MTR120033
MITRE TECHNICAL REPORT

Building energy technology recommendations to Fairfax County

Tasks 1-4 of sustainability study under Proffer #9, RZ 2008-PR-011

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Executive Summary

Environmental stewardship and growth are key Fairfax County Government (FCG) objectives as it guides the evolution of Tysons Corner from suburban edge-city to a more livable, sustainable, mixed-use urban center. The Comprehensive Plan estimates the number of jobs in Tysons Corner to nearly double in the next forty years and the number of residents to more than triple, yet FCG seeks to achieve carbon neutrality by 2030.

As FCG leads this transformation, it is working with developers to assure environmentally responsible growth with new construction. MITRE fully supports FCG's objectives for Tysons Corner, and as part of Proffer #9, RZ 2008-PR-011, we have considered how FCG negotiates with developers on the subject of energy conservation.

The proffer was originally intended as a guide to both developers and FCG about energy efficient building technologies. We offer references on individual technologies, but find that since energy efficiency is a function of design, integration, construction and use, the determination of a particular technology's general effect (in terms of energy and economics) on future Tysons Corner buildings is largely infeasible.

This does not mean that FCG is powerless to ensure energy efficiency in Tysons Corner – far from it, it fact. Instead, we find that FCG is already pursuing a strategy that will yield the best environmental and economic results. We recommend only minor additions to current proffer policy (we do not recommend any change to code).

1. We recommend that FCG continue its practice of using design and performance guidelines to set environmental goals while allowing developers to choose the best means of achieving them. We recommend continued use of LEED. To bridge the gap between energy-efficient designs and energy-efficient operations, we also recommend that FCG apply components of the ENERGY STAR program. In particular, we recommend that when a proposed development fits into an ENERGY STAR building profile, FCG encourage developers to earn Designed to Earn the ENERGY STAR (DEES) certification. And for all facilities (regardless of DEES certification), we recommend that FCG encourage continued reporting of operational energy consumption through the ENERGY STAR Portfolio Manager.
2. We recommend that FCG make public the data and results of ENERGY STAR benchmarking to the extent possible. Such reporting can create public pressure on building owners to rigorously pursue energy efficiency.
3. We recommend that FCG continue its investigation of district energy – specifically combined heat and power – but we note that this investigation should be completed before encouraging any related proffer for normal developments.
4. We strongly recommend that FCG continue its practice of not prescribing technologies as part of the proffer process. Such a strategy increases building costs without improving environmental benefit. It ignores primary determinants of a building's energy efficiency, and it unnecessarily burdens FCG itself.
5. We note that some data collection may benefit future consideration of wind and geothermal installations.

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1 Introduction

MITRE is pleased to support Fairfax County Government's (FCG) sustainability objectives for Tysons Corner with Proffer #9, RZ 2008-PR-011. We have studied building technologies to support FCG's interests in increasing energy efficiency and reducing greenhouse emissions. Specifically, this document satisfies the first four tasks defined in our proffer:

1. Describe emerging technologies that could, in the future, be added to buildings, facilities and sites and what accommodations may need to be made to these buildings, facilities and sites to implement these technologies. Identify those accommodations that could be economically incorporated during building design in anticipation of future adoption of these technologies.
2. Develop technical guidance, written for the educated lay person, for renewable energy supplies and distribution, efficient end use technologies, and operating methods suitable to our region, including active and passive systems, for new buildings and for retrofit of existing floor space. It is anticipated that this technical guidance will be used by staff to support recommendations made to developers during the zoning process, but there may be broader applications as well.
3. Describe the relative benefits and characterize the efficiency and emissions of technologies and systems and their lifecycle costs, including capital and operations and maintenance costs of these technologies.
4. Characterize market competitiveness of the technologies and systems, and the risks and uncertainties that affect investment decisions.

FCG intended these tasks to serve two purposes. First, the report was to give developers unfamiliar with energy efficiency technologies a primer on the subject for possible inclusion in future buildings. Second, the report was to help guide FCG's negotiations with developers – to help it steer developers toward energy efficient building designs.

To this end, we address the first two tasks, providing references to technologies, but note strongly that technology can be only a small determinant of efficiency. Form, integration with the environment, construction, and operations also figure into that calculus.

In all cases, the literature on building technologies shows that buildings are highly complex systems, and energy consumption is a function of site, design, construction, and use. The effects of particular building components are highly variable between installations and use profiles. The result is that we can enumerate energy efficiency technologies for buildings (Tasks 1 and 2), but we cannot offer general guidance on technology costs, payback periods, or market competitiveness (Tasks 3 and 4). A consequence of the inability to offer such guidance is that we explicitly recommend against FCG seeking general design accommodations for the possible retrofit of specific future technologies. We see no evidence of any future technology that is so promising in terms of potential energy (and long-term cost) savings and generally applicability to merit such an approach.

The fact that general cost-benefit rules are unavailable is a problem long known. The response has been the development of design guidelines, rating-systems, and benchmarks. These are the means of identifying energy efficient design and practice, and they are increasingly being employed as public policy tools by local and state governments to ensure energy efficiency so that they need not expend resources considering individual technologies at individual installations. We therefore include an additional task.

- Describe building energy rating, certification, and benchmarking tools, and discuss their relevance to FCG's environmental objectives.

We begin the discussion with a brief description of the future Tysons Corner – noting most especially the push toward dense, vertical development. We then step into the first two tasks. We break the discussion of individual buildings into three sections: renewable generation, energy storage, and conservation. Because FCG has expressed particular interest in district energy and because it blurs the boundaries of generation and conservation, we follow with a separate section on the subject. We follow this with a discussion of Task 3 and 4 where we show that general cost-benefit is unavailable, but reference the closest approximation of an answer for these questions. Our additional task follows. After that, though each section builds to its own recommendation, we close with a section that reviews all of the recommendations developed over the course of the document.

2 Background and Assumptions

2.1 The Future of Tysons Corner

As Tysons Corner evolves from an automobile-centric commercial edge-city to a mixed-use urban center, FCG intends to make the area, "… a model for environmental sustainability," to achieve Tysons Corner carbon neutrality by 2030, and to support a regional greenhouse gas reduction of 80% by 2050 (FCG, 2011).

At the same time, however, the Comprehensive Plan foresees big increases in the number of residents and jobs as well as big increases in available floor space with vertical development around the four metro stops as the primary source of density increase.

		2010	2050	Growth Factor
Jobs		112,600	201,600	1.79
Population		18,500	66,100	3.57
Household		9,300	33,000	3.55
Square Feet	Office	27,400,000	54,100,000	1.97
	Hotel	2,400,000	4,400,000	1.83
	Retail	6,200,000	6,900,000	1.11
	Residential	11,160,000	39,600,000	3.55
	Total	47,160,000	105,000,000	2.23

Table 1: Intermediate estimates for Tysons Corner in 2050 (GMU, 2008)

Our recommendations below are made in the context of densely packed, tall buildings that will stand for the next forty years or more.

2.2 Process

Throughout this document, we assume that if FCG adopts any of our recommendations, it will do so through the proffer process. At no point in this document do we recommend changes to code.

3 Tasks 1 and 2 – Available technologies

To address the first two tasks, we break energy technologies into three groups: on-site renewable generation, storage, and conservation. Because district energy spans at least two of these segments and because it is largely a function of systems beyond the control of an individual developer, we present it separately at the end of this section.

3.1 On-site renewable generation

In this section, we note the three means of renewable generation that may be technically possible in Tysons Corner: wind, geothermal, and solar. We are skeptical that wind is an economically viable path, but we do not have data to confirm that skepticism. Geothermal may offer some opportunity for gain, but we do not know if the available data on the geology of Tysons Corner supports even exploratory design of the underground vertical loop systems that would be necessary for dense, vertical development. Solar is likely the most plausible approach for renewable generation here, but again, dense, vertical development may limit its viability in individual buildings.

3.1.1 Wind

3.1.1.1 Technology and resource availability

The United States is one of the world leaders in wind power installations, and our wind power capacity has grown more substantially than any other renewable energy source with a sixteen-fold increase between 2000 and 2010 (DOE 2011). The lesson is that when wind energy is available, efforts are underway to exploit it. Specific to our concern of Tysons Corner though, Virginia's onshore wind capacity is minimal. The National Renewable Energy Laboratory's (NREL) wind capacity map (Figure 1 and Figure 2) indicates that this will not change, and so FCG does not need to take steps to encourage wind generation efforts by its developers.

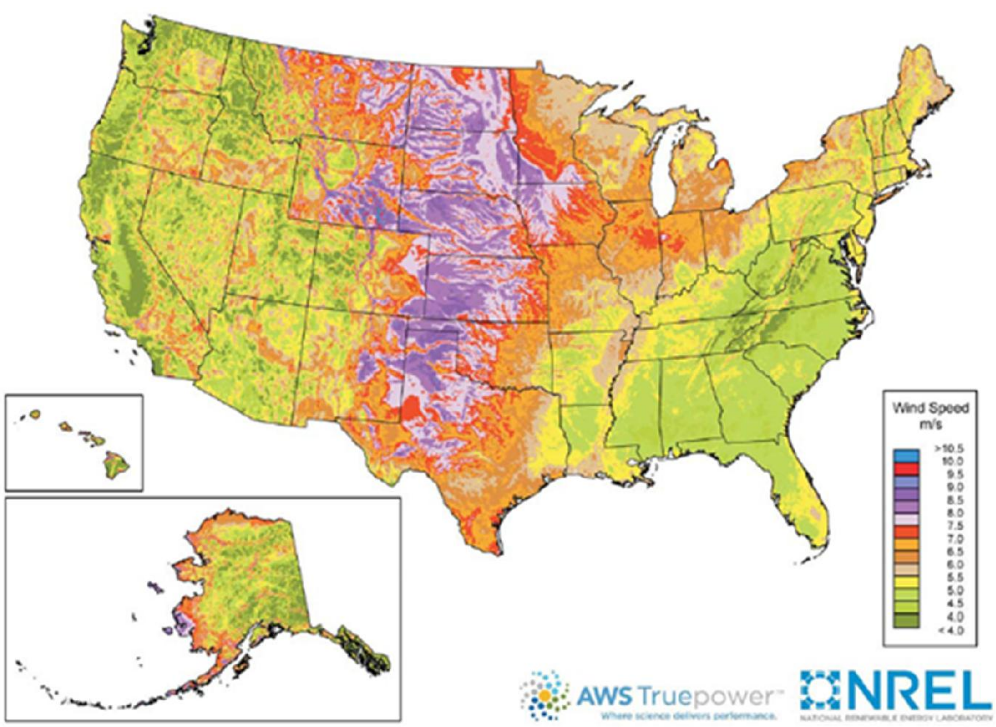

Figure 1: On-shore US wind resources (US Department of Energy, 2013)

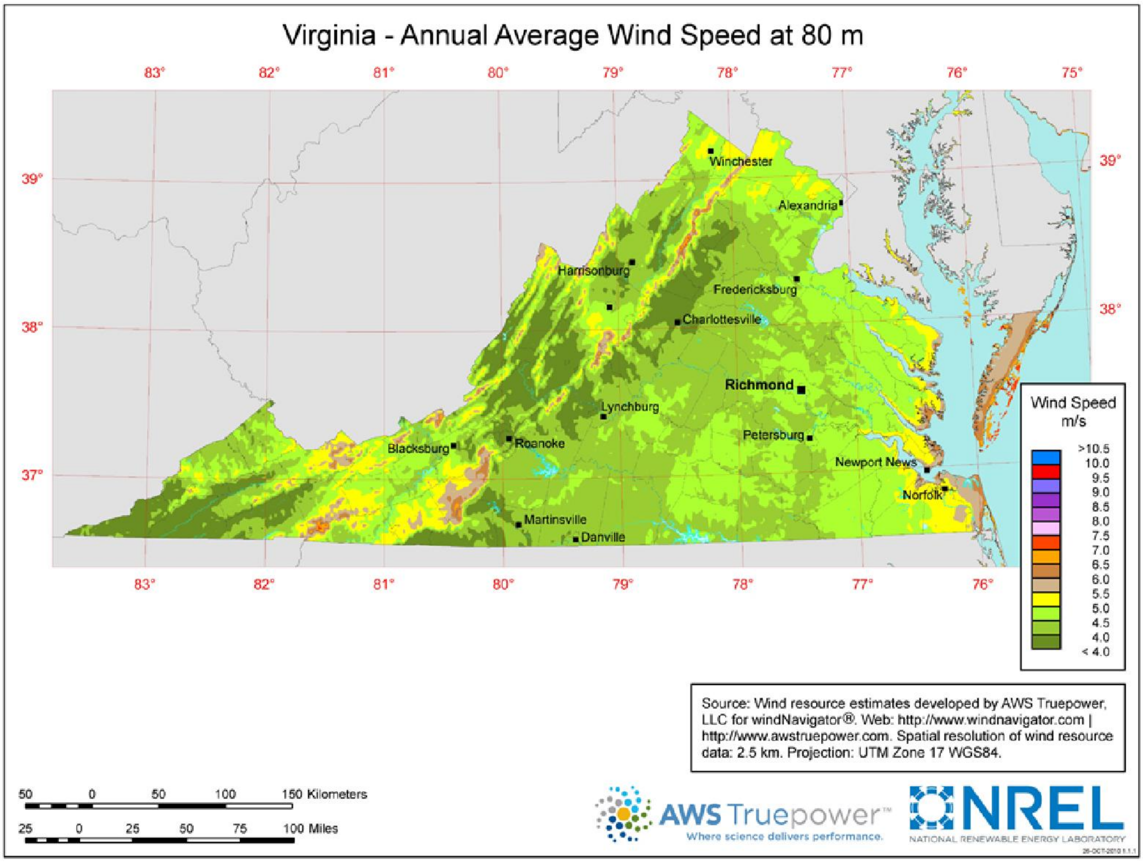

Figure 2: Virginia wind resources (US Department of Energy, 2013)

3.1.1.2 Recommendation

Wind generation requires fairly constant and strong prevailing winds (utility-scale generation currently requires annual average wind speed greater than 6.5 meters per second (DOE, 2013)). This holds true for both traditional external turbine systems as well as those inside buildings. In the former case, the blades are placed directly into the prevailing wind. In the latter (think of China's Pearl River Tower), prevailing wind is channeled (increasing speed, decreasing volume, and taking friction losses) into the building where smaller turbines are spun to generate electricity. In both cases, the prevailing winds must have enough kinetic energy to make harvesting it worthwhile.

The Virginia NREL map shows that Tysons Corner (and most of Virginia generally) simply does not have the wind potential to make wind generation practical. Relative to rest of Virginia, Fairfax has regions of relatively strong winds, but even here, we are at least 15% under the practical threshold. We recommend that FCG not encourage installations unless a developer has himself proposed the project.

If, however, FCG wishes to explore the option further, it could use the proffer process to map the prevailing wind fields over Tysons Corner. High-quality logging anemometer systems can be purchased and installed for a few thousand dollars. Aesthetically, they are unobtrusive, and they require little training to generate useful, long-term data sets.

3.1.2 Geothermal

3.1.2.1 Technology and integration

The Ground Source Heat Pump (GSHP) uses the thermal capacity of the Earth to help heat and cool buildings. Such systems pump water (perhaps mixed with antifreeze) into underground pipe loops for thermal transfer and then pull it back out of the ground into building mechanical systems. In winter, the ground is warm relative to the atmosphere and the water pumped out is warmer than the water pushed in. In summer, the reverse holds. The water pumped out is cooler, and the water pumped in is warmer. That temperature difference can be exploited to do work or to eliminate work that otherwise induces electrical load.

Geothermal systems are relatively simple with few components to maintain, and they can reduce HVAC electrical load 25%-50%. They are, however, expensive to install (IEA 2011, 23), and like every building component, their effectiveness is a function of the specific implementation. Building size, thermal load, thermal properties of both the ground and ground water formations all influence loop design. In Tysons Corner, the density and vertical development objectives will necessitate vertical loops (this is not the case for the whole of Fairfax County where development is less dense, and less expensive, horizontal system are possible). In large vertical installations, loops can reach multiple hundreds of feet in depth (Collins et al., 2002), and test bores are necessary to actually design the full loop field (McCray, 1997). This means that the final determination of feasibility requires a non-trivial investment, and any developer considering this initial expense will be looking to minimize the chances that the concept proves infeasible for his installation.

The first step in minimizing that risk will be gathering all available data describing the ground under Tysons Corner. To the extent that such data exists, it is likely held in three places. First, the County's own Department of Public Works and Environmental Services (DPWES) publishes the soil maps guide, which indicates that Tysons sits on top on a cap of unconsolidated sand, silt, clay, and gravel. This cap itself lies on metamorphic rock. Within the Commonwealth's Department of Mines, Minerals, and Energy (DMME), the Division of Geology and Mineral Resources serves as Virginia's geological survey and may have additional data. Metropolitan Washington Airports Authority may also have some information left over from the Silver Line tunnel excavation. Unfortunately, we have no information about any of the three agencies as to whether they have enough information to afford a developer enough confidence even to conduct exploratory boring on a new development site.

3.1.2.2 Recommendation

The envisioned density and heights of development in Tysons Corner will dictate that any geothermal installation uses vertical loops and that the loops will be under the buildings themselves. The primary expenses of vertical systems are found the boring and planting of the piping, not the above-ground components. This precludes retrofit, and so FCG's only concern with GSHP is installation during initial construction. There are no provisions for later installation of such systems.

Instead, FCG should concern itself with new installations. The problem is that an engineering study is necessary to determine the general suitability of the GSHPs in Tysons Corner. We are aware of no such general study, and so we recommend against FCG encouraging the installation of GSHP if the developer does not support the idea.

If FCG wishes to pursue this avenue for the future, however, a comprehensive engineering study of the issue may be of interest. We cannot provide a cost estimate for such an effort, however. Indeed, we expect that it is cost prohibitive for a single developer on a single project. Instead, it may be feasible to encourage developers to augment DPWES and DMME databases if a general engineering study cannot be completed from their existing stores.

3.1.3 Solar

Solar may be the most promising of the renewables here in Northern Virginia. Dominion confirms some potential of photovoltaic electricity generation (Figure 3) with its plan to rent roofs on commercial properties in Northern Virginia for the installation of solar arrays (FCG 2011). Its intent is to shed peak load and delay large infrastructure upgrades.

3.1.3.1 Technologies

For on-site generation in Tysons Corner, three solar technologies are relevant: photovoltaics, active systems, and passive systems.

Photovoltaic systems convert the solar energy into electricity. These are panels with which we are all familiar. Active systems heat a medium (generally water) that is mechanically moved through the building. If the medium is water, it can be used directly, thus reducing water heating requirements on the electrical system. Indirect use is also possible if the medium is used in a heat exchanger, rather than being consumed.

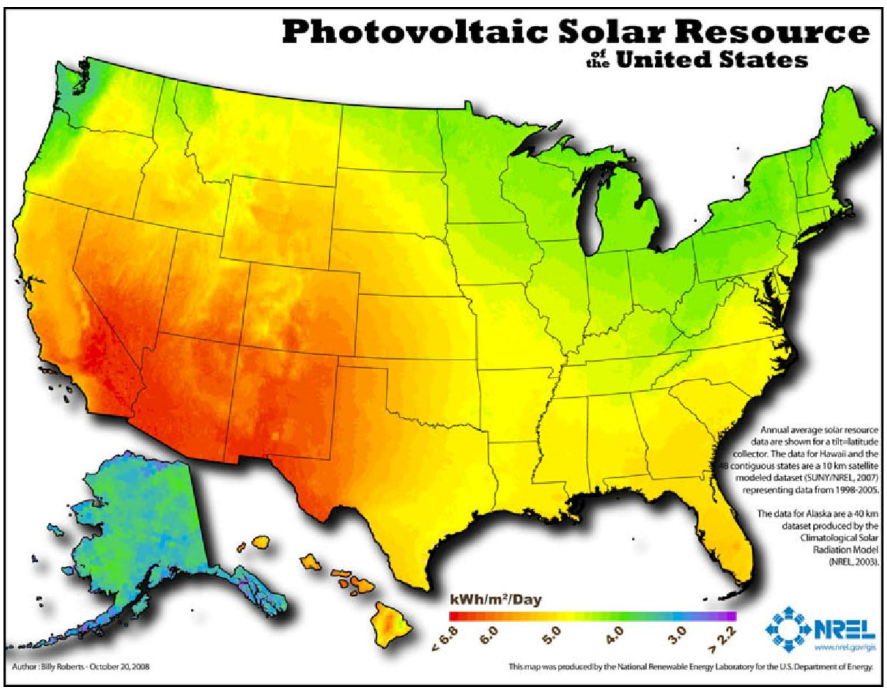

Figure 3 – Photovolatic solar resources (annual average) (NREL, 2008)

Photovoltaic and active systems require maximum exposure to direct sunlight - an unobstructed, unshaded direct exposure to the southern sky. To maximize insolation – the rate at which direct solar radiation reaches a collection surface – its offset from the horizontal must vary over the course of the year as the sun crosses lower in the sky in winter and higher in summer. In Tysons Corner at about 38.9º N latitude, the offset will range roughly between 24º and 54º from the horizontal. This means that such collection panels systems have to go on the roof.

Vertical installation (a photovoltaic window, for example) is impractical. In the most advantageous case, only south-facing surfaces have unobstructed, day-long lines of sight to the sun, but because of their offset from the ideal, the maximum energy shone upon them is reduced 40%-80% depending on the season (it varies with the sine of the angle of solar incidence with the vertical). In the more practical case, the surface also has to be higher than the shadows cast by buildings neighboring to the south. This means design also has to account for future neighboring development, a task that may be impossible but for the southern boundary of vertical development. East and West-facing vertical surfaces receive direct light during the morning and afternoon respectively, but not all day. They, of course, are also subject to the same vertical losses and the difficulties with neighbors.

Passive systems are generally functions of design; they generally do not involve the installation of any particular technologies. These are systems that either minimize insolation or capture solar energy as heat for transfer into the building without mechanical assistance. This means the design can use building mass itself to capture heat during the day and then radiate it at night. More likely in our region, however, passive design is just a good orientation of windows and shading. In summer, the point is to minimize direct insolation while still capturing enough indirect light to minimize the need for electrical lighting. In winter, direct insolation helps to minimize heating load, but it may again be possible only for unshaded, unblocked south-facing surfaces.

3.1.3.2 Recommendation

Specific to the case of individual buildings in Tysons Corner, however, the application of solar devices is likely limited. Photovoltaic generation and active systems are best employed where the roof surface area is large relative to the building's floor area. That is not the case in Tysons Corner where urban density and vertical development will be the rule.

Passive systems are generally functions of design, rather than technology implementations, so while insolation management will be a core concern for energy efficiency design, FCG will likely find it difficult, at best, to negotiate proffers on the subject.

As with wind and GSHP, we recommend that FCG encourage the adoption of solar systems only if the developer originally proposes and supports the installation.

We do not, however, follow the same path on the subject of data collection. Insolation is well-known and easily available from NREL (NREL, 2010); there is nothing to be gained from a proffer of data collection on this subject.

3.2 Storage for load-shifting

Load shifting technology moves electricity consumption from one part of the day to another part of the day by storing the energy in some other form. This can be in response to intermittently available renewable electricity, or it can be employed as a means of exploiting the cost difference between peak and off-peak electricity prices. In Tysons Corner where renewables will be of little consequence, cost savings are the only driver.

3.2.1 Technologies

Energy storage technologies exist in various forms: thermal storage, batteries, kinetic storage with flywheels, capacitor storage, and superconducting magnetic energy storage.

Thermal storage for cooling is the form most likely to be proposed for use in Tysons Corner. In such systems, off-peak electricity is used to chill water (roughly 40°F) or make ice. Throughout the day, that low temperature source is used to boost the efficiency of traditional cooling systems. There is no general rule to the form of such system that best suits all needs. Instead, as we have noted above and throughout, the financial case of thermal storage is highly specific to a particular site and implementation (WSU 2003, 2).

In terms of financial effects, if there is near term benefit for a particular installation, then that benefit will diminish over time. First, if time-of-day pricing is ever employed with smart meters on a large scale, we can expect changes to the consumption load profile – indeed this change is the purpose of time-of-day pricing. Price sensitive consumers decrease peak load (expensive) consumption in favor of increased off-peak (cheap) consumption (all without the aid of any storage devices). The shift itself then raises off-peak demand relative to peak demand, and the price difference shrinks. Exacerbating the diminishing value of load shifting is the emergence of plug-in vehicles. These vehicles increase overall consumption, but they do so disproportionately at night. Again, off-peak demand rises faster than peak demand, and the value of shifting shrinks.

In terms of environmental effects, such systems may increase total emissions. If compressor efficiency is not so greatly improved by shifting compressor use from daytime (hot ambient temperatures) to nighttime (cooler ambient temperature) that it does not overcome the losses intrinsic in the cooling of the transfer fluid and its subsequent storage, then energy use increases. Compressor efficiency differences resulting from ambient air conditions are quite obviously functions of the particular systems; we offer no general rule as to whether this is the case. If energy use increases, then presumably emissions increase, though, of course, this is a function of generation fleet fuel mix and ambient temperature efficiency differences.

3.2.2 Consequences

For the Tysons Corner building operator, the financial benefit of an energy storage system is a function both of the consumption that can be shifted and the future difference of peak and off-peak electricity prices. That makes for two layers of cost-benefit uncertainty, and the anticipated general trend of the price difference makes such technologies less attractive over time.

From the perspective of FCG, storage for load-shifting brings two effects. First, it seems reasonable to guess the load shifting increases overall consumption (there are losses in thermal medium cooling and in storage) and emissions. Showing otherwise for a particular installation requires that FCG have expertise both with the cooling units themselves and with the emissions performance of the generating fleet serving the area. It is unreasonable to expect FCG to build and maintain this expertise for the purpose of encouraging the use of thermal storage systems, and so it seems wisest to assume that load shifting is an environmental minus, directly contrary to FCG's objectives.

The second environmental effect is the reduction of peak energy consumption. This reduces the need for increased transmission capacity into Tysons Corner and, therefore, decreases pressure for additional substations and power lines, which may be a beneficial result. Multiple means of limiting the need for additional transmission capacity exist, however, and so the prescription of storage for load shifting is complicating at best and counterproductive at worst. FCG may have the power to limit new transmission capacity through its zoning powers. Dominion already has incentive programs for peak load shedding and photovoltaic installations where appropriate, neither or which require new capacity and both of which actually reduce aggregate load.

Combined heat and power (CHP) is an answer itself, so constrained peak capacity may also work towards FCG's objectives with district energy.

3.2.3 Recommendation

We recommend that Fairfax remain neutral on the implementation of load-shifting in an individual building. Environmentally, a net increase in energy consumption is specifically counter to FCG's carbon-neutrality objective, and the implications on the form of the grid in Tysons Corner are murky. Economically, we foresee the benefit of storage for load shifting as diminishing over time. The result here is like that for generation technologies: we recommend that FCG only pursue energy storage systems only if they are originally proposed and supported by the developer.

3.3 Conservation

We finally turn to conservation. Given the likely unsuitability of renewables and thermal storage, we assumed that this is where FCG would find itself recommending the majority of technologies. That turns out not to be the case. Instead, a building is a system. It is not the additive collection of parts. We begin this section with a discussion of this concept and show that energy consumption is largely determined by factors that are largely independent of technology. We then point to references for insulation, windows, passive systems, lighting, and HVAC without adding to their content.

3.3.1 Building as a system

We began this effort with the stated proffer objective of defining a relationship between cost and benefit for various building technologies. Our literature review, however, returned again and again (and again and again) to the idea of a building as a system. Design, construction, commissioning, and operations are inseparably intertwined. A general prescription of technologies for use in Tysons Corner is infeasible. Analysis of a component is highly situation dependent. Nowhere is this more pronounced than in the consideration of individual building components. We have seen no example of any literature showing estimates precise and accurate enough for the general case that they are appropriate for technology prescription by FCG. The literature that does show precise comparison between technologies is highly specific to the particulars of the test environment.

3.3.1.1 Form, Integration, and Operations

Emphasis of the building as system notion begins most intuitively with discussions of building design and relationship with the surrounding environment. Solar thermal gain is a huge determinant of cooling and heating load. A building with its long axis running from East to West maximizes thermal gain in the winter, and (assuming its south-facing windows are appropriately shaded with external overhangs) minimizes summertime gain. Exhaust vents situated to blow in the direction of local prevailing winds makes HVAC more energy efficient. Landscaping to prevent snow buildup against the building reduces wintertime heating load. Well-placed windows reduce the need for lighting which in turn reduces HVAC need. Combined with good interior shading and interior surface reflectivity, the effect can be amplified further. Advantageously positioned (and used) operable windows can allow the use of natural airflow to reduce HVAC load. Good design practices fill books (LANL, 2002), and they can be employed without anything more than commonplace building components.

Less intuitive is the fact that the integration of design, construction, and operation also play an outsized role in the determination of a building's energy efficiency. The Net-Zero Commercial Building Consortium (CBC) states explicitly that, "integrated design is more critical to the development of low/zero-energy buildings than is any given technology. Tremendous efficiency opportunities… can be accomplished with today's technology," (CBC 2011, 11). This integration begins with design and proceeds through operations. The effects of building form need to be estimated for the specific instance over the course of design to allow continuous improvement of the design, and the estimation is best done with building information modeling systems so estimation reflects the building as a system. This, however, pertains to the design process, not the technology actually employed in the building.

The alternative – simply including a particular technology early in design without assessing its impact – leaves the architect blind to any shortcomings until the very end where fundamental re-design is more expensive. This opportunity for energy gain is a function of good design and engineering practice. The only technology recommended here is building information modeling, and this isn't even part of the building.

Integration flows into construction. In any construction effort, time and budget are the developer's primary concerns, yet construction is an intricate dance between the builder, his sub-contractors, and the various supply chains feeding the building. The substitution of a component – a low performance window on a south-facing unshaded wall, for instance – may be necessary to maintain the critical build path, but its operational effects will ripple through the HVAC system and will derail carefully-laid plans to achieve a particular energy consumption target. Design and scheduling must account for such possibilities and build flexibility into the construction process. Again, this is practice – not technology.

Even once the building is constructed, the notion of integration extends into commissioning and operations. The systematic monitoring and maintenance of the building to make sure it meets design specification and performance estimates can add 1% to initial construction costs, but it can save 8-20% in ongoing operations costs. The building's design, however, impacts the ability of a building manager to effectively commission the building immediately and then provide similar such services over its lifetime. The architect must design with such activities in mind years in advance (LANL, 2002), but yet again, this is practice, rather than technology.

3.3.1.2 Recommendation

To the extent that this document is to inform developers, the Los Alamos document is a good source for general design practices (LANL, 2002).

To the extent that this document is to help FCG encourage proffers for particular designs or technologies, this section should show that much of what determines a building's energy consumption is simply beyond FCG's direct influence. To constructively specify energy-efficient building form, FCG would have to be intimately involved in design, construction, and operations. FCG does not have the manpower to do that for every project even in just Tysons Corner, and this alone is reason enough to jettison the idea of doing so. We, therefore, recommend that FCG take no action directly on building form, integration, construction, or operations.

Instead, in Section 5, we propose that FCG attack the issue indirectly. It can (and we heartily argue that it should) affect energy consumption for every building in the region by specifying overall energy performance standards and encouraging public reporting of consumption.

3.3.2 Conservation technologies

Now we finally arrive at a discussion of conservation technologies. The previous discussion shows that technology is only one of many drivers of energy efficiency. It is, of course, an active area of research however, and it comes in two general classes: technology to reduce the need for electricity consumption and technology to make that electricity consumption more efficient. In all cases, we refer to source material. It is voluminous, and we have no technical additions. Again, however, the literature emphasizes that it is the building system, not the component that yields the energy-efficiency effect.

3.3.2.1 Reducing the need for consumption

Investigation into shell insulation (PNNL, 2009), passive thermal systems, phase change materials (CBC 2011; DOE 2011), and windows (CBC 2011; LBNL 2010; Jelle, et al., 2012); are all attempts at energy efficiency by reducing the need for HVAC loading and electrical lighting (NREL 2007). All are measured in terms of heat transfer per unit of surface area, but of course, on their own, no estimate of the resulting building performance is possible without explicit modeling of the whole building system. No general cost-benefit analysis is available.

3.3.2.2 Reducing direct load

Direct energy consumption in the building comes in the form of lighting, thermal control (ambient air, water, and refrigeration), and miscellaneous plug loads.

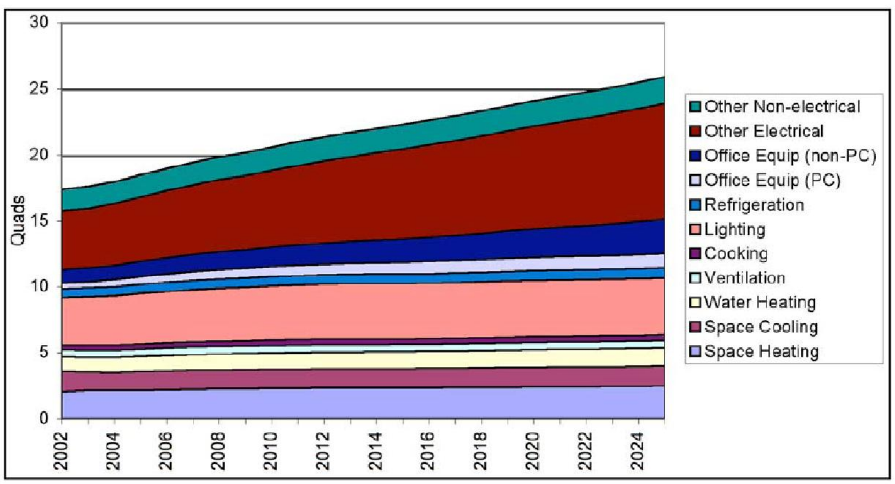

Figure 4: Commercial building energy consumption by use (ORNL, 2004)

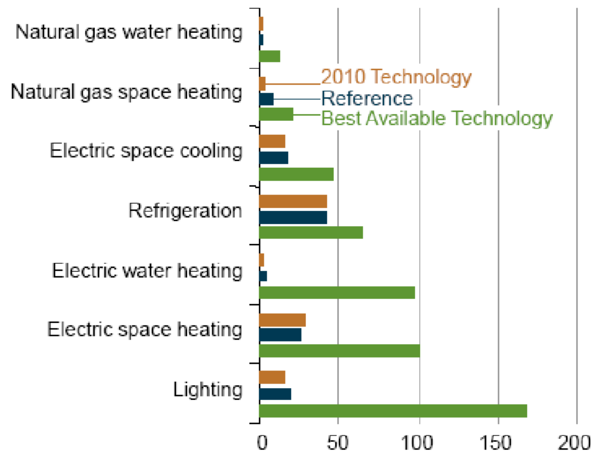

Figure 5: Estimated energy consumption reduction by 2035 (EIA 2011)

3.3.2.2.1 Lighting

Lighting both is the primary electrical draw in a building and presents the biggest opportunity for system-gain (its potential is greater than 100% because lighting itself induces loads on an HVAC system). The Clean Building Consortium estimates that good use of existing lighting control technology can reduce electricity consumption by 40-60% or more (CBC, 2011) emphasizing that even lighting itself is a system to be managed as such. In the case of new installations, the group recommends high-efficiency fluorescent systems for general lighting and improved performance metal halide for higher ceilings. In time, further improvement may come from longer life metal halide (MH) lamps with low wattage and dimming, improved white light LED and OLED efficacy, improved solid state lighting (SSL) standards; and improved sensor integration. Again, since lighting is a system within the larger building system, its specific effect cannot be determined without close inspection of the design itself (ORNL, 2004; DOE 2011).

3.3.2.2.2 Thermal control – mechanical and plumbing

To achieve net-zero goals, experts state that HVAC systems must drastically increase the level of integration and interoperability (CBC 2011). Commissioning, or the quality-oriented process of verifying and documenting the performance of facilities and systems, is traditionally performed right before initial building occupancy. Increasingly, building professionals are realizing that significant initial and continuous commissioning is required for high performance buildings (CBC 2011). Advanced controls and sub-metering will be increasingly necessary to ensure buildings perform as designed. While improved operator education will continue to play a large role, intelligent controls will increasingly be programed to recognize energy-wasting conditions and notify or correct the situation.

The CBC Mechanical Systems and Controls working group has identified the underutilization of existing HVAC technologies as a major barrier to near-term energy-efficiency (CBC 2011). Much research is available as reference with architects, developers, and operators as the intended audiences (DOE 2001, DOE 1999; DOE, 2002; DOE 2009; EPA 2010). In all cases, however, the effects of particular technologies are highly variable based on their specific implementation. The documents make no attempt to define a general “right answer” for any of the technologies or their use.

3.3.2.2.3 Miscellaneous Electric Loads

Commercial Miscellaneous Electric Loads (C-MELs) are defined as plug load besides those related to HVAC, water heating, and lighting. Unfortunately, this category is projected as the largest growth end-use of commercial source energy use as buildings become tighter systems (TIAX, 2010). These loads are non-standard and difficult, if not impossible, to integrate into building-wide energy efficiency efforts. Additionally, they are beyond the scope of a study of building energy efficiency technologies, but we strongly suspect that there can be no prescriptive approach here. Instead, as we will recommend below, we suggest that that continued benchmarking and public reporting of consumption may be a means of addressing them indirectly.

3.3.3 Recommendations

3.3.3.1 For the developer

The references above provide starting points for any investigation into a conservation technique or technology – both its (very) general applicability and its technical implications. The determination of its suitability for a particular development in Tysons Corner, however, is specific to the particular development. Building information modeling tools are the best available means of assessing and evolving a design for maximum energy efficiency.

3.3.3.2 For FCG

For FCG, as we did with the discussion of building form, we strongly recommend that FCG continue its practice of not prescribing technologies or designs to developers. A building is a complicated system. Such prescription addresses only part of the energy efficiency, does so usually to negative cost and environmental effects, and places a huge burden on FCG itself.

First and foremost, technology prescription ignores huge opportunities for environmental gain. It cannot affect the form of a building – whether it is positioned and designed to minimize the need for lighting, cooling, or heating. It cannot integrate the design, build, and operate lifecycle – whether the architect has carefully modeled energy consumption and worked with the general contractor to ensure that sourced components actually complement each other as expected. It cannot affect the building's use. Sure, sensors can be installed to automatically dim lights, but if occupants simply prefer to always have the lights on, the prescription is useless in the end.

Second, even as it addresses design elements directly, it does not directly address the energy efficiency of the whole system. In doing so, if FCG is to do this with the intended effect, this is a hugely increased burden on FCG. The purpose of technology prescription is to satisfy an energy consumption target for a building, not to put a particular technology into the building for the sake of putting a particular technology into the building. We see above that the estimation of a particular component's effect is error-wrought without installation specifics and without sophisticated modeling tools. This means that in order to most effectively prescribe technologies, FCG must maintain the modeling and design capability to identify opportunities for technology specification, and it must maintain a constant watch over the design as it evolves. If the building is subject to an overall energy consumption performance expectation, this further means that FCG's modeling and design capabilities must be superior to that of the architect as he will also be looking for the most cost-effective means of satisfying the consumption objective.

FCG does not maintain the skill and manpower to make this feasible even for a single building, let alone all new construction in Tysons Corner, nor should it. The result is that any specified technology will in most cases be sub-optimal; the prescription is a constraint on the developer's feasible design options. If the developer is meeting an otherwise defined performance expectation, the prescription increases his costs. The same environmental effect could have been achieved for fewer dollars. If the developer has a fixed budget, the constraint results in degraded environmental performance. An improved environmental effect could have been achieved for the same cost. Neither result is a positive one for FCG or for the developer.

Happily, the shortcomings of the prescriptive approach are addressed entirely by a performance-based approach. This is the basis of our additional task. By specifying a performance objective, FCG achieves its environmental objectives with limited burden to itself, and it leaves the developer free to satisfy the objectives by the most economically efficient means – be they technology, design, or use. Even more happily is the fact that FCG already takes this approach.

3.4 District Energy

District energy, specifically in the form of combined heat and power (CHP), may offer the biggest source of energy and environmental gains in Fairfax and is a tantalizing target as a result. The Comprehensive Plan already acknowledges this potential with its support of community energy systems. Supporting this interest are two previous studies that generally consider district energy in the area (FVB, 2011; NVRC, 2011). By necessity, we draw heavily from these two reports, and refer the reader to them for further details. We cannot expand on their content. Expansion of the existing technical document would require additional details that simply don't exist yet (for instance, where would the generation plant even go?). Expansion of the legal discussion requires expertise beyond our skill set. Instead, we limit this discussion to their implication.

3.4.1 Potential benefit

The energy benefit of CHP lies in the fact that CHP combustion technologies are less emissions-intensive than large-scale coal-fired base load, that transmission losses are minimized, and that CHP captures and uses the waste heat from electricity generation. Where traditional coal-fired grid efficiencies range 30-45%, CHP systems typically operate at system efficiencies between 60-80% (EPA, 2007).

From a national perspective, Oak Ridge National Lab has estimated that that the heat energy lost through the traditional U.S. utility sector is greater than the total energy use of Japan (ORNL 2008). The same report estimates that expansion of CHP to 20% of domestic electricity generational capacity could save nearly half the energy consumed by all U.S. households and the CO_2 equivalent of removing 154 million cars from the road.

Locally, Metropolitan Washington Council of Governments recently sponsored a report on the potential of District Energy Systems (DES) in the region (FVB 2011). In that report, eight forms of district energy are evaluated. As in all general investigations, the authors make general assumptions and then find that CHP may deliver reductions in both source energy consumption and greenhouse gas emissions.

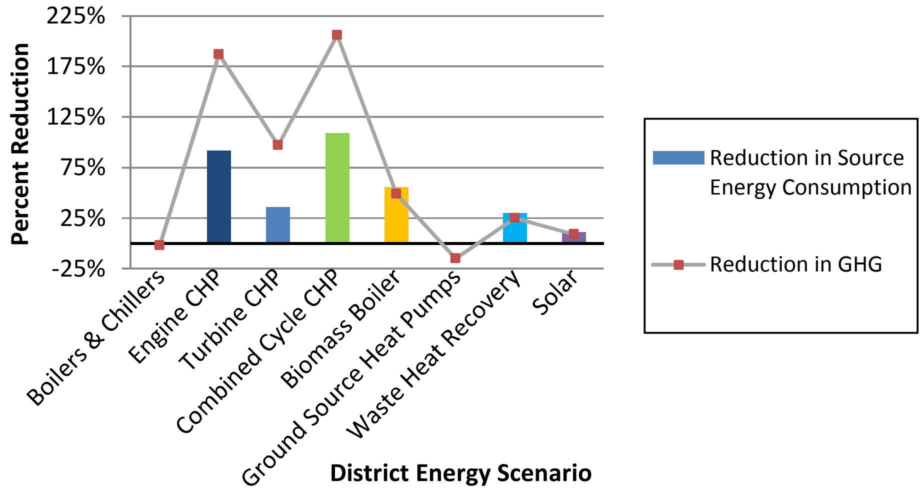

Figure 6: Source energy and GHG reductions under sample district energy implementations (built from FVB, 2011)

In the figure, reductions greater than 100% are possible because thermal demands typically exceed electricity demand and the surplus is sent back to the grid. In doing so, CHP systems reduce the GHG emissions implied by the waste heat and by the more GHG-intensive generation at centralized grid plants.

3.4.2 Recommendations

At the start its discussion of cost and benefit, the MWCOG report authors note, "It cannot be overstressed that the generalized characterization of technologies (including efficiencies and costs) in this report should not be applied to specific cases without a case-specific evaluation of loads, densities, fuel and electricity costs and other unique circumstances. Further, in order to fully assess a potential district energy system, a long-term economic proforma analysis of revenues and expenses, including a build-up of customer base and plant capacity is required to fully reflect the internal rate of return on the multi-year stream of investments." The Northern Virginia Regional Commission report is a legal analysis (NVRC, 2011). The report predicts that, for non-campus applications, the most likely path to CHP (independent of Dominion providing such services itself) is a public-private partnership between the county and a private partner.

The combination of these two recommendations simplifies FCG's available decisions relative to proffers concerning district energy. The sure determination of economic feasibility requires a detailed engineering, financial, and legal analysis. The form of the plant, it power output, its heat output, its fuel, its location, its profit distribution, its environmental constraints, its financing terms, its potential customers, market energy costs, zoning restrictions, legal authorities, and state regulation all must be analyzed specifically for the particular application.

We therefore recommend that, in light of such significant uncertainty, unless an applicant is proactively pursuing a district energy approach (or similar effort), the county not seek proffers on the subject of district energy in favor of seeking proffers with more certain benefit. Doing otherwise incurs a certain opportunity cost for an unquantifiably uncertain gain of uncertain magnitude.

If FCG wishes to proceed towards district energy, we recommend that it first seek help from federal resources to identify appropriate private sector partners and to identify most relevant case studies for comparison. EPA's Combined Heat and Power Partnership (EPA, 2012) and DOE's Mid-Atlantic Clean Energy Application Center (DOE, 2012) are good starting points.

4 Tasks 3 and 4 – Cost, benefit, and market competitiveness

On Tasks 3 and 4, we fall short. The literature includes studies comparing particular technologies in particular controlled environments do exist, of course. The problem, however, is that there are no general cost or break-even analyses that provide enough certainty for use as policy instrument. The applications are simply too varied, and the technologies' effects confounded by the rest of the building system in which they are employed. Remember, each building is a system, and its eventual consumption is a function of the interplay between design, environment, construction, use, and maintenance. The effects of a single technology simply cannot be teased out to estimate their general effect on system consumption. A pair of neighboring buildings with equivalent design can have vastly different consumption profiles, showing that technology effects can be highly variable. Even for a single installation, engineering analyses to determine the effects of particular sub-systems or design elements are difficult and can be crude. Building information modeling software tools have eased this, but their results focus on a particular building, not the general fitness of a technology.

Compounding the difficulty of estimating energy consumption effect is the difficulty of estimating the financial effect. Buildings will have differing rate structures even from the same utility depending (at a minimum) on use profiles, installation size, existing contracts, and load shedding responsiveness. The financial benefit of energy efficiency investment accrues differently depending on ownership and tenancy. Financing terms differ between installation, location, building purpose, technologies, technology applications, owners, project duration, capital access, credit worthiness, interest rates, and market competition. Just as each project requires its own engineering analysis, each project requires its own financial analysis.

This is why general cost-benefit analyses simply do not exist. Case studies exist, yes, but no general solution exists. This is a problem that frustrates universally; FCG is not unique in this respect. It is also a problem that various groups, most notably the US Department of Energy, have been working to solve.

Most recently, DOE has launched a beta version of its Buildings Performance Database (DOE, 2012). The purpose of this database is to house and make available actual energy consumption profiles for buildings categorized by a number of different characteristics. As we might expect from the discussion above, these categories include general form, technologies employed, location, and building purpose. This is the closest resource available to addresses Tasks 3 and 4 of this study. If FCG is looking to provide general guidance on technologies for curious developers, this is where they should go for quick an easy analysis. The caveats, however, are that the tool is in beta and that its outputs cannot ever offer certainty.

We do note that the fact that this database exists is proof that FCG's problem is widely felt. The facts that it requires a user to characterize the entire facility and that its output is a range of possibilities further emphasize the notion of a building as a system, not an additive collection of components. The fact that the database is currently incomplete is evidence that general analyses are not available, and the fact that it is incomplete after two years of development indicates that it is indeed a difficult task.

5 Additional Task - Certification and Benchmarking

Though DOE's tool is new, the problem of designing for energy efficiency and even of identifying energy efficient buildings is an old one. As we have seen, the solution is not in the form of a general cost-benefit analysis of the various means of reducing energy. Instead, the solutions that have resulted are design certification and benchmarking tools. It turns out that these are the best tools by which FCG can ensure building energy efficiency. Given that the originally proposed cost-benefit analysis is not feasible, we include an additional investigation of these tools and strongly recommend them as means of encouraging energy efficiency in Tysons Corner.

Conveniently, such certifications form the basis of FCG's current approach with its use of LEED guidelines, rather than technology prescription. We contend that this is the correct approach for Fairfax. We, therefore, recommend that Fairfax continue with this approach, but we do recommend an extension from just a consideration of building design to a consideration of building use. To make that recommendation, we first discuss LEED and show that because energy consumption is also a function of use and site, it cannot ensure long term energy gains. We then offer ENERGY STAR to show that it offers FCG a mechanism to encourage energy efficiency over the long term. For completeness, we briefly discuss the idea of Net-Zero as a future alternative to ENERGY STAR. We close the section with a more complete discussion of the recommendation itself.

5.1 LEED

Fairfax County is already well acquainted with LEED ratings which are administered by the U.S. Green Building Council (USGBC). At its most basic level, LEED is a point-driven system that broadly considers a building's environmental footprint with five general categories: Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials & Resources, and Indoor Environmental Quality.

LEED certification likely on the average reduces overall energy consumption compared to a traditional building. Energy & Atmosphere, however, is only one category of the LEED scoring system. One study of 100 LEED certified commercial buildings showed an average 18-39% per unit floor area reduction in energy use (Newsham, Mancini and Birt 2009) relative to like uncertified buildings. The same study, however, noted LEED's shortcomings in that despite average improvement, a quarter to a third of LEED certified buildings actually used more energy than their comparable conventional counterparts.

Further, among buildings LEED certified at any level, the study could not show a statistically significant relationship between the level of certification and the reduction of energy consumption. Within the sample, mean energy use intensity drops with increased LEED rating, but the variability prevented a statistically significant indication of a general trend in the greater building stock.

The variability of LEED's effectiveness relative to the operational effects results from the fact that LEED is a set of best practices for design and construction before building occupancy. There is no component to monitor the building post-occupancy, despite the fact that operational energy savings often falls short of proposed savings.

This means that LEED certification is, on average, productive in terms of improving energy efficiency – and since the certification looks across a broad spectrum of concern, it is of broader environmental benefit – but it is not sufficient to ensure energy efficiency.

USGBC is well aware of the problem and is actively looking to develop remedies with its Building Performance Partnership. Under this partnership, LEED certified buildings feed their operational back to USGBC so that the rating system can be improved. In the meantime, to bridge the gap between design and operations, we turn to ENERGY STAR.

5.2 ENERGY STAR

ENERGY STAR is a program jointly administered by the Department of Energy and the Environmental Protection Agency to help protect the environment and reduce energy costs by improving energy efficiency. It has become the standard for assessing *operational* (remember LEED is a pre-occupancy rating system) energy efficiency and has become a common instrument of public policy for multiple federal agencies, states, and local jurisdictions (DOE, 2013).

The ENERGY STAR buildings initiative was a response to an EPA study in the early 1990s that demonstrated the difficulty of predicting a building's operational energy performance from technology specification alone (EPA 2009). ENERGY STAR's prevalence today suggests the study remains relevant today. Its lessons are two-fold. First, even experts doing detailed analysis of specific facilities with standard, repeatable tools find it very difficult to accurately predict either the overall energy consumption of a building or the effects of particular upgrade. Building Information Modeling tools have emerged and matured over recent years to better predict a specific design's energy consumption, but a gap remains with reality. Second, calculations based on a design specification alone are inadequate to ensure energy efficiency. Continuous monitoring of actual energy consumption is necessary to effect and maintain energy efficiency efforts. These are exactly the same problems USGBC is attempting to tackle with LEED, and in fact, it is using the ENERGY STAR reporting tool to collect the operational data to resolve the difficulty.

5.2.1 Effects and prevalence

The program is intended to offer two energy-specific benefits. First, for the individual building, it has been estimated that ENERGY STAR labeled buildings use about 40% less energy than their peers (CoStar 2008). The program also addresses existing buildings, which are often low-hanging fruit in achieving energy savings. Improved operational efficiencies of 8-12% are commonly reported after tuning building operations (BOMA, 2006). Both cases serve FCG's environmental objectives. The second benefit is the database of building energy consumption as it is a tool to drive improvements in the state of the art. External to the program itself, there are also indications that certification is beneficial indirectly by increasing resale and lease prices (CoStar, 2008).

EPA states that by the end of 2010, more than 12,600 buildings (2 billion ft^2 of building space) have been awarded ENERGY STAR certification and that over 200,000 buildings (18 billion ft^2) representing more than a quarter of total market) have been assessed using Portfolio Manager, the ENERGY STAR reporting and calculation tool. EPA further estimates that commercial building improvements related to the ENERGY STAR Program have saved 112.9 billion kWh (roughly equivalent to about 4% of a year's non-industrial commercial use of energy in the US) since the program's inception in the early 1990s (EPA, 2010; LLNL, 2011).

5.2.2 Certifications and Portfolio Manager

The program offers two building certifications. The ENERGY STAR label is the primary mechanism. It compares peer buildings using operational energy consumption data. A building shown to be in the top quartile of its peers in terms of energy intensity (energy divided by floor space) can earn the ENERGY STAR designation (subject to occupancy, ownership, and indoor air quality restrictions). The Designed to Earn ENERGY STAR (DEES) certification is a bridge between design and operational performance. During development, the Architect of Record initiates the DEES process to help establish energy consumption goals with EPA's Target Finder tool. If the project appears to satisfy benchmarks, DEES certification is issued, and the developer can use the label on its plans and marketing materials.

Once the building has been occupied and operational for a year, it can earn the ENERGY STAR (as opposed to only DEES). Building owners report their consumption data and building characteristics with ENERGY STAR Portfolio Manager, which is a free online tool. The tool normalizes the inputs for a particular building and compares its consumption to peer facilities to determine the building's consumption percentile, which is its ENERGY STAR score.

Portfolio Manager itself is of particular interest to Fairfax for a pair of reasons. First, once an account has been established for a particular building, the tool allows for automated import from the utility (though FCG may have to work with Dominion and ENERGY STAR to make that functionality available for Tysons Corner buildings). The process of benchmarking, therefore, is a small burden on a building owner. And second, Portfolio Manager allows a building owner to share the consumption data with a third-party. This gives FCG the ability to monitor the on-going operations of buildings in Tysons Corner and, therefore, to judge and improve its negotiating position over time.

5.3 Net-zero energy performance indices

Net-zero energy indices are the next evolution in energy efficiency measures. Such measures are currently under development as part of Zero Energy Buildings (ZEB) initiatives, which are intended to encourage the development of buildings which on average over time require no input energy (in either fuel or electricity) beyond that which they can produce themselves from renewables for building operations, excluding plug loads.

The U.S. Energy Independence and Security Act (EISA) 2007 authorizes the Zero Energy Commercial Building Initiative (CBI) to work towards the goals of net zero energy for all new commercial buildings by 2030, 50% of commercial building stock by 2040, and 100% of commercial building stock by 2050. The European Union has set a much more aggressive target of 'nearly zero' energy consumption for all public-authority used buildings by 2018 and for all new buildings by 2020 with its Energy Performance of Buildings Directive (EU 2010; Marzal 2011).

Consensus has not yet formed around the most appropriate net-zero energy measures. The difficulty in such definition is the separation of the building's energy consumption from its occupants' energy consumption. HVAC, for instance, counts against the building and would be considered in a net-zero measure; miscellaneous electric loads are not as they not intrinsic parts of the building system. The interplay between the two represents the grey area that is the trouble for net-zero definition.

Like ENERGY STAR, the zero-energy measure treats the building as a complete system and focuses on energy alone. While ENERGY STAR currently is based on a *peer* rating, net-zero measures intend to provide a more absolute measure of building performance as an *asset* rating. While there is no standard measure yet, Department of Energy is in the process of defining one (Federal Register, 2011). The important part is that however the measure is eventually defined, the asset rating will be included in ENERGY STAR Portfolio Manager in parallel to the existing peer rating scale. When this happens, FCG need not revise the reporting procedures it encourages, but it can begin to specify performance as a function of a net-zero asset rating target.

5.4 Recommendations for certifications

LEED, ENERGY STAR, and NetZero all exist because of the problem with which FCG finds itself grappling. There are no general technology inclusions that ensure a design is energy efficient, and there is no guarantee that a building designed with efficiency as a priority will be energy-efficient in practice.

Employed as policy, these tools give a developer maximum flexibility to meet environmental objectives at minimum cost – be it through technology, design, operations, or some combination. This is why local and state governments are increasingly adopting them as public policy instruments to push energy efficiency (NRC 2010). Locally, the District of Columbia does the same and goes a step further with ENERGY STAR requirements (ENERGY STAR, 2008). Clearly, the District has different operating authorities than does FCG, but the point is that such an approach is not new to the region.

FCG already pursues certification-based approach with its use of LEED. We recommend that it continue this course, rather than looking for more direct influence over the technology particulars of a building. Building code already specifies energy efficient installation standards; FCG does not need an additional layer of prescriptive specifications. We recommend continued use of LEED. Even if it does not guarantee energy efficiency, as a general environmental stewardship tool, it offers wider benefit.

To complement LEED, we recommend that the county encourage Designed to Earn the ENERGY STAR certification and encourage annual benchmarking with Portfolio Manager. ENERGY STAR augments existing prescriptive building codes (VA 2009) by requiring building owners to report and compare actual energy use. We recommend DEES certification, rather than ENERGY STAR certification for two reasons. First, a new development may not neatly align with the ENERGY STAR categories. A campus-style multi-building design, for example, is not applicable, though may offer lower overall energy consumption. Most new development will fit into DEES, but all cases will not, and FCG should therefore be judicious in its encouragement of DEES. Second, because the ENERGY STAR cannot be awarded until after a year of operations, certification cannot be guaranteed from design itself. If the proffer is for ENERGY STAR certification, but the building operator fails to achieve the label, we assume that FCG has little recourse, absent incorporation of an enforcement mechanism into the proffer.

The intent is to improve the efficiencies of the individual buildings, pave the way towards net-zero measurement, grow the ENERGY STAR databases, and improve the LEED rating systems themselves. In the former two cases, the benefits accrue to the building owner. He is hopefully able to use the benchmarking to reduce energy costs, and use of Portfolio Manager helps to pave the way to net-zero measurement as it becomes available. In the latter two cases, the practice means that Tysons Corner development helps to improve the state of the art and, therefore, has a longer and further reaching effect greater than just the new development itself.

Since reporting is a requirement for ENERGY STAR participation, we also recommend that FCG encourage building owners to make public their energy consumption performance. From developers, FCG should negotiate access to the consumption data through Portfolio Manager, and the County should post the annual benchmarking results publicly online. DC already has similar laws on the books, so Fairfax would be well within the mainstream with the policy. Additionally, each facility should have posted its ENERGY STAR scores from each benchmarking along with its LEED Certification. The point is to encourage public pressure for improved energy-efficiency.

Now we turn to net-zero. Pilot efforts are underway to develop such buildings, but consensus has not yet emerged around appropriate measures or acceptable scores for good use as policy instruments. We recommend that Fairfax closely monitor developments pertaining to net-zero, and we presume that, in time, net-zero measures will be the best means of specifying performance - just not yet.

We understand and fully support FCG's goal of making Tysons Corner an innovation center that drives improvement of building energy technologies, and so we recommend that FCG allow risk to trump certification. If a developer acting in good faith proposes a project with new, risky technologies that may offer a chance at breakthrough energy performance, and if that riskiness is enough to jeopardize FCG's usual preferred form of certification, then we suggest that the county accept a commitment to proceed with the risky process in lieu of a commitment to the certification (though maintaining a reporting component to the commitment) and proceed with the risky project. Even if the project fails to bring the hoped-for effect, the learning is still more valuable than the effects of a single certified building. If Fairfax indeed wants to be a leader here, it will have to support experimentation (which can fail to meet objectives), and sometimes it will have to be ahead of standards.

6 Recommendations

We have presented our recommendations throughout the document as they were developed. We present them here again to close the document and show them as a complete set. Again, we note that we make these recommendations with the assumption that if they were to be adopted, they would be implemented through the proffer process.

We also emphasize again that we think FCG is already pursuing an appropriate strategy to achieve its environmental and economic objectives. Our recommendations are only minor additions.

6.1 Building technologies

We strongly recommend the FCG continue its practice of not employing a prescriptive approach to building technologies or components. This holds for both for technologies included at initial construction and for technologies for which a developer might provision in anticipation of future installation. This is because a building is a system. Its energy consumption is function of its design, its construction, its relation to its surroundings, and its operations. The prescriptive specification of technology ignores primary energy efficiency drivers and imposes a huge administrative, technical, and personnel burden on FCG itself. These are recognized difficulties, and indeed, they are why design certification and performance standards were originally created. This is why we explored the additional task, and this is the basis for fourth and fifth recommendations.

6.2 Data collection

In section 3.1.1 we noted a lack of data to confirm or deny the utility of wide-spread wind generation in Fairfax County (though we are skeptical). In 3.1.2, we noted a possible lack of data on the geology under Tysons Corner. Wind data can be gathered easily and may represent an interesting proffer. Augmenting geology databases is certainly far more expensive (possibly to the point of exceeding the cost of a reasonable proffer). If the costs turn out to be reasonable, however, FCG may be interested in a proffer to coordinate with DPWES and the Commonwealth's DMME in an effort to expand their data sets to enable more exploratory investigation of GSHP in Tysons Corner.

6.3 District energy

We recommend that FCG not pursue proffers preparing the way for district energy with the reasoning that until more certainty exists on this subject, such proffers represent opportunity costs that can be spent with more definite results elsewhere.

6.4 Third-party certifications and performance guidelines

We recommend that Fairfax continue its current practice of performance-based guidance to Tysons Corner developers as it is a perfect mirror of FCG's own attempt to promote both environmental stewardship and economic growth. With the guidelines, FCG defines the recommended level of environmental performance, but the developer has the flexibility to meet those objectives at lowest possible cost.

FCG should continue to support LEED certification of projects. But because LEED only considers design, FCG should also encourage at least Design to Earn ENERGY STAR certification and then annual reporting in ENERGY STAR Portfolio Manager to ensure energy-efficiency in practice. FCG should also strongly encourage building owners to help improve LEED by using Portfolio Manager to report energy performance back to the U.S. Green Building Council.

We also recommend that FCG pay close attention to the evolution of Passive House and net-zero methodologies, and as these practices mature, we recommend FCG use them to specify building performance targets.

We do note, however, that certification guidelines (though not Portfolio Manager reporting) should not be applied rigidly if a developer wishes to be a test case for unproven energy-efficiency techniques or technologies. FCG wants Tysons Corner to be a center for building technology innovation, to do that it must give developers the freedom to experiment. FCG should coordinate with DOE programs to recruit suitable experimentation developments, and it should apply flexibility to its guidelines so that policies meant to encourage a minimum level of environmental stewardship do not hamper attempts to exceed it.

6.5 Public reporting

We assert that public reporting of energy consumption data and ENERGY STAR ratings will boost public awareness of the issue and, in turn, further encourage building operators to reduce consumption. We recommend that FCG take advantage of the reporting into Portfolio Manager and make that information public. FCG should post on its own web site the consumption data and comparison scores for all buildings in Tysons Corner that are being reported in the tool.

Building owners should display their own results (raw data and performance scores to allow comparison) at the entrance of the building.

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