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*by Nicholas J. Thies**

Buildings in urban areas are entirely lacking in significant energy-use developments. Energy production and distribution in urban areas are hugely inefficient, losing most of their production to waste heat.[1]

Over the past 100 years, the clay surrounding London's Underground has warmed and is no longer able to absorb the trapped waste heat, causing the Underground temperature to increase to over 30°C.[2] In November 2013, London's Mayor Boris Johnson announced a new initiative to channel this waste heat from the Underground tunnels and an electrical substation to provide heat to 500 homes, thereby cutting winter energy costs.[3] Excess body heat from passengers and heat generated by trains gets trapped underground,[4] and by installing a ventilation system the waste heat can be channeled, stored, and distributed to tackle fuel poverty.[5] This project was generated as part of Mayor Johnson's target to produce 25% of London's energy from local sources by 2025.[6] Reporters who maintain that the project will be unable to supply London with enough energy to meet the impending increase in energy demand have justly criticized it.[7] Yet, this initiative will reuse waste heat to reduce CO2 emissions by over 500 tones each year[8] begging the question: "What else could be done in an urban environment?"

> *"The largest consumer of fuel used in energy production is waste heat."*

The largest consumer of fuel used in energy production is waste heat. In 1971, an estimated 68.5% of the fuel used to produce electricity in the United States was lost as waste heat.[9] Today, not much has changed; in fact, it is worse. The United States Environmental Protection Agency estimates that the average efficiency of fossil-fueled power plants is 33%, losing two-thirds of the energy to heat.[10] Like the heat in London's Underground, energy that is being transported is continuously letting off energy in the form of heat, delivering a fraction of what was created at the plant.[11] This is nothing but good news. To effectively double or triple the efficiency of energy production, no additional fuel is needed other than what is currently being used. In place of more fuel, an effective waste heat-recovery system can use the design of cities to make urban areas the most energy efficient and greenest areas on earth.

A projection by The World Energy Outlook shows nearly three quarters of worldwide energy will be used in urban areas by 2030.[12] The growth of urban populations—which used two-thirds of the world's energy in 2006—accounted for over 70% of global GHG emissions, while only half of the world's population lived in cities.[13] It is the organization of cities, more commonly known as urban morphology, which accounts for the increased use in energy and, ultimately, the resulting significant waste of energy created by urban designs.[14]

Made even more significant by the complex nature of urban morphology[15] is the clear and significant role of buildings in urban design and, consequentially, energy use.[16] Throughout the world, buildings are the most substantial users of energy, averaging from 20% of all energy use in developing countries to 40% in the developed world.[17] In London, the energy use of buildings accounts for nearly 70% of the city's total energy use.[18] Moreover, the majority of energy used by buildings becomes waste heat,[19] which, like London's Underground, could be redirected to be a part of the Underground's system of insulated energy.[20]

The difficulty with capturing waste heat is that the surrounding geology so easily absorbs it.[21] However, in redesigning the system through which energy travels, waste heat can be protected from escaping.[22] This can be accomplished through a system based on decreasing the distance between the site of energy production and the city center, insulating the underground channels through which energy travels, and directing the earth's natural underground heat sources to this insulated channel.[23]

Conclusion

Waste heat represents the largest area for improvement in energy production[24] and gives us insight to the future of urban morphology. To accommodate for this new system of energy conservation, cities will need to develop new forms of waste heat recovery as a foundation for urban development. New cities should be built based on the idea of capturing waste heat and utilizing the natural reserves of energy that cities have the

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unique advantage to obtain. This can already be seen through the work of architects, whose designs distinguish between the passive and active areas in buildings, where an active area uses the design of the building to maintain its energy needs and a passive area must find its energy elsewhere.[25] For the most part, the design for a more energy efficient future is already in place. Because of their dense populations, tall buildings, and infrastructure (all things which have traditionally been causes of greenhouse emissions), cities are already built to develop channels for waste heat and more efficient energy distribution. In the end, it is the urban areas that will be the most energy efficient. New styles of cities and urban development that will incorporate the capture and distribution of waste heat in its founding are on the horizon and will be forever intertwined with city planning and urban morphology.

Endnotes: London Calling to the Underground: Waste Heat in Urban Morphology is Going down the Tube

1 U.S. Envtl. Prot. Agency, *Combined Heat and Power Partnership: Efficiency Benefits*, http://www.epa.gov/chp/basic/efficiency.html (last visited Nov. 4, 2014); *see also* Edward F. Renshaw, *Public Utilities and the Promotion of District Heating*, 106 Public Utilities Fortnightly 26 (1980), *see also* Joan L. Pellegrino, Energy use, loss and Opportunities Analysis 25 (2004), *available at* https://www1.eere.energy.gov/manufacturing/intensiveprocesses/pdfs/energy_use_loss_opportunities_analysis.pdf.
2 Duncan P. Nicholson et al., *The Design of Thermal Tunnel Energy Segments for Crossrail, U.K.*, 167 Engineering Sustainability 118, 119 (2014).
3 Press Release, Mayor of London, Waste Heat from the Tube Will Help to Warm Hundreds of Homes (Nov. 15, 2013)(*available at* https://www.london.gov.uk/media/mayor-press-releases/2013/11/waste-heat-from-the-tube-will-help-to-warm-hundreds-of-homes).
4 *See* Nicholson et al., *supra* note 2, at 119.
5 *See* Press Release, *supra* note 3.
6 *See id.*
7 James Woudhuysen, *All this Carbon-Cutting is a Waste of Energy*, Spiked (Feb. 2, 2012), http://www.spiked-online.com/newsite/article/12038#.VDxIInLu2mQ.
8 *See* Press Release, *supra* note 3.
9 Edward F. Renshaw, *Public Utilities and the Promotion of District Heating*, 106 Public Utilities Fortnightly 26 (1980).
10 U.S. Envtl Prot. Agency, *Combined Heat and Power Partnership: Efficiency Benefits*, http://www.epa.gov/chp/basic/efficiency.html (last visited Nov. 4, 2014)
11 *See* Renshaw, *supra* note 9, at 26.
12 Kayla, *Energy Use in Cities*, theworldisurban.com (Mar. 14, 2011), http://theworldisurban.com/2011/03/energy-use-in-cities.
13 *See id.*
14 Phillip Rhode et al., *Cities and Energy: Urban Morphology and Residential Heat-Energy Demand*, 41 Env't and Plan. B: Plan. And Design 138, 139 (2014).
15 *See* Kayla, *supra* note 12.
16 *See* Rhode et al., *supra* note 14, at 139.
17 *See id* at 138.
18 *See id*.
19 *See* Renshaw, *supra* note 9, at 26.
20 *See* Rhode et al., *supra* note 14, at 139.
21 Duncan P. Nicholson et al., *The Design of Thermal Tunnel Energy Segments for Crossrail, U.K.*, 167 Engineering Sustainability 118, 119 (2014).
22 *Id.* at 118.
23 *Id.* at 118.
24 Joan L. Pellegrino, Energy use, loss and Opportunities Analysis 25 (2004), *available at* https://www1.eere.energy.gov/manufacturing/intensiveprocesses/pdfs/energy_use_loss_opportunities_analysis.pdf.
25 Ahmad Okeil, *A Holistic Approach to Energy Efficient Building Forms*, 42 Energy and Buildings 1437 (2010).