Attachment A – Microgrid Benefits by Category

To evaluate the potential for a microgrid at a given site, it is first necessary to understand the potential benefits that microgrids can deliver. No single outcome drives the decision to build the typical microgrid – as with other multi-faceted choices, such as a family buying a house, many factors come into play. The full set of benefits is incorporated into scoring worksheets. The opportunities for realizing these benefits at a candidate site can then be rated accordingly, in conjunction with ratings based on known costs and barriers for microgrid deployment.

This list of potential benefits assumes a "typical" microgrid configuration matching the climate conditions, available generation resources, and prevailing market prices and pricing trends for energy that are found in Washington DC:

- One or more property owners, at least roughly contiguous, at least moderate density of loads, consisting of some combination new, renovated, and existing buildings
- Combined Heat & Power, using recip engines, combustion turbines, fuel cells, and/or microturbines, fueled with some combination of pipeline natural gas and methane or producer gas from various local sources of biomass
- Photovoltaics, predominantly rooftop, with occasional opportunities for solar thermal
- Existing or new standby or back-up generation, using some combination of diesel or biodiesel and natural gas
- Thermal distribution including some combination of hot water, chilled water, condenser water, and steam, potentially with thermal storage
- Electric distribution at 4160V or 13.2kV, using new or existing wires, with small number of points of common coupling back to the Pepco grid (usually just one), and modest (if any) battery storage

I. <u>Thermal Energy-Cost Benefits to Microgrid Participants</u>

A. Capital cost reduction for heating and cooling capacity in new buildings

i. Economies of scale

a) Capital equipment for new buildings. Example: The cost of six boilers or chillers to serve each of six buildings can be twice the cost of a single unit that is six times as large, especially for high-efficiency units.

b) Freeing up leasable space within new buildings, and existing buildings if current equipment is removed. Reduce or eliminate mechanical room, cooling towers, penthouse. Smaller total square footage is required for microgrid assets, even after including pumps for distribution system, plus can re-locate equipment to least-valuable location within the entire microgrid area.

ii. Moderate peak requirements with diversity of load:

a) Diversity across multiple users – example: If every apartment has its own heating or cooling unit, it must be sized to meet peak needs. But not everyone is home at the same time, and not everyone has the same thermostat set-point. With individual units, the worst-case-design-day maximum is replicated over and over. With a district system (or even a central single-building system), the total required peak capacity is 25% - 50% lower.

b) Diversity across types of users – example: An office building requires chilling capacity to meet its peak requirements at mid-afternoon, when office use, outside temperature, and direct sunlight are all at their maximum. A multi-family apartment building requires much less chilling capacity in mid-afternoon (especially with programmable thermostats), but needs extra chilling capacity to meet its peak requirements in the early evening, when many residents return home after work amid still-high temperature and humidity. Similarly, hot water use at a streetcar maintenance barn peaks when fewer steetcars are not in use, i.e. after each rush hour, while residential hot water use peaks just before people leave for work. The microgrid shares thermal capacity across the diverse loads, reducing total peak requirements.

iii. Spread out redundancy requirement over larger number of users. Example: N+1 redundancy without district energy typically means two boilers at each apartment building, each boiler capable of meeting full load (100% extra capacity). Instead, a microgrid is served by a mix of several boilers of different sizes plus waste heat recovery, so the same redundancy is provided at, for example, one-quarter the cost (25% extra capacity).

iv. Reduce peak capacity requirements with thermal storage. Load-shifting is a typical function for storage, moving demand from peak-hours to off-peak. But thermal storage also makes CHP more cost-effective to run overnight during summer (for chilled water storage) or shoulder seasons (for DHW production to meet morning residential peak usage). So less capacity is needed from dedicated boilers and chillers, and more of that capacity can come from recycled heat off the CHP system.

v. Clear backlogs at existing buildings for deferred maintenance and infrastructure investment. Especially important for some non-profit institutions with limited access to capital or for for-profit businesses with steep requirements for rapid return on capital.

B. Operating cost reduction for supplying heating, cooling, and domestic hot water

i. Cogeneration

a) Recycled heat costs significant less than heat from dedicated boilers, while absorption chillers provide chilled water at somewhat lower cost than dedicated larger electric chillers.

b) With thermal storage, CHP can recycle more heat, for example by running overnight during summer (for chilled water storage) or shoulder seasons (for DHW production to meet morning residential peak usage).

ii. Higher efficiency equipment

a) Cooling: Large electric chillers (5 to 6 COP) are significantly better than window units, but not better than high-quality (20 SEER) residential heat pumps.

b) Heating: Large boilers (90-95% efficient) are significantly better than older boilers (80% or less), offer a vast improvement over electric heaters, and can lower energy costs compared to air-source heat pumps, but are not better than new high-quality (>90%) residential gas heaters.

iii. Lower labor and contract maintenance costs
   a) Main effect: Larger, more centralized equipment reduces the number of failure points and scheduled maintenance checks.
   b) Less time is required to go from unit to unit for maintenance activities.
   c) Greater standardization can be designed in, reducing training complexity and spare parts inventory.
   d) Professional staff focused only district energy equipment mostly eliminates the need to bring in outside contractors for repairs.

iv. Earn new revenues at existing buildings by using boilers and chillers as peak / back-up capacity for the microgrid (if existing equipment is retained)

v. Substitute gas for electric. For thermal applications, using electricity at 12 to 15 cents / kWh (Pepco residential price) is three to four times more expensive than using natural gas at $10 / MMBtu (central-plant firm gas price). Any opportunities to move away from electric hot water heaters, space heaters, or electric heat pumps will reduce energy costs significantly.

vi. Interruptible rates. End-users cannot be expected to operate dual-fuel thermal equipment, but central-plant designers have the opportunity to trade-off modest increases in capital cost and complexity, for added fuel flexibility and significantly lower gas prices ($2 - $3 / MMBtu lower for Washington Gas delivery in DC)

vii. Summer burner tips. By purchasing relatively consistent quantities of natural gas through the whole year (because of natural-gas fired cogeneration), winter peak purchases are not as extreme, and better overall gas rates can often be negotiated (including under DC's special cogeneration gas tariff).

II. <u>Electricity Energy-Cost Benefits to Microgrid Participants</u>

A. **Capital cost reductions for electric service**

i. Interconnection. For new construction or for loads that have never been connected to the grid, the local utility can charge certain costs directly to end-users. Any on-site generation, such as PV, CHP, or standby power, can entail specific interconnection costs. In particular circumstances, these costs can run into the millions, but are subsumed within the microgrid interconnection.

ii. Diesel standby generation. With on-site generation already present and supplying end-users on a regular basis, separate standby generation is usually unnecessary. In some cases, code waivers may be needed, since microgrids are newer than the date of the last update to the safety requirements.

iii. PV economies of scale. As the price of the solar panels themselves continues to drop, a larger percentage of PV costs come from overhead, permits, coordination, etc. Installing solar across multiple buildings in one transaction means bulk purchase discounts and reduced installation costs totaling a 20% to 40% discount.

iv. Existing or new incentives. Government policies designed to support cleaner and more resilient energy sources can offset significant capital costs, in the form of tax credits, accelerated depreciation, direct payments, etc.

B. **Operating cost reduction for supplying electricity**

i. High-efficiency CHP. On a marginal-cost operating basis, each kWh from a modern CHP system costs less than a retail kWh purchased from the grid. In DC, the difference can be 7 - 8 cents vs. 11 - 14 cents / kWh (before any revenues from heat recovery). Differences are greater when grid prices are higher, including for low-voltage residential customers incurring relatively larger account charges.

ii. Recycled heat for CHP. Roughly equal amounts of energy come from CHP in the forms of electricity and heat. Recycling that heat offsets the need to produce heat or hot water from other sources, such as burning natural gas. A less valuable but still important savings come from converting the heat into cooling with absorption chillers, offsetting the need to run electric chillers.

iii. REC sales for PV and CHP. The cleaner energy sources for a microgrid reduce carbon emissions and other pollutants. Various market-based incentives monetize this benefit, such as tradeable Renewable Energy Credits.

iv. Peak reduction. A substantial portion of the electric bill for medium-voltage Pepco customers is the monthly demand charge, driven largely by summer cooling needs. A microgrid provides multiple ways to reduce that peak:

a) Recycled heat from CHP runs absorption chillers, so a portion of the cooling load is met without needing peak electricity.
b) Using chilled water storage, cooling can be stored during times of lower demand (overnight from CHP, and also when PV production peaks around noon) and then substituted for electricity use at times of peak demand (late afternoon and early evening).
c) Efficiency upgrades, including replacing inefficient chilling (especially window-unit air conditioners) can significantly reduce chilling-related peak demand.
d) Peak demand can also be driven up by electric space heating or in particularly cold weather by air-source heat pumps. District heating would provide a major improvement in that situation.

v. Demand response. Revenue can be derived from the ability to control the use of grid power.

a) Reducing grid imports:
   - Standby generation, including redundant generators, can be turned on.
   - Even though heat is usually the

more valuable thermal product from CHP (offsetting hot water demand), the recycled heat can be re-directed to absorption chillers, reducing electricity demand.
- Thermostats can be re-set and chilled water production reduced, along with other standard demand-response measures such as reducing the intensity of indoor lighting.

b) Revenue from controlling grid imports:
- Explicit payments under various demand response programs
- Peak reduction, as described above.
- Freeing up the microgrid generation resources for grid export, particularly during the hours and days with the highest sale-price back to the grid.

vi. Grid export / Ancillary services. A complex set of interactions between a microgrid and the larger utility distribution system can create opportunities for additional benefits and revenues. These benefits vary widely, depending on details about the resources within the microgrid, the conditions for the surrounding utility grid, and the specifics of the utility connection to the microgrid.

vii. Bulk purchase for remaining grid electricity. Since many users are combined within a microgrid, they can collectively negotiate a better rate for purchasing whatever electricity is not generated on site. Generally, the larger the bulk purchase, the better the price, as the District government has achieved through its own city-wide purchasing programs.

III. <u>Economic Benefits to the Utility Grid</u>

A. Easier to meet PSC goals and requirements to integrate distributed generation – e.g., lots more rooftop PV
B. Reduce substation and transmission burden, from new distributed generation
C. Reduce peak demand from cooling – high-efficiency chillers, plus absorption chillers using recycled heat from CHP
D. With lower peak and overall demand, can defer substation expansion and other distribution system investments, perhaps indefinitely.
E. Aggregated resource for demand response, including both end-user behavior and more flexible deployment of standby generation, reducing complexity and administrative overhead compared to engaging each individual end-user for demand response
F. Potential for grid export, including hour-ahead ISO markets (whenever prices above marginal cost of production), taking advantage of market efficiencies to meet power requirements especially at times of peak demand
G. New resources for ancillary services, including reactive power, fast frequency regulation, etc., deferring or eliminating the need for the utility to invest directly in dedicated resources to provide the same functions (e.g., capacitor banks for dynamic VAR)

IV. <u>Non-Economic Benefits to the Community</u>

A. <u>Neighborhood Benefits</u>

i. Strengthen neighborhood level institutions, organizations, and identity, through the process of creating and shaping a microgrid and through the permitting and approvals process.

ii. Ongoing strengthening of the ties that bind a neighborhood together, reflecting the physical and visible ties of pipes and wires traversing the area.
iii. Education: providing an awareness, a platform and a concrete mechanism for ongoing education about energy, sustainability, infrastructure and consumption.
iv. Better metrics and awareness about energy use, providing fuel for the urge to be greener

B. Environmental Justice Benefits

i. Neighborhood-level access to capital for residential solar deployment
ii. Level of investment into public infrastructure
iii. Enjoyment of environmentally-related amenities, from green space to clean energy to outdoor pools to fresh vegetables
iv. Redress for environmental inequities imposed in previous generations, from homes with poor insulation because of mortgage red-lining to damage to local waterways or actual dumping of hazardous wastes.
v. Extra resiliency for an exposed population – properties exposed to flooding, lower income residents, evacuation centers at schools, etc.

C. Benefits for the District

i. Local jobs
ii. Engine for economic development
iii. Secure outside investment
iv. Enhance attractiveness of new real estate developments
v. Unlock new value from existing energy distribution or generation assets
vi. Energy alternatives and new infrastructure that is responsive to local needs and priorities
vii. Provide the ultra-reliable energy needed by certain government and international users, keeping them in the District
viii. Put DC in the forefront of sustainable urban development

V. Environmental, Emissions Reduction, and Sustainability Benefits

A. Maximizing solar output

i. Ensure that each new building maximizes its available space for installing solar
ii. Provide easy financing to install maximum amount of solar
iii. Economies of scale to reduce installation costs for solar, increasing the amount that is cost-effective
iv. Eliminate interconnection issues that could otherwise limit the scale of solar, increase its cost, or introduce permitting delays

B. Maximize efficiency gains from CHP

i. Absorb all thermal output (recycled heat) and at all available temperatures
   a) Single thermal host that can absorb all the recycled heat
   b) OR good balance of end-users with uses for heating, cooling, and low-grade heat (e.g., domestic hot water, outdoor swimming pool, etc)
   c) Time-of-use profile to utilize recycled heat during all hours of production
   d) OR thermal storage mechanism to

ensure full utilization, regardless of time of use

- ii. Replacing or substituting for less efficient energy sources
  - a) Using district cooling instead of old-fashioned window-unit air conditioners
  - b) Replacing oil-fired furnaces
  - c) Upgrading from older, less efficient boilers or chillers
  - d) Substituting for electric water heaters
- iii. Utilize emissions-lowering methods for pollutants other than carbon dioxide
  - a) Fuel cells
  - b) SCR / Urea after-treatment
- iv. Operate with high capacity factor and high efficiency
  - a) Installing state-of-the-art CHP equipment with top-rated efficiency
  - b) End-use profile and energy cost calculus that enables round-the-clock operating of the CHP systems
- v. Supply a high percentage of on-site energy needs (other than load met by solar)
  - a) Relatively level load profiles, avoiding need for either undersized CHP that doesn't meet a lot of load, or oversized CHP that sits idle and incurs excess capital costs
  - b) Sizing CHP relatively close to typical daily peak

C. Feedstocks to substitute for pipeline natural gas
- i. Waste wood for gasification
- ii. Food waste, FOG, municipal biosolids, and other organics for anaerobic digestion or gasification
- iii. Other waste-to-energy resources (without incineration)

D. Opportunities to integrate other renewables
- i. Run-of-river hydro or other hydro-kinetic generation
- ii. Heat-mining from sewage pipes or other resources
- iii. Ground-source heat exchange (without undermining thermal utilization for CHP)
- iv. On-site or building-integrated wind power

E. Efficiency
- i. Financing for constructing higher efficiency buildings as part of overall microgrid financing
- ii. Financing for energy retrofits as part of overall microgrid financing (if retrofits haven't already been performed)
- iii. Availability of greater expertise in optimizing building design or operations
- iv. Economies of scale to make energy efficiency measures cost-effective across a larger set of users simultaneously, including retrofits, purchases of high-efficiency lighting, etc.
- v. Greater economic reward to implementing energy conservation and peak-demand reduction measures, such as reducing capital cost requirements for installing CHP

VI. Reliability and Resiliency Benefits

A. Reduce or eliminate vulnerability to grid outages, both local and regional
B. Reduce or eliminate vulnerability to grid disturbances and power quality issues
C. Provide seamless transition to relying solely on microgrid resources when the grid is unavailable (with additional investment potentially required to avoid momentary outage)
D. Reduce or eliminate the need for back-up

diesel engines at individual buildings

E. Strengthen the surrounding grid through the delivery of ancillary services
F. Strengthen the surrounding grid through reduction in demand at times of peak stress
G. Replace or augment primary feeder undergrounding under DC Plug to deliver the same or better reliability improvements at a lower cost to the ratepayers.
H. Provide greater diversity and flexibility of resources in meeting energy needs, reducing vulnerability to any particular reliability threat (including cyber-security)