Open Windows
Getting to Energy Efficiency
in NYC Buildings

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Fellow, CUNY Institute for Urban Systems
The CUNY Building Performance Lab

• A serious* perspective on operational challenges in building performance and energy efficiency in NYC
• Industry collaboration with CUNY education and research
• Workforce development for building operations
• Seed-funded by NYSERDA

• serious -- seasoned, somewhat skeptical; informed by experience and practical knowledge
Our Open Carbon Window: Sticking a wedge into it

- Robert Socolow, Princeton physicist
- Conceptualize the challenge
- Divide the wedge into manageable segments
Our Open Carbon Window: What IS the connection between carbon and energy use?

\[ CH + O_2 \rightarrow CO_2 + H_2O + HEAT \]

- Fossil and biomass fuels are CH molecules. Combustion produces and releases CO2.
- Biomass made by photosynthetic uptake of CO2 from atmosphere, so its combustion is, to some extent, carbon neutral. Also the basis of “forestry-based sequestration.”
Our open carbon window: Sticking a wedge into it
The Biofuel Carbon Cycle

\[ \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{CH} + \text{O}_2 \]

**CARBON UPTAKE (PHOTOSYNTHESIS)**

**CROP ("BIOMASS")**

**PROCESSING TO FUEL**

**COMBUSTION**

\[ \text{CH} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{HEAT} \]

**CARBON RELEASED**

How much energy?
Our open carbon window: Sticking a wedge into it - **Energy Efficiency**

- The largest “soft-path” wedge, by far
- Many technologies
- Many actions

**Table 1.**
Potential carbon reductions (in MtC/yr in 2030) based on the middle of the range of carbon conversions.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Reductions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy efficiency</td>
<td>688</td>
</tr>
<tr>
<td>Concentrating solar power</td>
<td>63</td>
</tr>
<tr>
<td>Photovoltaics</td>
<td>63</td>
</tr>
<tr>
<td>Wind</td>
<td>181</td>
</tr>
<tr>
<td>Biofuels</td>
<td>58</td>
</tr>
<tr>
<td>Biomass</td>
<td>75</td>
</tr>
<tr>
<td>Geothermal</td>
<td>83</td>
</tr>
</tbody>
</table>
Our open carbon window: Sticking a wedge into it: Energy Efficiency

How EE gets brought to market

– Codes
  • Effects new construction and building systems at points of major renovation

– Standards, regulatory or voluntary
  • Effects especially appliances, mass-market equipment

– Projects
  • Direct marketing of cost-effective measures
The Bank Window

- Little work gets done without a source of money

- Energy Efficiency as the “Next Window” for investing in urban buildings ??
The Bank Window

• Projects Line Up for Capital

• Capital Lines Up for Projects
The Bank Window: Capital’s EE Opportunity

• Technology & Equipment Investment
  – New technologies and industries that will mfr it

• Project Finance
  – Getting EE technologies applied and installed

• Carbon Trading
  – Certifying and securitizing the impacts of projects
Capital’s EE Opportunity
Energy Project Finance

• High cost-effectiveness
  – 3-5 year simple paybacks = 20 - 30% ROI

• Multiple partners and cash flows
  – Owner - “shared-savings”, equipment benefits
  – Government, Utilities - incentives (subsidies)
  – Brokers and Traders

• Specialist firms to realize technical potential -- “ESCOs”
  – Energy Performance Contracts
  – Clinton Foundation model for C40 global large cities
Capital’s EE Opportunity
Energy Project Finance

How an Energy Performance Contract Works

• Invest in goods & services for a site that will realize energy savings

• Site pays for project financing (loan or lease) with (a part of) energy savings for a specified contract period

• Purchasing a future stream of (avoided) energy payments

• Performance Guarantee
Capital’s EE Opportunity
Energy Project Finance
How an Energy Performance Contract Works

**Base Case (no EPC)**

<table>
<thead>
<tr>
<th>Utility</th>
<th>energy</th>
<th>Client / Site</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$(1)$</td>
</tr>
</tbody>
</table>

$(1) > $(2) + $(3)$

**Energy Performance Contract**

<table>
<thead>
<tr>
<th>Utility</th>
<th>energy</th>
<th>Client / Site</th>
<th>ESCO</th>
<th>Energy-saving goods &amp; services</th>
<th>Finance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$(2)$</td>
<td></td>
<td>$(3)$</td>
<td>$-capital$</td>
</tr>
</tbody>
</table>

“Open Windows” M.Bobker Presentation 8/4/07
to Governor’s Island series on NYC Sustainability
Capital’s EE Opportunity
Project Finance & Performance Contracts

ESCO Performance Contract Process

- Energy Audit – identify and quantify opportunities
- Finance & Contract
- Design & Install
- Operate (who?)
- Monitor & Verify Performance - “IPMVP”
Capital’s EE Opportunity
Project Finance & Performance Contracts

What Kinds of Work

– Lighting
– Mechanical (HVAC) systems
– Controls
– CHP, Cogeneration, Heat Recovery
– Building Shells
– Renewables for final step towards “net zero”
NYC OPPORTUNITY (WINDOW OF) Key Facts

- 950,000 buildings
- $10 billion annual energy
  - Almost 2/3 of cost is for electricity
  - But electricity only about 1/2 of Carbon
    (because of nuclear, hydro, coal, gas mix)

(facts courtesy of NYC Mayor’s Office documents)
NYC OPPORTUNITY (WINDOW OF)

How is Energy Use Distributed?

<table>
<thead>
<tr>
<th>BUILDING TYPE</th>
<th>HEAT</th>
<th>HOT WATER</th>
<th>LIGHTING</th>
<th>APPLIANCES*</th>
<th>COOLING**</th>
<th>OTHER</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4 family residential</td>
<td>7.6%</td>
<td>2.6%</td>
<td>1.7%</td>
<td>2.2%</td>
<td>0.6%</td>
<td>0.0%</td>
<td>14.7%</td>
</tr>
<tr>
<td>Multi-family residential</td>
<td>7.4%</td>
<td>7.4%</td>
<td>3.0%</td>
<td>3.9%</td>
<td>1.2%</td>
<td>0.0%</td>
<td>22.0%</td>
</tr>
<tr>
<td>Commercial</td>
<td>8.5%</td>
<td>2.8%</td>
<td>10.2%</td>
<td>4.5%</td>
<td>4.5%</td>
<td>0.9%</td>
<td>31.4%</td>
</tr>
<tr>
<td>Industrial</td>
<td>2.6%</td>
<td>2.1%</td>
<td>4.0%</td>
<td>3.3%</td>
<td>1.1%</td>
<td>0.2%</td>
<td>13.0%</td>
</tr>
<tr>
<td>Institutional/government</td>
<td>6.3%</td>
<td>4.0%</td>
<td>3.6%</td>
<td>1.7%</td>
<td>1.4%</td>
<td>0.9%</td>
<td>17.9%</td>
</tr>
<tr>
<td>ALL TYPES</td>
<td>32.4%</td>
<td>18.9%</td>
<td>22.5%</td>
<td>15.6%</td>
<td>8.8%</td>
<td>2.0%</td>
<td>100%</td>
</tr>
</tbody>
</table>

*Appliances include electronics and refrigerators as well as other appliances
**Cooling includes ventilation as well as air conditioning

Source: Con Edison; KeySpan; U.S. Department of Energy; New York State Energy Research and Development Authority
NYC OPPORTUNITY (WINDOW OF) Projected Growth

- Not static picture
- Greatest growth in electricity

Figure 4. New York City citywide CO2e emissions, showing compound annual growth rates for combustion vehicles, electricity, and heating fuels. A 0.91 percent CAGR assumes business-as-usual conditions.
NYC OPPORTUNITY (WINDOW OF) PlaNYC2030 “Wedge” targets

Figure 13. New York citywide CO\textsubscript{2}e emissions forecast and target.
NYC OPPORTUNITY (WINDOW OF)
Capital Requirement of the 2030 Wedge

Some back-of-envelope projecting
based on $10 billion NYC annual energy expense

30% savings at, say, a 5-year overall average payback = $15 billion market (capital required)

50% savings at, say, a 10-year overall average payback = $50 billion market (capital required)

Note, NYC proposing $80 million/year program for its municipal properties, about 10% of overall NYC energy expense
NYC OPPORTUNITY (WINDOW OF) PlaNYC2030 Sample Programs

<table>
<thead>
<tr>
<th>Key Area for Targeted Energy Efficiency Initiatives</th>
<th>After Information</th>
<th>Key Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key Area 1: Energy Efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enabling and increasing energy efficiency</td>
<td></td>
<td></td>
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<tr>
<td>Physical and technical enhancement</td>
<td></td>
<td></td>
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<tr>
<td>Requirement for energy efficiency</td>
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<tr>
<td>Potential to reduce energy efficiency</td>
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<td></td>
</tr>
<tr>
<td>Key Area 2: Commercial &amp; Industrial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upgrading and enhancing energy efficiency</td>
<td></td>
<td></td>
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<tr>
<td>Requirement for energy efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential to reduce energy efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Key Area 3: Residential</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upgrading and enhancing energy efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Requirement for energy efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential to reduce energy efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Key Area 4: Industrial &amp; Manufacturing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upgrading and enhancing energy efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Requirement for energy efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential to reduce energy efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Key Area 5: Renewable Energy</td>
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<tr>
<td>Upgrading and enhancing energy efficiency</td>
<td></td>
<td></td>
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<td>Potential to reduce energy efficiency</td>
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NYC OPPORTUNITY (WINDOW OF)

If the $$ and the Projects are there, isn’t EE a No-Brainer?

TWO WORDS:

“OPERATIONAL RISK”
The Final Window for Today
Operational Risk in Performance Contracts

• Is the project designed per intent?
• Is the project built as designed?
• Does the project perform as projected?
• Are savings maintained over time?
• Does anyone take the time to find out?
The Final Window for Today
Operational Risk in Performance Contracts

THE STORY OF THE OPEN WINDOWS

• From late 1970’s through 1980’s, virtually all NYC apartment building windows replaced
• How many of them stay open in winter?
• Why?
The Final Window for Today
Operational Risk in Performance Contracts

THE STORY OF VFD MOTOR CONTROLS

• Through the 1990’s, hundreds of large pump and fans had variable speed controls added.

• How many of them are actually varying motor speeds?

• Why?
The Final Window for Today
Operational Risk in Performance Contracts

HOW TO “KEEP THE WINDOWS CLOSED”?

• Understanding of adoptive behaviors in context of other priorities, metrics
  – Why do we chronically over-condition our buildings?

• Better feedback loops
  – better building conditions information
  – accountability for energy use

• Education and new skills
The Final Window for Today
Operational Risk in Performance Contracts

HOW TO “KEEP THE WINDOWS CLOSED”?  

• Must recognize the reality of operational “low-hanging fruit” and how to harvest it  
  – important experience documents significant program enhancement and reliability

• Capital will fail without inclusion of these management and manpower elements
Some extra slides on Carbon Markets
What is the source of EE’s perceived opportunity for capital?

• Derivative Market in Carbon
  – *Certified* carbon emissions reductions
  – Sell certificates -- additional source of revenues on top of energy savings

• Carbon Markets preferred to (carbon) tax
  – Kyoto Protocol - CDM
  – US - Local and Voluntary Markets
    • RGGI, Chicago CX
Out the Window?
Leakage & Hot Air in Carbon Markets

• Origin of the “hot air” concept under Kyoto trading – the case of Russia’s phantom CER’s
  – Illustrates “Baseline” as key. Difficulties in measuring energy reductions.

• Other kinds of “Leakage”
  – Additionality (free-ridership)
  – Persistence

• Certification Process