

# Demand-side options for system reserves

Balancing of variable production using dynamic demand on Bornholm

Edward James-Smith

Mikael Togeby

Ea Energy Analyses

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- Small consulting company with 12 fulltime employees, 6 students, 2 interns
- Commercial projects in Denmark, Nordic region, EU, IEA, Mauritius, South Africa and Canada
- Research projects in Denmark and Scandinavia
- Analyses of power systems, energy efficiency, energy economics
- Ea is interested in employing more students. Go to our web page, [www.eaea.dk](http://www.eaea.dk) for contact details

# What is the problem with wind turbines on Bornholm?

- Fluctuating production pattern of wind turbines
- No problem when connected to the large Scandinavian grid
- In islanding mode high penetration of wind turbines on Bornholm
- Can make frequency regulation difficult as other generating capacity cannot react quickly enough

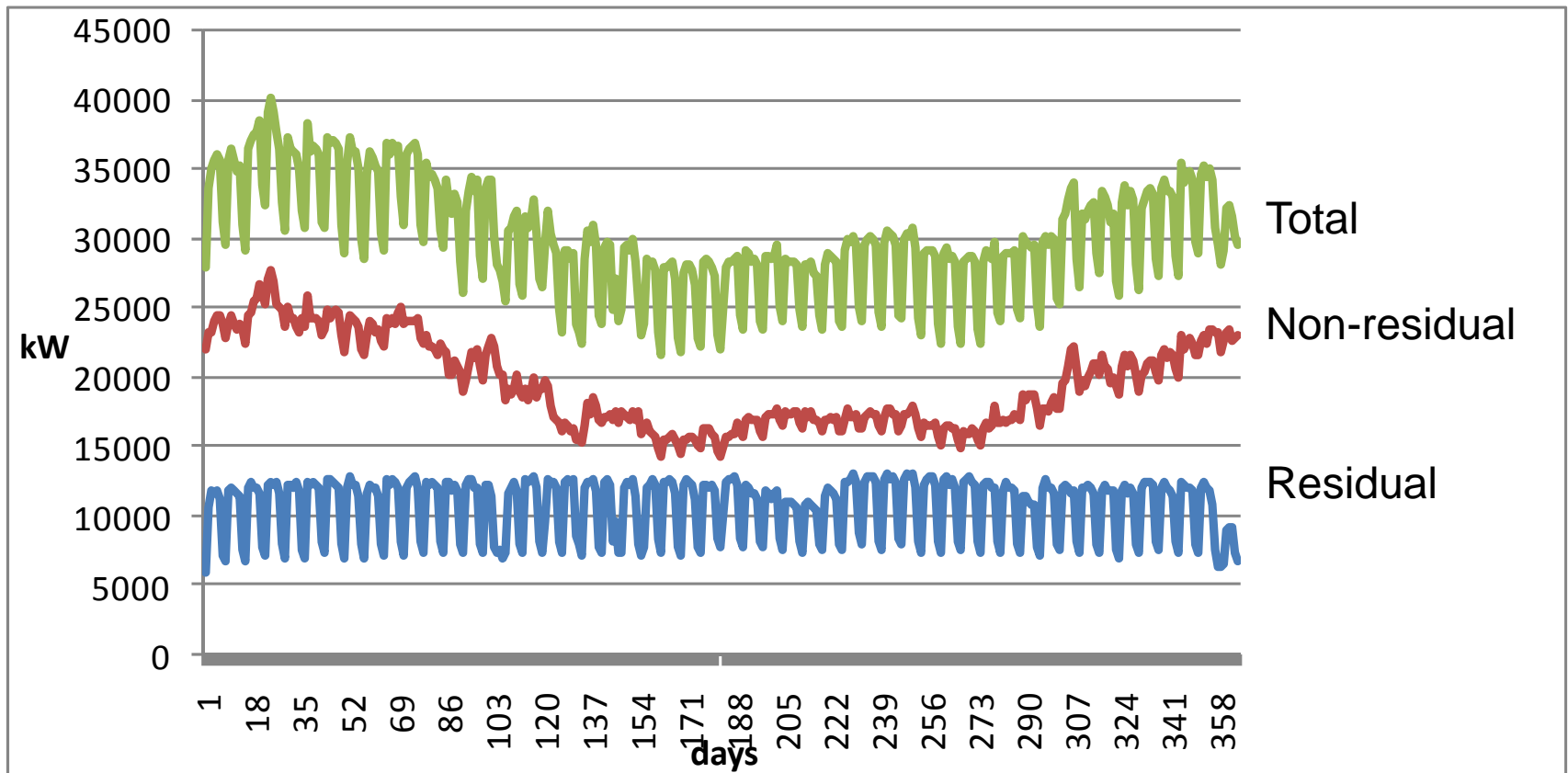
# Possible solutions

- Disconnect wind turbines
- Regulate wind turbines by reducing production
- Utilise demand to balance fluctuating production

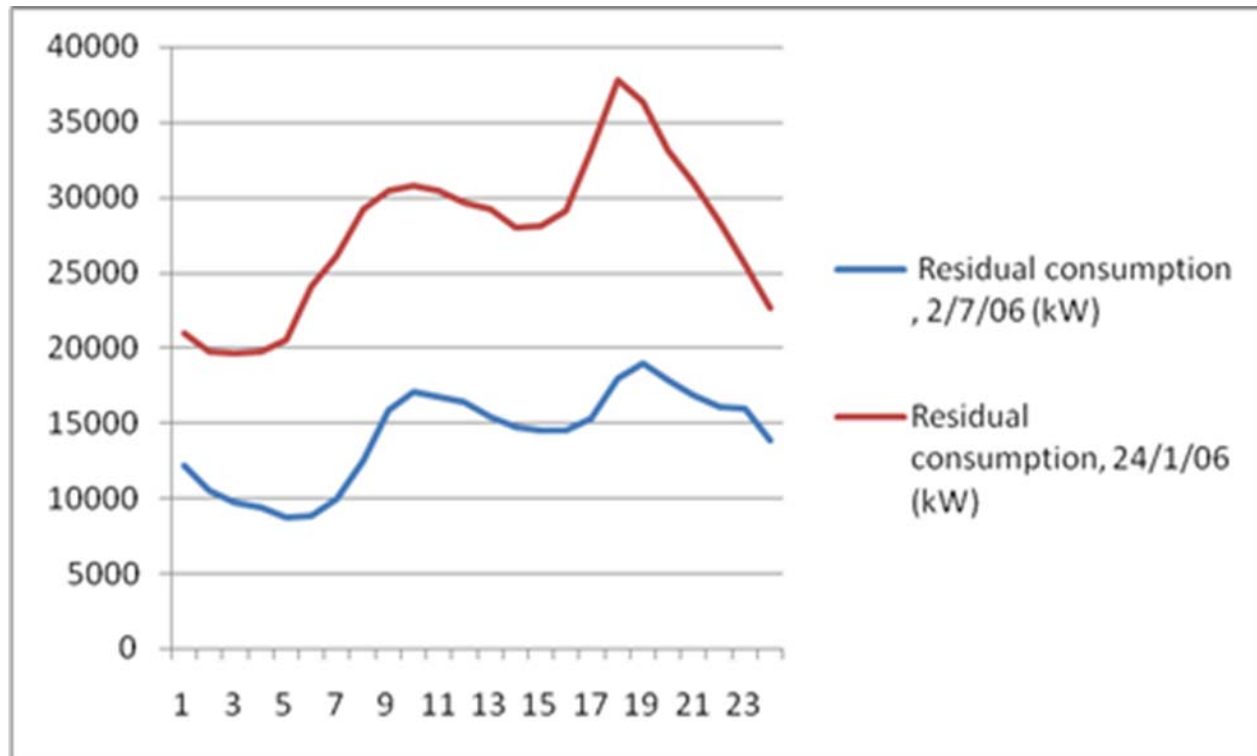
# Integration of fluctuating generation using coordinated control of demand and wind turbines

- If demand is used to balance variable production in islanding mode wind power can be utilised efficiently instead of being deactivated
- What demand capacity is available from electric heating on Bornholm?
- What is the relationship between temperature and demand for electric space heating?
- Can electric heating elements be useful for balancing frequency in islanding mode?

# Daily average consumption



# Residual consumption on a winter day compared to a summer day

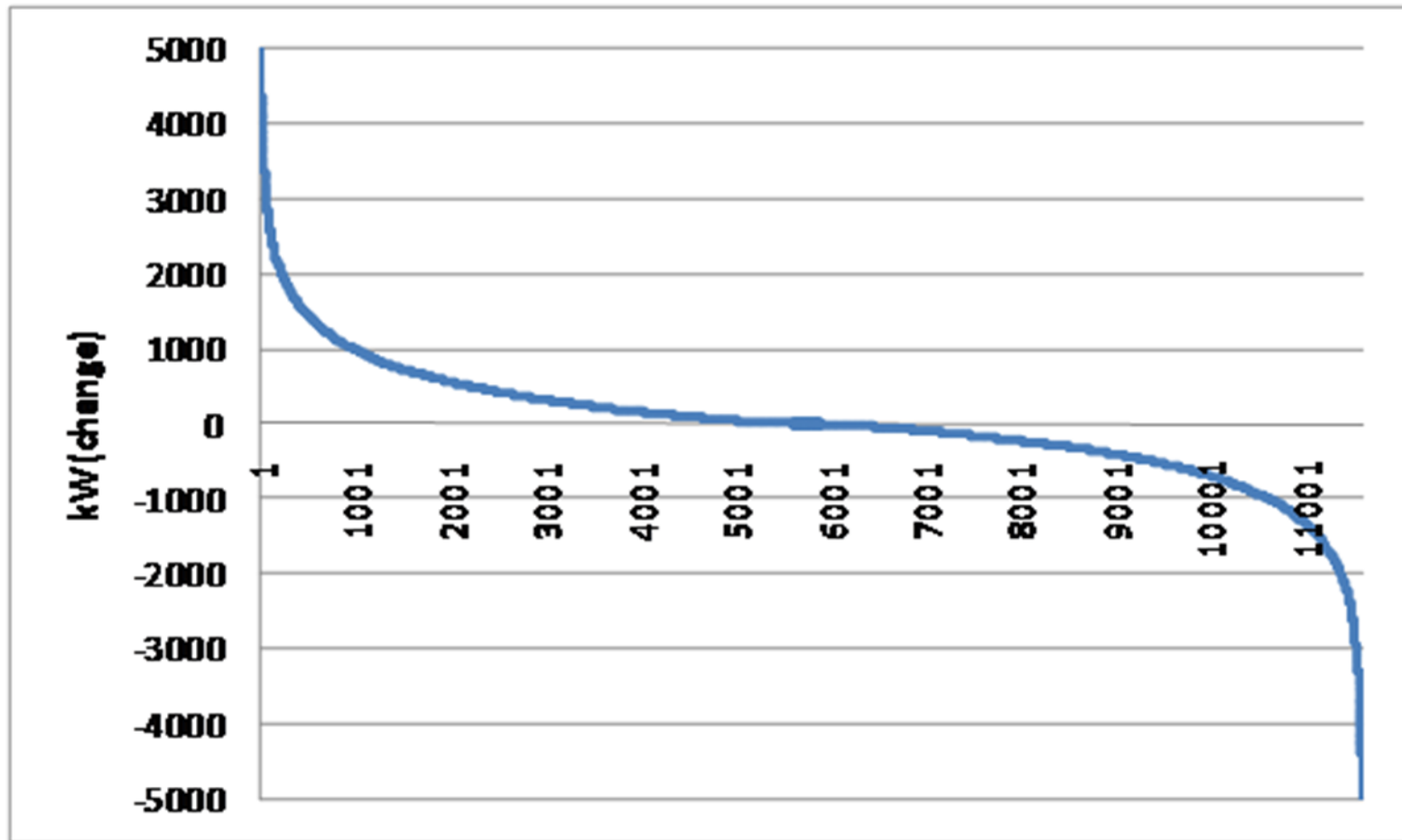


# Segments with electric heating

- 6,266 apartments, houses and weekend cottages with electric heating
  - 33.6 GWh/year in total
  - 18.2 GWh/year for heating
- 812 houses (13%) with electric heating with total consumption above 10,000 kWh/year
  - 11.1 GWh/year
  - 8.0 GWh/year for heating (43%)
    - 2.1 MW at 0°C
    - ~4 MW installed in households
    - Additional ~2 MW electric heating outside households



# Variation in wind power production on Bornholm over 4 months



15 out of all observation is outside the +/-5 MW range

# Utilising heating elements

- Are a few large or a number of small elements required on Bornholm? – dependent on wind production patterns
- Restrictions on activation of element capacity may reduce role of heating elements for frequency balancing in islanding mode
- Elements activated for very short continuous periods of time may have same effect as regulating at point of production as electric effect may be marginal
- If longer continuous periods of activation are norm, elements may be effective for balancing frequency and provide productive use of electric overflow

# Summing up

- 10 MW dump load at Nexø district heating network
  - Could deliver 2-3 MW instantly
  - 4.5 Mkr investment
- 812 households with electric heating have ~4 MW installed capacity
  - 2.1 MW used at 0°C
  - If investment is 5,000 kr. per unit: Total investment: 4.1 Mkr.