Modelling different Thermal Energy Storage (TES) options in a TIMES model

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Agenda

Aim and objectives
TIMES_City_heat model
Case study
Modelling TES
Preliminary results
Aim

to improve understanding of how to model different types of TES technologies, i.e., existing vs. potential investments, centralized vs. decentralized, in TIMES-based energy models

Objectives

- to discuss different TES options
- to identify particularities of the TES options
- to learn how to “translate” these particularities into TIMES attributes
- to discuss the values these attributes can/should get
REFERENCE ENERGY SYSTEM

Linear optimization,
Techno-Economic,
Partial-Equilibrium,
Dynamic model:
- 12 (and 72) time-steps/year
- Looking 20-50 years ahead

Conversion
- District heating:
  - CHPs
  - HOBS
  - HPs
- Individual heating
  • Heat storage
    - incl. in the network
    - incl. in buildings

Transmission/Distribution
- DH grid
- Fuel infrastructure
- Electric grid (cap)

Demands (heating)
- Commercial buildings (COM)
  Specified per service Type
- Residential buildings (RSD)
  Specified per Building Type

Energy use by energy carrier, presented by:
- Time/Sector/sub-sector
- Mix of heating/cooling equipment (cent. vs. individ.)
- Generation and storage capacities

End-use tech-s:
- Total System Costs
- Running Costs
- Investment costs

Environmental
- GHG
- Air pollutants

Typical scenario assumptions
- Demand projection >30 years

Energy prices
- Import prices

Resources
- Renewables resources (pot)
- Imp restrictions

Policy
- Taxes/subs tec
- Targets

Environmental assumption
- High
- Medium
- Low

Techno-Economic Parameters (examples)
- Investment cost
- Fixed O&M costs
- Variable O&M costs
- Efficiency
- Availability factors
- Heat-to-Power ratio

Environmental Parameters
- Emission factors:
  - CO2, NOx, SO2
  - VOC, PM10, PM25...
- Sets of external costs:
  - High/Medium/Low
Studied case

• **City of Eskilstuna, Sweden**

• **70,000 inhabitants**

• **District Heating (DH) system**
  
  • DH provides 700 GWh/yr of heat
    
    • 65% of the total city’s heating demand
  
  • 90% of the heat is from biomass
  
  • a CHP plant and heat only boilers

• **Centralized hot water tank (900 MWh)**
### Existing Storage

<table>
<thead>
<tr>
<th>Sets</th>
<th>TechName</th>
<th>TechDesc</th>
<th>Comm-IN</th>
<th>Comm-OUT</th>
<th>CommGrp</th>
<th>STG_EFF</th>
<th>STG_LOSS</th>
<th>NCAP_AFC</th>
<th>NCAP_AF</th>
<th>STOCK~2015</th>
<th>STOCK~2050</th>
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</thead>
<tbody>
<tr>
<td>STS</td>
<td>STGHCENTES100</td>
<td>Network Thermal Energy Storage (NTES)</td>
<td></td>
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</tr>
</tbody>
</table>

| | | | | | | | | | | | |

### Ackumulator – storage

- **Name**: Vattumanen storage

| | | | | | | |

- 60
- 60
- 900
- 200
# Modelling of TES – Investments

## -FI_Process

<table>
<thead>
<tr>
<th>Sets</th>
<th>TechName</th>
<th>TechDesc</th>
<th>Tact</th>
<th>Tcap</th>
<th>Tslvl</th>
<th>PrimaryCG</th>
<th>Vintage</th>
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</thead>
<tbody>
<tr>
<td>I: Process Set Membership</td>
<td>Technology Name</td>
<td>Technology Description</td>
<td>Activity Unit</td>
<td>Capacity Unit</td>
<td>Timeslice</td>
<td>Operational Commodity Group</td>
<td>Vintage Tracking</td>
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<tr>
<td>STS</td>
<td>STGHCWLT101</td>
<td>Large Water Tanks (LWT)</td>
<td>TJ</td>
<td>TJ_a</td>
<td>DAYNITE</td>
<td>NRG</td>
<td></td>
</tr>
<tr>
<td>STS</td>
<td>STGHCSWT101</td>
<td>Small water Tanks (SWT)</td>
<td>TJ</td>
<td>TJ_a</td>
<td>DAYNITE</td>
<td>NRG</td>
<td></td>
</tr>
<tr>
<td>STG</td>
<td>STGHCUTES101</td>
<td>Underground Thermal Energy Storage (UTES)</td>
<td>TJ</td>
<td>TJ_a</td>
<td>SEASON</td>
<td>NRG</td>
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<tr>
<td>STG</td>
<td>STGRHABITES101</td>
<td>Buildings Thermal Energy Storage (BITES)</td>
<td>RHAPA</td>
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<td>DAYNITE</td>
<td>DEM</td>
<td></td>
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<tr>
<td>STG</td>
<td>STGRHABITES102</td>
<td>Buildings Thermal Energy Storage (BITES)</td>
<td>RHAPB</td>
<td>RHAPB</td>
<td>DAYNITE</td>
<td>DEM</td>
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</table>

## New Processes

<table>
<thead>
<tr>
<th>Sets</th>
<th>TechName</th>
<th>TechDesc</th>
<th>Comm-IN</th>
<th>Comm-OUT</th>
<th>CommGrp</th>
<th>START</th>
<th>STG_EFFECT</th>
<th>STG_LOSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>I: Process Set Membership</td>
<td>Technology Name</td>
<td>Technology Description</td>
<td>Input Commodity</td>
<td>Output Commodity</td>
<td>Group</td>
<td>Starting Year</td>
<td>Efficiency</td>
<td>Storage loss</td>
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<tr>
<td>STS</td>
<td>STGHCWLT101</td>
<td>Large Water Tanks (LWT)</td>
<td>HETHHP</td>
<td>HETHHP</td>
<td>DEM</td>
<td>2025</td>
<td>0.98</td>
<td>0.68</td>
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<tr>
<td>STS</td>
<td>STGHCSWT101</td>
<td>Small water Tanks (SWT)</td>
<td>HETHHP</td>
<td>HETHHP</td>
<td>DEM</td>
<td>2025</td>
<td>0.98</td>
<td>0.34</td>
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<td>STS</td>
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<td>Underground Thermal Energy Storage (UTES)</td>
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<td>2025</td>
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<td>0.53</td>
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<td>STG</td>
<td>STGRHABITES101</td>
<td>Buildings Thermal Energy Storage (BITES) - RHAPA</td>
<td>RHAPA</td>
<td>RHAPA</td>
<td>ACT</td>
<td>2025</td>
<td>1</td>
<td>0</td>
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<tr>
<td>STG</td>
<td>STGRHABITES102</td>
<td>Buildings Thermal Energy Storage (BITES) - RHAPB</td>
<td>RHAPB</td>
<td>RHAPB</td>
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<td>43.80</td>
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</table>

## Max capacity bound

<table>
<thead>
<tr>
<th>NCAP_AFC~DAYNITE</th>
<th>NCAP_AF~LO</th>
<th>CAP_BND<del>UP</del>2025</th>
<th>CAP_BND~0</th>
<th>Life</th>
<th>PRC_CAPACITY</th>
<th>INVCOST~2016</th>
<th>INVCOST~2050</th>
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</thead>
<tbody>
<tr>
<td>Max capacity bound start year</td>
<td>Max capacity bound I/E rule</td>
<td>Lifetime of Process</td>
<td>Capacity to Activity Factor</td>
<td>Investment Cost</td>
<td>Investment Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>k€/TJ_a</td>
<td>k€/MW</td>
<td>k€/TJ_a</td>
<td>k€/MW</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>40</td>
<td>1</td>
<td>823.6</td>
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<tr>
<td>0.0</td>
<td>0.0</td>
<td>20</td>
<td>1</td>
<td>113 889.9</td>
<td>113 889.9</td>
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<tr>
<td>1.0</td>
<td>25.0</td>
<td>5</td>
<td>50</td>
<td>31.54</td>
<td>31.54</td>
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<tr>
<td>0.8</td>
<td>0.0</td>
<td>1.2</td>
<td>1.2</td>
<td></td>
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</tr>
</tbody>
</table>

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*Source: Svenska Miljöinstitutet (SMI)*
PRELIMINARY RESULTS – sub-annual heat deliveries
PRELIMINARY RESULTS – import/export balance

Total system cost – 765 MlnEUR
Thank you!
## Thermal Energy Storage in TIMES

### Table 1. Assumed techno-economic parameters of the investigated TES technologies.

<table>
<thead>
<tr>
<th></th>
<th>Existing TES</th>
<th>Investment TES options</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unit</td>
<td>TES in DH network</td>
</tr>
<tr>
<td>Cycle efficiency</td>
<td>%</td>
<td>1</td>
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<tr>
<td>(inflow/outflow)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yearly losses</td>
<td>%</td>
<td>36.5*</td>
</tr>
<tr>
<td>Maximum inflow/outflow</td>
<td>MWh</td>
<td>5*</td>
</tr>
<tr>
<td>Lifetime</td>
<td>Yr</td>
<td>-</td>
</tr>
<tr>
<td>Investment cost</td>
<td>kEUR/TJ</td>
<td>-</td>
</tr>
<tr>
<td>Fixed O&amp;M cost</td>
<td>kEUR/TJ</td>
<td>-</td>
</tr>
</tbody>
</table>
Extra info – Electricity prices

El. price 2018
El. price 2030
El. price 2050