URBAN INGENUITY

HOTD Microgrid Market Potential Analysis: Expanding Steam and Electric Loads

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I. Background:

This memo provides RFI respondents with an estimate of the technical market potential of the HOTD plant in order to inform the design and financial analysis of proposed enhancements. This bottom-up assessment of an expansion of the GSA HOTD energy generation plant and distribution network quantifies the economics of serving additional loads and providing a wider variety of services.

Specifically, this analysis examines the ability of the existing HOTD plant to access new markets and new revenue streams: 1) by serving the electricity loads of existing federal steam energy customers; 2) by adding new non-federal customers directly adjacent to the existing steam tunnels to receive both electricity and steam energy; and 3) by modestly expanding the existing distribution network to reach additional nearby customer loads.

Some highlighted findings from this market potential analysis include:

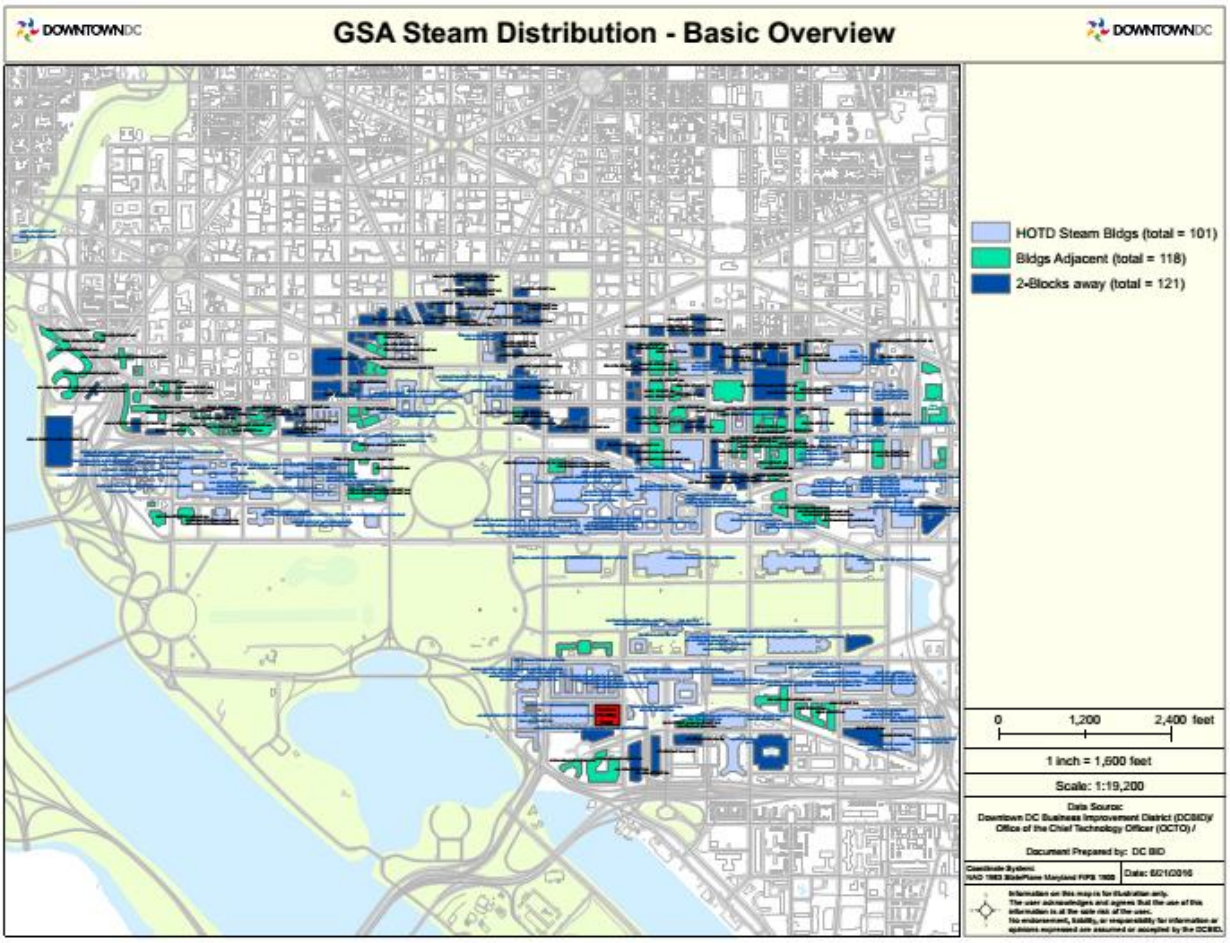
- The technical market potential – if *all* adjacent and nearby properties were served by the HOTD plant, and existing HOTD customers procured electricity from this system – is over $260 million in annual revenue for energy services, the bulk of it from supplying electricity.
- Serving just 25% of electricity demand for existing HOTD customers and only 25% of properties adjacent to steam tunnels represents nearly a $40 million annual market.
- Nearby properties that could be served by HOTD are almost 30% non-office users, representing new opportunities to help balance loads and improve operational efficiency.
- Additional value can potentially be delivered in the form of enhanced environmental sustainability and increased security, reliability, and climate resilience.

These numbers do not include any future construction adjacent to the service area. Results are presented in phased steps, to show incremental investment opportunities based on the size and ambition of the desired potential plant expansion, and pending deeper economic analysis by potential investors.

Urban Ingenuity provides these results under a grant from the District of Columbia Department of Energy and Environment (DOEE), undertaken in partnership with Georgetown University. We are grateful for the in-kind contribution of GIS modeling services provided by the DC Downtown Business Improvement District (BID).

II. Overview of Project Opportunity:

Since its initiation in 1933, the Federal government has continually invested in an extensive underground steam distribution system throughout broad sections of downtown Washington. Most of that distribution system consists of walkable tunnels, while other portions utilize buried steam lines. With a relatively modest marginal investment, the HOTD plant can leverage this existing infrastructure to add electricity service for existing customers, and to serve additional customers with electricity and steam. The map below illustrates the general areas and the specific buildings that are within the reach of the existing steam distribution system.



GSA provides steam for 71 buildings today, many of which could potentially receive electricity as an expanded service that utilizes the same infrastructure. Scores of buildings are directly adjacent to existing steam tunnels or buried lines, in position to receive new steam and new electric service. Still more properties are nearby, close enough to extend the existing distribution network across a single paved street in order to add them to the network with a relatively modest investment.

The potential to add these services to existing and new customers can provide a steady stream of reliable future revenue and can induce third party capital investment, while enhancing service quality, reliability, and cost effectiveness for government customers in the federal core of the nation's capital. While

regulatory issues must be addressed to enable such an arrangement, these appear solvable in the current policy and regulatory environment within Washington DC.

Key Findings:

- The total technical potential for adding electricity service just to the existing HOTD customer base for steam energy represents on the order of a $100 million market.

- The total technical potential of extending steam supply and electricity to serve new properties with adjacent and nearby steam tunnels and buried lines would provide an annual benefit of roughly $150 million.

- The bulk of potential *new* revenues would result from electricity sales, because of higher consumption compared to steam, higher dollar value per unit energy and the fact that existing customers of the plant already receive steam service.

- Converting a fraction of the technical potential into actual customers would still result in substantial revenues from a practicably serviceable market. For example, extending electricity service to only 25% of existing GSA customers, and extending electricity and steam to just 25% of new, non-GSA customers would generate nearly $40 million in new annual revenue.

- About five million of the 19 million potential additional square footage near the steam tunnels is non-office. Since existing loads are largely office-type functions, concentrated into work hours on weekdays, the result is unbalanced loads and a system that is underutilized during non-peak hours. Eleven million of the 56 million total square footage in this analysis consists of residential apartment and hotel loads. These significant new non-office users could be added under this approach to level out office users' peak requirements and improve efficiency by adding consumption on nights and weekends.

Overview of Benefits:

Securing capital for substantial new investment in a modernized and more resilient energy district and microgrid for the federal core of Washington DC requires positive customer response to any potential service offerings, which would rely upon specific outcomes and benefits, including:

1. *Lower Energy Costs*: Energy costs can be reduced for both current and new users, when compared to current tariff rates and/or through postponing potential rate increases;

2. *Improved Operations*: New customers would rely upon successful ongoing operations and system maintenance, presumably enabled by stronger cash flow and fresh capital investment;

3. *Additional On-Site Space*: New users can reclaim valuable space that is currently or would otherwise be devoted to on-site boilers, cooling towers, back-up generation, etc.;

4. *Increased Reliability & Resilience*: Users and the District as a whole would benefit from a redundant, autonomous power source that can sustain mission-critical operations during a storm, regional power outage, cyber-attack, climate impacts, or other grid disruption;

5. *Reduced Greenhouse Gas Emissions*: Users, the District, and the planet will all benefit from greenhouse gas reductions and enhanced environmental sustainability.

A table providing the full results of the market assessment is found on the next page, with a full exposition of the methodology for the analysis on the following pages.

Tiered Scenarios for Expanding Electricity & Steam Loads		**Tier 1: Existing GSA-HOTD Customers** *Add electric service*	**Tier 2: New Adjacent Customers** *Steam & electric via existing tunnels*	**Tier 3: Economic Expansion** *Lowest-cost expansion of existing distribution*	**Tier 4: Practical Expansion** *More expensive extension of existing distribution*	**Total *New* Customer Technical Potential** *Adjacent & nearby to tunnels and buried lines*
Demand	Number of New Buildings	**71**	*63*	*84*	*76*	**223**
	Square footage (in millions)	**55**	*19*	*20*	*17*	**56**
	New Electric (Avg MW)	**112**	*37*	*25*	*51*	**114**
	New Steam (Avg Mlbs/hr)	**N/A**	*58*	*16*	*42*	**116**
	New Electric (Annual GWh)	**979**	*325*	*220*	*451*	**995**
	New Steam (Annual Mlbs)	**N/A**	*408,000*	*112,000*	*294,000*	**814,000**
Annual Revenue	Electric ($ Millions, @11¢/kWh)	**$108**	*$36*	*$24*	*$50*	**$109**
	Steam ($ Millions, @$30/Mlb)	**N/A**	*$14*	*$4*	*$10*	**$29**
Annual Additional Value	Increased Reliability	**$9**	*$3*	*$2*	*$4*	**$9**
	GHG Reductions (Social Benefit)	**$3**	*$1*	*$1*	*$1*	**$3**
Total Annual Value	Annual Value at 25% of potential market	**$30**	*$13*	*$8*	*$16*	**$37**
	Annual Value at 50% of potential market	**$60**	*$27*	*$15*	*$33*	**$75**
	Total Annual Value of Technical Potential	**$119**	*$54*	*$31*	*$65*	**$150**

III. Tiered Scenarios

This analysis estimates potential revenues for expanding both the services offered and the HOTD customer base. This can be accomplished by: 1) re-using the existing distribution system to reach additional customers, and 2) supplying both existing and additional customers with electricity in addition to steam. We focused on properties that are directly "adjacent" to the existing distribution loop, and we also look at a separate group of owners that are "nearby" enough to economically connect.[1]

The revenue estimations provided in the summary table above rely on the following four categories of customers and the services provided to them:

Tier 1 – Existing Customers: Provide electricity to existing GSA customers in the Federal Government, to expand revenue and resilience, but no new thermal services.

Tier 2 – New Adjacent Customers: Provide both steam supply and electricity to non-GSA properties that are directly adjacent to the existing steam tunnels.[2]

Tier 3 – Economic Expansion: Extend steam supply to additional properties adjacent to buried steam lines and also extend electricity to properties nearby (within one block of) existing steam tunnels, as both groups likely can be economically served.

Tier 4 – Practical Expansion: Further extend steam supply to nearby properties (within a block of existing steam service, whether through tunnels or buried lines) and also extend electricity to properties adjacent to and nearby buried lines (as opposed to tunnels). This tier of property owners can also be practically serviced, though initial investment costs for the extended distribution system would be higher.

Note: Scenarios 2 through 4 address the potential for serving new customers only, so the totals do not include existing HOTD customers (Scenario 1).

IV. Study Limitations

A) The building analysis in this study uses data from the District Department of Energy and Environment's benchmarking and disclosure program. Just under half of the total square footage accessible to the existing HOTD distribution system is reflected in this data set. For the buildings that did not report (or were not required to report) their data, the

[1] We define "nearby" buildings as being one street away from existing steam pipes, and exclude any buildings that have to cross more than one street.

[2] Technical potential under the phase 2 scenario includes steam consumption for the Watergate complex, which is already served by its own central steam plant. However, these numbers are small relative to the total opportunity, and the existing assets could potentially could become integrated into a larger system. Watergate represents at most 4% of the total and can be excluded or integrated into the system.

analysis assumes their load profile is similar to the benchmarked buildings. Future analyses should refine these findings further.

B) This analysis did not investigate practical considerations at the HOTD plant itself for implementing expanded services to a larger customer base. Additional analysis would be required to determine if the existing available space within the plant and its outdoor yards (including removal of obsolete infrastructure such as coal-related equipment) would be sufficient to install new generation equipment.

C) Similarly, additional engineering analysis would determine the feasibility of adding medium-voltage electrical cables to the existing steam tunnels. Visual inspection of the tunnels indicates available space with separation from the existing steam pipes, as shown in these representative photos:

D) This analysis addresses only the revenue portion of any potential future investment scenario. Capital and operating costs would clearly factor into decisions for public or private investment. However, with a given operating margin, the revenue estimates should provide a basis for order-of-magnitude estimates of the new capital investment which those revenues could sustain.

E) No loads or revenue estimates are provided for cooling services. Physical limitations of the existing tunnels may not permit the addition of chilled water distribution. Existing cooling distribution infrastructure was not examined, since all current HOTD chilled water service is provided through buried pipes (vs tunnels). New service areas, with newly installed distribution infrastructure that includes chilled water, could offer prime opportunities for additional revenues and for seasonal balance of thermal services.

F) Finally, this study did not consider additional potential for future expansion of distribution infrastructure to serve new development efforts, with electricity, steam, hot water, and/or chilled water. Such expansion may be especially relevant to the south of the HOTD plant and also deeper into downtown areas not currently reached by existing steam tunnels. There is strong potential for cogeneration, solar, and other resources to serve sites throughout the service territory using this distribution infrastructure, which can add to future revenue opportunities.

V. Methodology & Assumptions

For this initial phase of analysis, a bottom-up GIS study resulted in estimated potential revenues for steam and electricity from serving new customers relying solely on existing distribution infrastructure. This data was drawn from the District Department of Energy and Environment's Energy Benchmarking dataset for 2014, refined under the DC Comprehensive Energy Plan contract, with additional analysis under this effort. The spatial analysis followed the following process to modify these data sets and derive the findings calculated here. The analysts:

1. Used GIS to identify every building in four categories: adjacent to the steam distribution system (both tunnels and buried lines) or nearby (crossing a maximum of one public street).

2. Added flags to the existing 2014 DC Energy Benchmarking database to represent buildings identified in the GIS analysis.

3. Summed kWh and therm consumption, converted to average MW and Mlb/hr loads.

4. Generated total square footage for additional GIS-identified buildings that have not reported benchmarking data (approximately 55% of the total square footage), broken down into the same four categories (adjacent and nearby to tunnels and buried lines).

5. Scaled total load estimates to include the non-benchmarked square footage, and finally,

6. Generated quantitative outputs:

   Total square footage, annual kWh and therms for all buildings not already HOTD customers that are a) adjacent to steam tunnels; and b) adjacent to buried steam pipes
   - Estimated greenhouse gas reduction associated with that level of kWh output
   - Estimated reliability value associated with that level of kW demand

Assumptions for Revenue Calculations:

To calculate annual revenue and total annual value of additional HOTD services, we used the following calculations and assumptions:

Calculated revenues assume a price of 11¢/kWh for electricity and $30/Mlb for steam. These are below regional utility prices of $13¢/kWh and the existing GSA price of $38/Mlb, respectively.

Reliability is defined as avoided cost of interrupted service. Average CAIDI and CAIFI assumptions for this region were translated into 6 hours of interrupted services, unevenly distributed over 2 events and then valued according to DOE's Interruption Cost Estimate Calculator.[3]

Greenhouse gas reduction social benefits are calculated using the following assumptions:

- Carbon reduction from cogeneration: 22%
- Cogeneration percentage of total: 65%
- Grid-power carbon intensity: 1100 lbs / MWh
- Social cost of carbon: $35 / ton

[3] Source: Table ES-1 in Michael J. Sullivan, Josh Schellenberg, and Marshall Blundell, "Updated Value of Service Reliability Estimates for Electric Utility Customers in the United States", Lawrence Berkeley National Laboratory, Report #LBNL-6941E, January 2015, p. xii