach Codes - a set of statewide optional construction standards for energy efficiency that exceed the requirements of the state's mandatory codes - http://bcapcodes.org/code-status/local-adoptions/
      b And see the US Conference of Mayors Alliance for a Sustainable Future
   2. *The 'Inspiration' Lighthouse:*
      a International Living Future Institute: A comprehensive design, implementation, and operations protocol for transformation toward a civilization which is socially just, culturally rich, and ecologically restorative. - ILFI
   3. *The 'Equity' Lighthouse:*
      a US Passive House Institute: A cost-optimized platform for attaining zero net (annual) and net (annual) positive buildings with primary focus on passive building strategies, and indexed to source energy limits related to our global CO2 emission budget.

4. *The 'Economics' Lighthouse:*
    a Project Drawdown: A comprehensive plan to reverse global warming, bringing together a broad coalition of researchers, scientists, graduate students, PhDs, post-docs, policy makers, business leaders and activists to assemble and present the best available information on climate solutions in order to describe their beneficial financial, social, and environmental impact over the next thirty years.
5. *The 'Innovation' Lighthouse:*
    a University research like Rensselaer Polytechnic Institute's Center for Architecture Science and Ecology – An academic-industrial alliance to accelerate a more aggressively experimental process that leads to development of new systems that produce a paradigm shift in the way that our future cities metabolize energy, water, and resources.
    b And negative emissions technologies, a critical compliment to the emissions diet...a good summary article from National Geographic: https://www.nationalgeographic.com/environment/2018/12/climate-geoengineering-series-intro/
6. *The 'Comfort' (or rather, 'Lack of Discomfort') Lighthouse:*
    a ASHRAE 55 – Standard 55 specifies conditions for acceptable thermal environments and is intended for use in design, operation, and commissioning of buildings and other occupied spaces. Thoughtful building design that makes use of the wider array of available thermal comfort mechanisms and opportunities can be leveraged to result in significant energy savings, whether through operational improvements on an existing conditioning system or when evaluating options for a retrofit. Thermal comfort is a subjective assessment by a person expressing their satisfaction with their local thermal environment. In practice, there are a number of traditional variables (activity, clothing, air temperature, radiant temperature, air velocity, humidity) that influence the body's heat balance with the environment, and in turn that person's perception of thermal comfort; but it should be noted that there are many other factors that can affect either the body's heat balance, or their subjective response (age, gender, health, culture, climate, season, personal control, past thermal history, and expectations).
        - A comfortable indoor environment is about 20 to 24 °C (68 F – 75 °F) and 20-60% RH. If one widens the comfort range, a larger proportion of people will be uncomfortable. That does not mean that an indoor summer temperature of 26 °C (79 °F) will be uncomfortable for most people but it will be uncomfortable for a significant proportion (more than, say, 10%) of the North American population…The temperature that defines comfort is not the air temperature, but something called the operative temperature. The operative temperature is a combination of the air temperature, the weighted average of all surface temperatures of a space (defined by the mean radiant temperature, MRT), and air velocity.

At low air velocity, the operative temperature is the simple average of the MRT and air temperature…With a high performance building enclosure (e.g. a perfect wall and exceptional glazing) the surface temperatures of a room will become very close to the air temperature, and comfort will be enhanced, even if the air temperature approaches the extremes of the comfort band. A typical modern building enclosure during cold weather will have wall and window surface temperatures that are several degrees below the indoor air temperature, and therefore to reach a comfortable operative temperature the indoor air temperature will need to be higher. The reverse is true in the summer. - John Straube, https://www.buildingscience.com/documents/insights/bsi-022-the-perfect-hvac

- From the studies reviewed so far, it is not unreasonable to state that the static PMV model works well in air-conditioned buildings but not in naturally ventilated premises, where occupants could interact with their surroundings to make themselves more comfortable through adaption. Adaptive models tend to have a wider range of comfort temperature, which could have significant energy savings in both air-conditioned and naturally ventilated buildings. Based on this, we believe there are three specific issues that need to be addressed and warrant further research and development work:
  1. Firstly, is the adoption of the PMV–PPD and Adaptive models mutually exclusive? Can one model complement the other?
  2. The second issue is about the socio-economic and cultural context. How will social norm (e.g. dress code) and environmental awareness/attitudes affect people's thermal acceptability of their immediate thermal environment?
  3. The third issue is about the responses to climate change in terms of mitigation and/or adaptation.

     Thermal comfort and building energy consumption implications – A review, Applied Energy 115, Elsevier

IV. Done

A. A few parting links:
   1. This presentation can be downloaded here – http://www.siteisreal.com/research/
   2. Information on the 2021 IECC update process from the New Building Institute - https://newbuildings.org/code_policy/2021-iecc-base-codes/
   3. Status and ranking of States' energy efficiency policies and programs - https://aceee.org/state-policy/scorecard
   4. Useful reference book on low carbon construction - The New Carbon Architecture by Bruce King
   5. A useful standard on earthen construction - ASTM E2392 2016 Standard Guide for Design of Earthen Wall Building Systems
   6. USDA Information on Agroforestry, Food Foresting, Silvopasturing - https://www.usda.gov/topics/forestry/agroforestry

7. Valuable information on decreasing city water consumption - https://unfccc.int/sites/default/files/resource/City%20Water%20Resilience%20Framework.pdf
8. More research on improving thermal comfort strategies - https://viterbipk12.usc.edu/wp-content/uploads/2017/06/2014-Applied-Energy-Yang2c-Yan2c-Lam-Thermal-comfort-and-building-energy-consumption-implications-—-A-review.pdf

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