Analysis of Current Energy Efficiency Standards and Codes for On-site Sustainable Construction

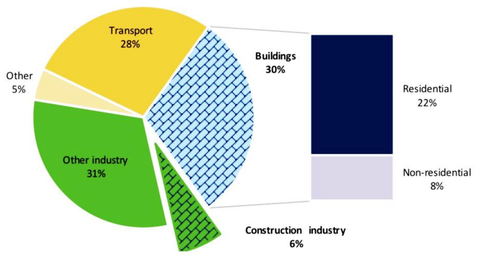
Bobuchi Ken-Opurum
PhD Student in Architecture – Engineering – Construction Management

Carnegie Mellon University
Civil and Environmental Engineering

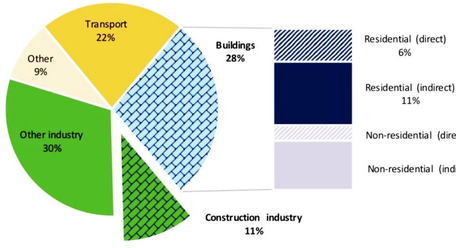
Introduction

The construction process demands high amounts of energy for these activities: **temporary lighting; transportation; generator, equipment**, and **machinery use; welding; heating and cooling.**

*Global Energy Consumption by Sector, 2015**



*Global Energy related CO2 Emissions by Sector, 2015**



*Source: Abergel, Dean, & Dulac (2017)

Construction industry has the lowest energy consumption by sector, but generates almost double its consumption in CO2 emissions. Largest when compared to other sectors

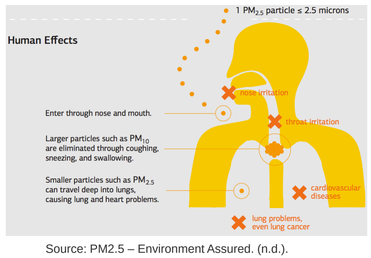
The Case for Construction Energy Efficiency

- ❑ Inefficient site management impacts energy use
- ❑ Decentralized industry increases gap in monitoring of energy use
- ❑ Site energy activities generate environmental emissions
- ❑ Health complications abound from site energy emissions

Construction activities and equipment generate

- Particle Matter PM10
- Sulphur Dioxide SO_2
- Nitrogen Dioxide NO_2

PM 2.5

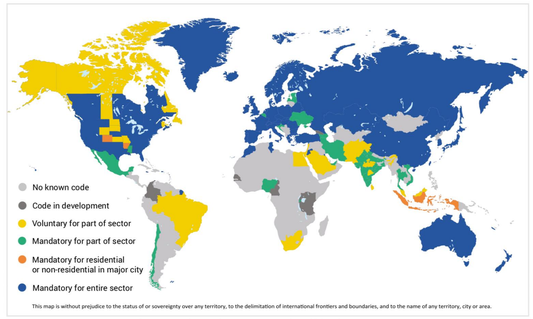


Source: PM2.5 – Environment Assured. (n.d.).

Energy use, environmental emissions and health impacts are linked, reaffirming the importance of energy efficiency standards towards the support of the 'healthy trifecta'.

However, regulations on energy efficiency for the construction phase are limited.

Country, State, and Province building energy codes, 2016



Source: Abergel, Dean, & Dulac (2017)

~ 2/3rd of countries lack mandatory building energy codes. Even less have construction energy codes

Methodology

1. Reviewed four green building codes, and fourteen voluntary building standards – texts.

Codes Alias	Applicable Sections
National Building Energy Efficiency Code, Nigeria	2
International Energy Conservation Code (2018)	3
International Green Construction Code (2015)	2
Environmental Sustainability Measures, Singapore	6

Standards Alias	Applicable Sections
WELL Building Standard (v2), U.S	7
BREEAM (2016), International	16
LEED (v4.1), International	14
EPA Nonroad Compression-Ignition emissions, U.S	1
EPA Nonroad Large Spark-Ignition emissions, U.S	1
EPA Nonroad 19kW below Spark-Ignition emissions, U.S	1
Green Star, South Africa	1
Green Building Initiative (2010), U.S	5
ICC/ASHRAE (2015), U.S	6
Zero Carbon Building Standard, Canada	4
ASHRAE Standard 90.1 (2016), International	5
ASHRAE Standard 90.2 (2018), International	3
ASHRAE Standard 189.1 (2017), International	5
National Carbon Offset Standard, Australia	1

Texts were reviewed for key terms related to energy efficiency and/or sustainable construction. Context was grouped into:

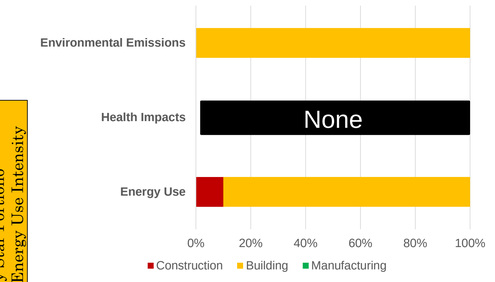
- Manufacturing: Resource sourcing to supply
- Construction: Ground breaking to substantial completion
- Building: Substantial Completion to end of life

2. Investigated construction site energy consumption to determine factors influencing inefficient site energy management.

Results and Discussion

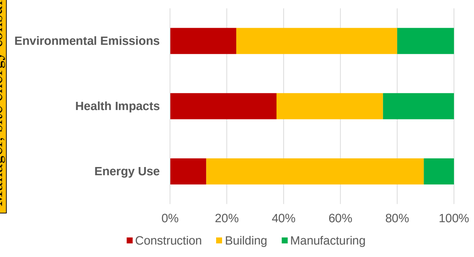
There is a gap in the codes and standards for the construction phase of development, i.e., groundbreaking to substantial completion.

Normalized Percent "hits" of key terms per grouping from total codes



Common Key Terms
IEQ, Lighting Power Density Energy Star Portfolio Manager, site energy consumption, Energy Use Intensity

Normalized Percent "hits" of key terms per grouping from total standards



- ❑ Results show that regulations that impact the health of construction personnel is limited in texts. Analysis shows 3 hits in 70 sections reviewed for standards, and no hits for codes
- ❑ Temporary lighting had the most hits in the texts, though guidelines only specified outdoor building energy use and light pollution
- ❑ EPA emission standard regulates engine hp size for energy efficiency of nonroad diesel fuel for generators
- ❑ Health sections were concerned with IEQ, and less than 5 have regulated energy use implications on health
- ❑ Individual site energy consumption could not be determined due to limited research studies

Conclusion

Sustainable building standards and codes are focused mainly on improving Indoor Environmental Quality (IEQ), the health of occupants, and limiting the environmental impacts of buildings. There is a gap on the full lifecycle of the building production which includes manufacturing of materials, and construction of the building.

This research has shown that more data is needed to ascertain individual construction activities and equipment energy use, in order to determine how to manage it and attain sustainable construction. PM emission data sourcing is needed in standards and codes to ensure it is considered.

The EPA provides an equation based on level of construction activity and emission factor, using either a "top down" or "bottom up" methodology.

Top Down emission Factor:
$EF_{PM\text{-}k} = k \times EF_{TSP}$

where: k = fraction of TSP that is PM-k
EF = Emissions factor, 1.2 tons TSP/acre/month

Lastly, two key terms, temporary lighting and energy star portfolio show a way for improvement

- Energy STAR portfolio, is required by majority of standards for calculating GHG emissions consistently across the building sector. Changes towards construction inclusion may rely upon changes in the tools such as ENERGY STAR, as much as the standards and codes themselves.

- Temporary lighting is relevant for the frequency of night construction, working in spaces void of fenestration, or requiring task specific lighting. Reduced nighttime work was at the foreground of reduced carbon footprints of construction sites in Malaysia (Esmaeilifar et al, 2015)

Further Work

- ❑ Determine the connection between inefficient lighting and health implications on construction workers
- ❑ Corroborate results through a survey sent out to construction firms in residential, commercial, and civil sectors
- ❑ Estimate reductions in environmental emissions from energy efficiency standards
- ❑ Predict emission reductions over 20 year period for construction processes with the increase in energy efficient standards

References

Abergel, T., Dean, B., & Dulac, J. (n.d.). GLOBAL STATUS REPORT 2017 (Rep.). Retrieved https://www.worldgbc.org/sites/default/files/UNEP 188_GABC_en (web).pdf
PM2.5 – Environment Assured. (n.d.). Retrieved from http://www.environment-assured.com/pm25/
Sharrard, A. L., Matthews, H. S., & Roth, M. (2007). Environmental Implications of Construction Site Energy Use and Electricity Generation. *Journal of Construction Engineering and Management*,*133*(11), 846-854. doi:10.1061/(asce)0733-9364(2007)133:11(846)
Estimating Particulate Matter Emissions From Construction Operations: Final Report (pp. 1-52, Rep.). (1999). Environmental Protection Agency:National Service Center for Environmental Publications (NSCEP).
Esmaeilifar, R., Samari, M., Mirzaei, N. F., & MohdShafiei, M. W. (2015). How is electricity consumption on construction sites in Malaysia related to sources of CO 2 ? Advances in Environmental Biology, 95, 160-163. Retrieved from http://www.academia.edu/11164412/How_is_electricity_consumption_on_construction_sites_in_Malaysia_related_to_sources_of_CO2