Decarbonizing buildings and cities: smart energy consumption planning is as important as energy consumption reduction

Chris Caerts (Research Activity Leader)
Energy Performance Contracting

• Barriers for deep renovations that achieve high emission reductions
  • Large *investment* and long *pay-back times*: >40yr ... >100yr
  • Uncertainty\lack of trust\ about projected savings
  • Complexity

✓ Performance Guarantees (energy consumption) by ESCO.
✓ Optionally financing by ESCO.

Source: BPIE
Active Building Energy Performance Contracting

- Barriers for deep renovations that achieve high emission reductions
  - Large *investment* and long *pay-back times*: >40yr ... >100yr
  - Uncertainty/lack of trust about projected savings
  - **Complexity**

- Increased focus on electrification and Demand Response value streams with performance guarantees.
- Increased focus on residential buildings.
- Extend to clusters of buildings: neighbourhoods, communities.
Active Building Energy Performance Contracting

Model flexibility, and from that forecast Demand Response Value streams (Implicit and Explicit Demand Response) … … so that performance guarantees can be given … … in a way that the operational performance can be compared with the guaranteed performance.
Active Building Energy Performance Modelling tool

Data

ABEPEM

Scenario Creation and Scenario-based Forecast Creation

Design and KPI Configuration

Energy Cost Cash Flow Calculation

Flex Model Creation

Financial/Economic KPI Calculation

Operational Measurements

Guarantee Assessment (applying IPMVP)
Flex Model creation and Energy Cost Cash Flow Calculation incl. DR Value Streams

- Template building database
- Modelica Digital Twin (white-box model)
- EPC Measures (Design)
- Scenarios, Forecasts
- Dynamic Thermal Behavioural Grey-box model
- Scenario-based Model-driven Optimization & Quantification
- IEA Annex 60 (IFC based automation)
- Building Measurement data
Example – reducing heating emissions by 40%

<table>
<thead>
<tr>
<th>Gas</th>
<th>Consumption</th>
<th>Carbon Intensity</th>
<th>Efficiency</th>
<th>Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18.000 kWh\textsubscript{th}</td>
<td>200g/kWh</td>
<td>~100%</td>
<td>3.600 kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-40%</td>
</tr>
<tr>
<td></td>
<td>30.000 kWh\textsubscript{th}</td>
<td>200g/kWh</td>
<td>~100%</td>
<td>6.000 kg</td>
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<tr>
<td>Heat-pump</td>
<td>Consumption</td>
<td>Carbon Intensity</td>
<td>Efficiency</td>
<td>Emissions</td>
</tr>
<tr>
<td></td>
<td>12.000 kWh\textsubscript{el} (30.000 kWh\textsubscript{th})</td>
<td>300g/kWh</td>
<td>~250%</td>
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<td>12.000 kWh\textsubscript{el} (30.000 kWh\textsubscript{th})</td>
<td>150g/kWh</td>
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<td>1.800 kg</td>
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-70%
Example – reducing heating emissions by 40%

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</tr>
<tr>
<td><strong>Emissions</strong></td>
<td>3.600 kg</td>
<td>3.600 kg → 1.800 kg</td>
</tr>
<tr>
<td><strong>Energy Cost</strong></td>
<td>1.260 €</td>
<td>3.203 €</td>
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**Energy Cost**

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<tr>
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## Adding PV and DR Active Control

### Gas - Baseline
- **Consumption**: 30,000 kWh
- **Emissions**: 6,000 kg
- **Energy Cost**: 2,100 €

### Gas - Renovation
- **Consumption**: 18,000 kWh
- **Emissions**: 3,600 kg
- **Energy Cost**: 1,260 €

### Heat-pump + Renovation
- **Consumption**: 9,600 kWh (24,000 kWh)
- **Emissions**: 2,880 kg
- **Energy Cost**: 2,562 €

### Heat-pump only
- **Consumption**: 12,000 kWh (30,000 kWh)
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### Add PV & Self-consumption optimization
- **Consumption**: 9,600 kWh
- **Emissions**: 2,314 kg - 1,222 kg (avoided emissions)
- **Energy Cost**: 971 €

### Add PV
<table>
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### Add PV & DR Active Control
- **3x less emissions!**

### Self-consumption, Dynamic prices, Energy Trading, Ancillary services, Congestion Management, …

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**Emission Targets Financial KPIs**

- Building Envelop measures
- Electrification and Demand Response

**Add PV & Self-consumption optimization**

- **No net metering**
  - **Consumption**: 9,600 kWh
  - **Emissions**: 1,955 - 863 kg (avoided emissions)
  - **Energy Cost**: 1,480 €

**3x less emissions!**

- **-61%**
- **(-82%)**

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**Self-consumption, Dynamic prices, Energy Trading, Ancillary services, Congestion Management, …**

- **-20%**
- **-52%**

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**Energy Cost**

- **-40%**
- **-40%**

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**-20%**

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**Heat-pump + Renovation**

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**3x less emissions!**

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- **(-82%)**
Take-aways

• Decarbonization: consuming less AND consuming smarter
  • electrification (carbon intensity) and DR active control (carbon intensity, price, incentives)
• Emission reductions and business case improves over time without additional investments:
  • Improving carbon intensity of electricity
  • Smaller price gap gas-electricity, and more dynamic electricity prices
  • More opportunities for and value from DR active control

• Active Building EPC concept / ABEPEM tool: optimal mix of building envelop measures and electrification with DR
  • Highest emission reduction for target investment and pay-back time
  • Lowest investment and shortest pay-back time for target emission reduction
• Energy Efficiency / reducing consumption is still important!
Thank you

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VITO/Energyville