Energy efficiency study of industrial factories using time-series data analysis and thermal imaging

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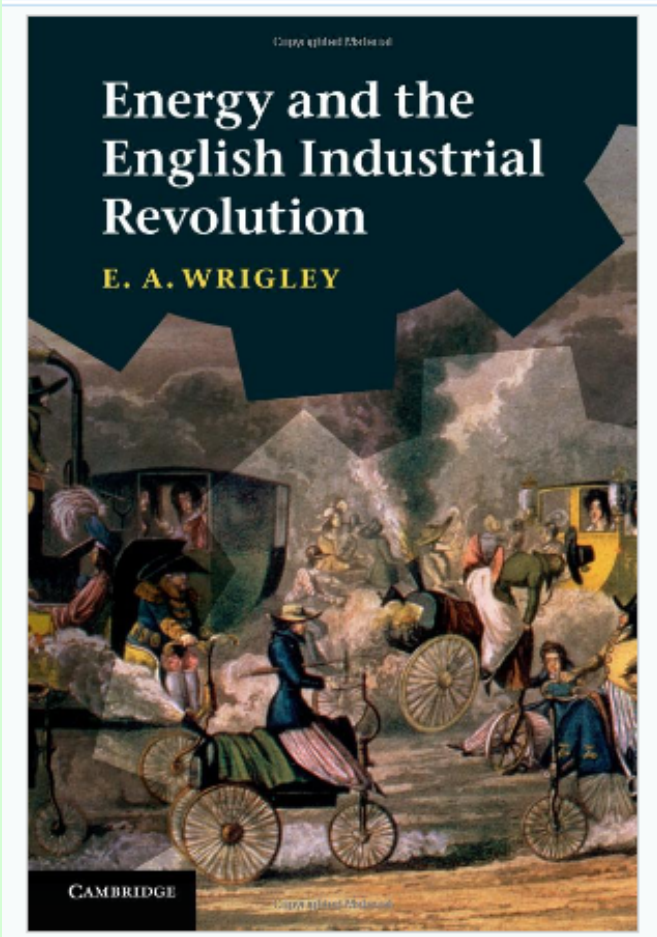
Energy and the English Industrial Revolution

- Many technical and energetic innovations through history that could have been revolutionary
- English industrial revolution was the first to be sustained
- What was special this time?
  - Using coal, we finally escaped constraint of limited land
  - Transition from fungible to consumptive economy
  - Can we reverse this transition?



EA Wrigley, 2010

Industry, energy and growth (after Wrigley, 2010)

- Coal miner consumes 3500 calories per day
  - Assume he digs 500 pounds coal per day
  - He produces 420 x energy value of his food
- Coal used in a steam engine ( =1%)
  - Engine output is 23 x miner's hard work input (digging)
  - Engine output is 3.3 x horse output (but a horse eats five times as much as miner!)
- Coal allowed the English economy to escape land constraint, but now we worry more about...
  - Energy Returned on Energy Invested (increasing price)
  - Greenhouse gas emissions (climate change)
  - Energy security

Policy context

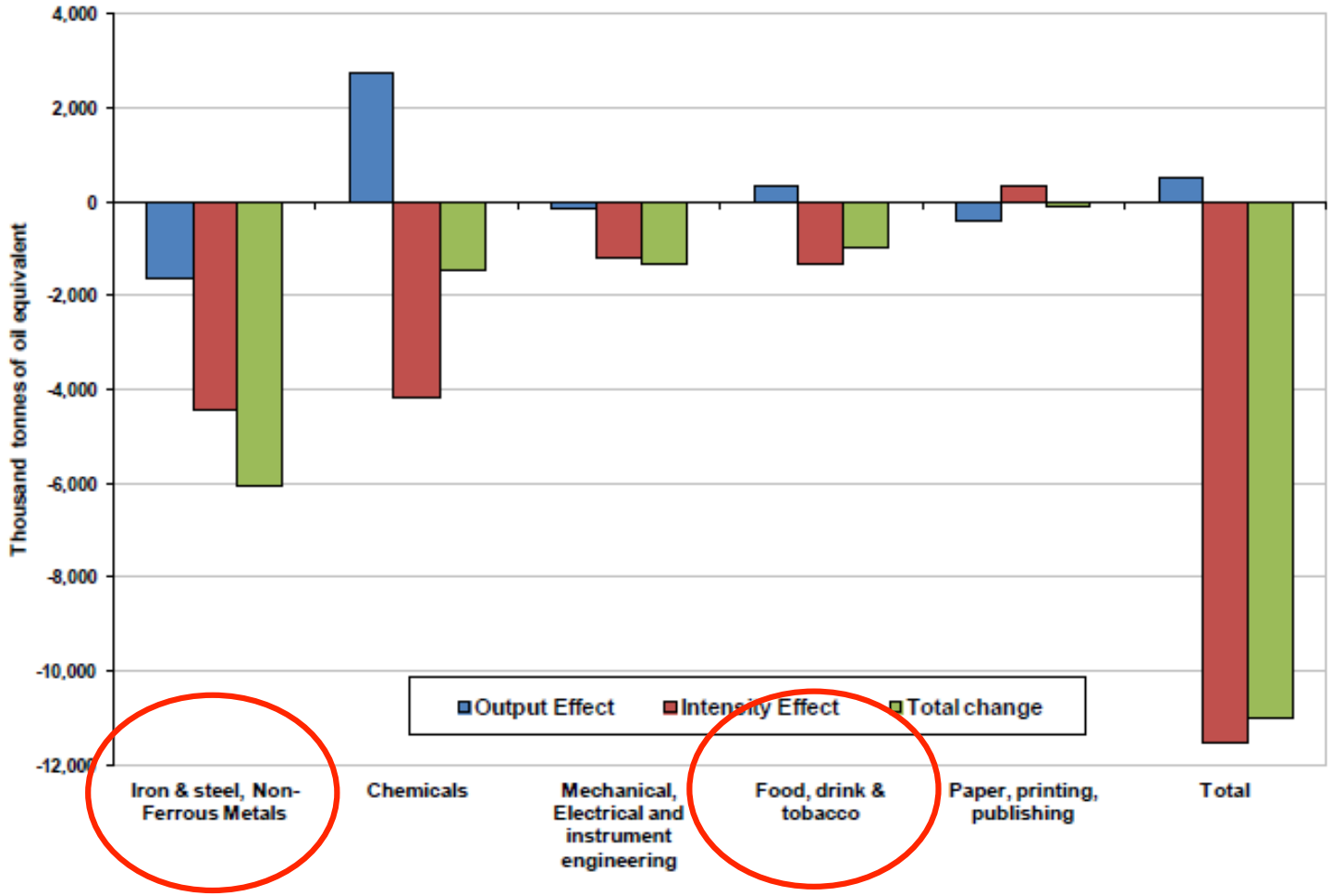
- UK government targets
  - 80% reduction in GHG by 2050 (w.r.t. 1990)
  - 34% reduction in GHG by 2020 (w.r.t. 1990)
- UK policy instruments
  - Carbon reduction commitment (CRC) energy efficiency scheme (install meters, publish energy data)
  - Climate change levy (carbon tax)
  - Climate change agreements (targets to reduce tax)
  - EU emissions trading scheme

UK industrial emissions (DECC, 2011)

- Significant decrease since 1990
  - Post-industrial economy (?)
  - Structure of industry
  - Outsourcing
  - Global recession
  - Efficiency gains

UK industrial energy use (DECC, 2011)

Chart 5: Factors affecting change in UK industrial energy use between 1990 and 2010



Source: DECC, ECUK Table 4.7

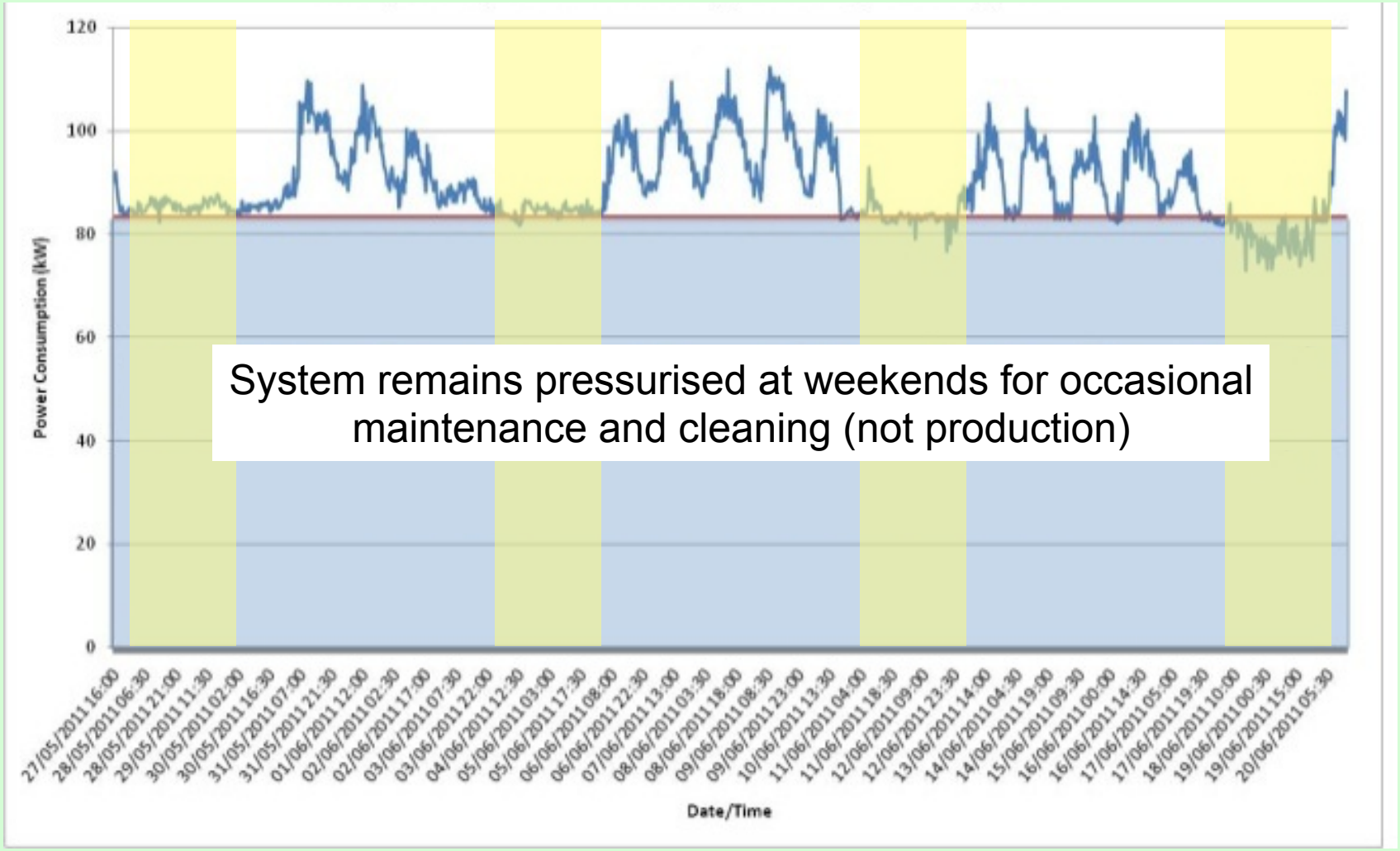
UK food industry

- Food and drink is largest manufacturing sector in UK (UKTI, 2012)
  - £76.2 bn turnover
  - Direct emissions of 152 MtCO2
- Low and medium temperature processes as well as chilling
- Many facilities heat and cool simultaneously
  - Heat pumps?
- Opportunity to use waste heat

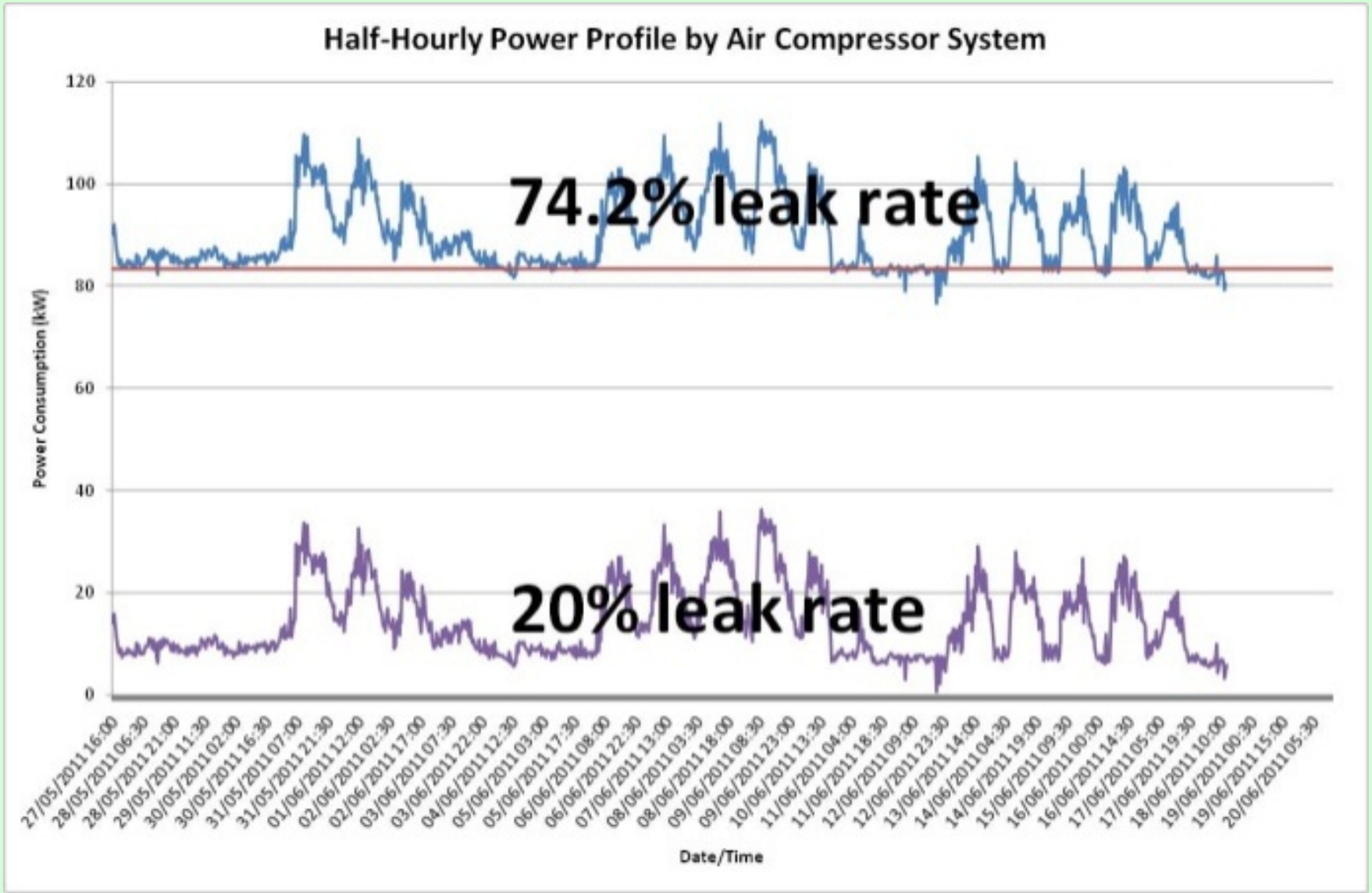
Company A – biscuit manufacturer

- Energy consumption in 2010 (half hourly data)
  - 6200 MWh electricity (cost of €545K)
  - 12,200 MWh gas (cost of €234K)
- No electrical sub-metering at time of study
- Study focused on compressed air and ovens
  - Compressed air represents 2% of food sector emissions (FDF, 2012)
  - Leakage means efficiency may be as low as 10%
  - Idling compressor may consume up to 70% of full load power (mainly due to leaks)
- Shop floor 'energy champion'

Compressed air use at Company A



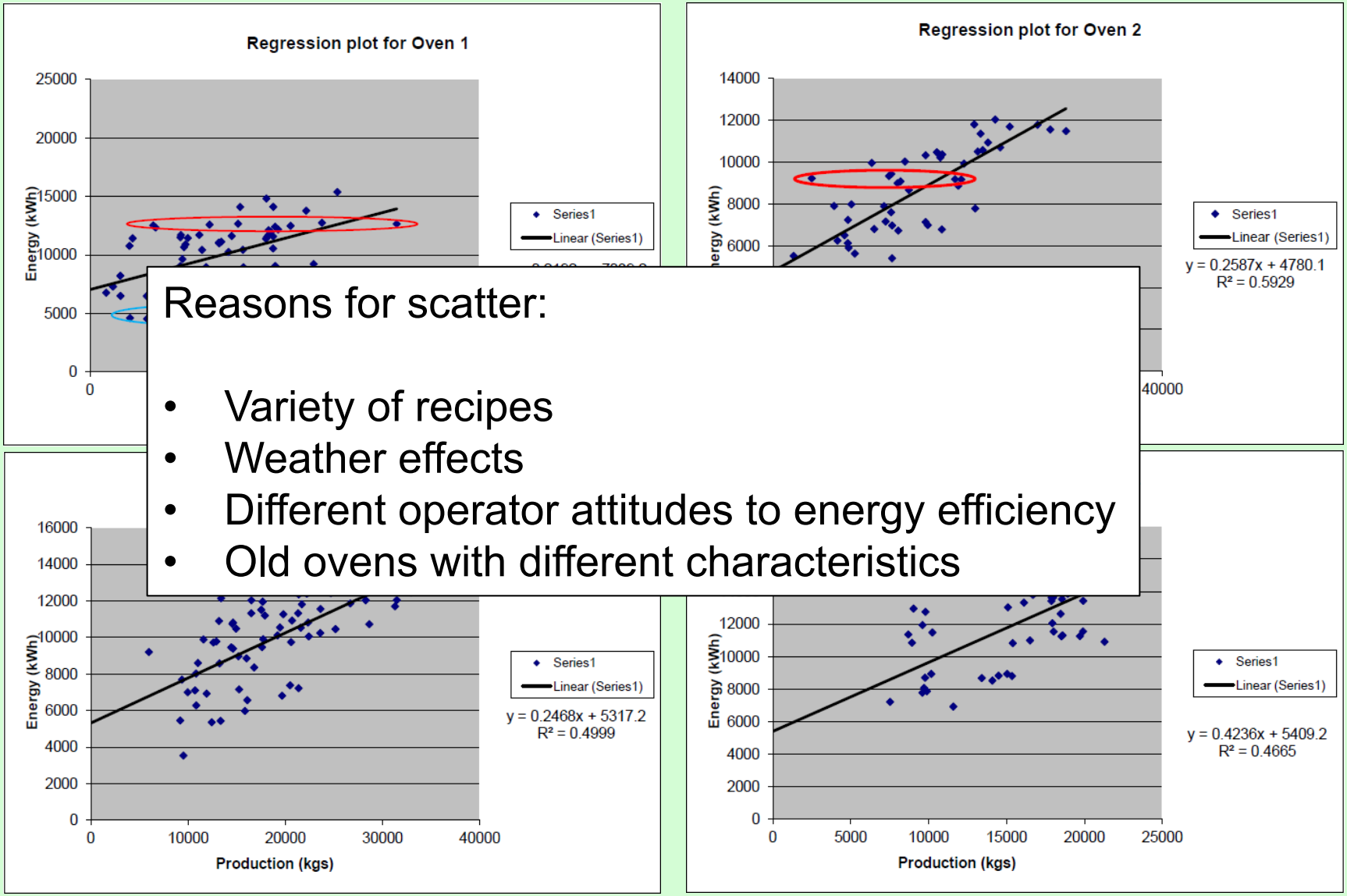
Compressed air leaks at Company A



Potential savings

- If study period is representative, then annual savings by power down could be 148 MWh
  - €13K per annum
  - Could be higher in reality, since true off-shift period is 18:00 on Friday to 06:00 Monday
- Company A had invested in time switches for compressor (cost €9.7K), but not used...
- Reducing leaks from 74% to Carbon Trust minimum of 20% would save €61K p.a.
- Company A had bought ultrasonic leak detectors, but not used ...

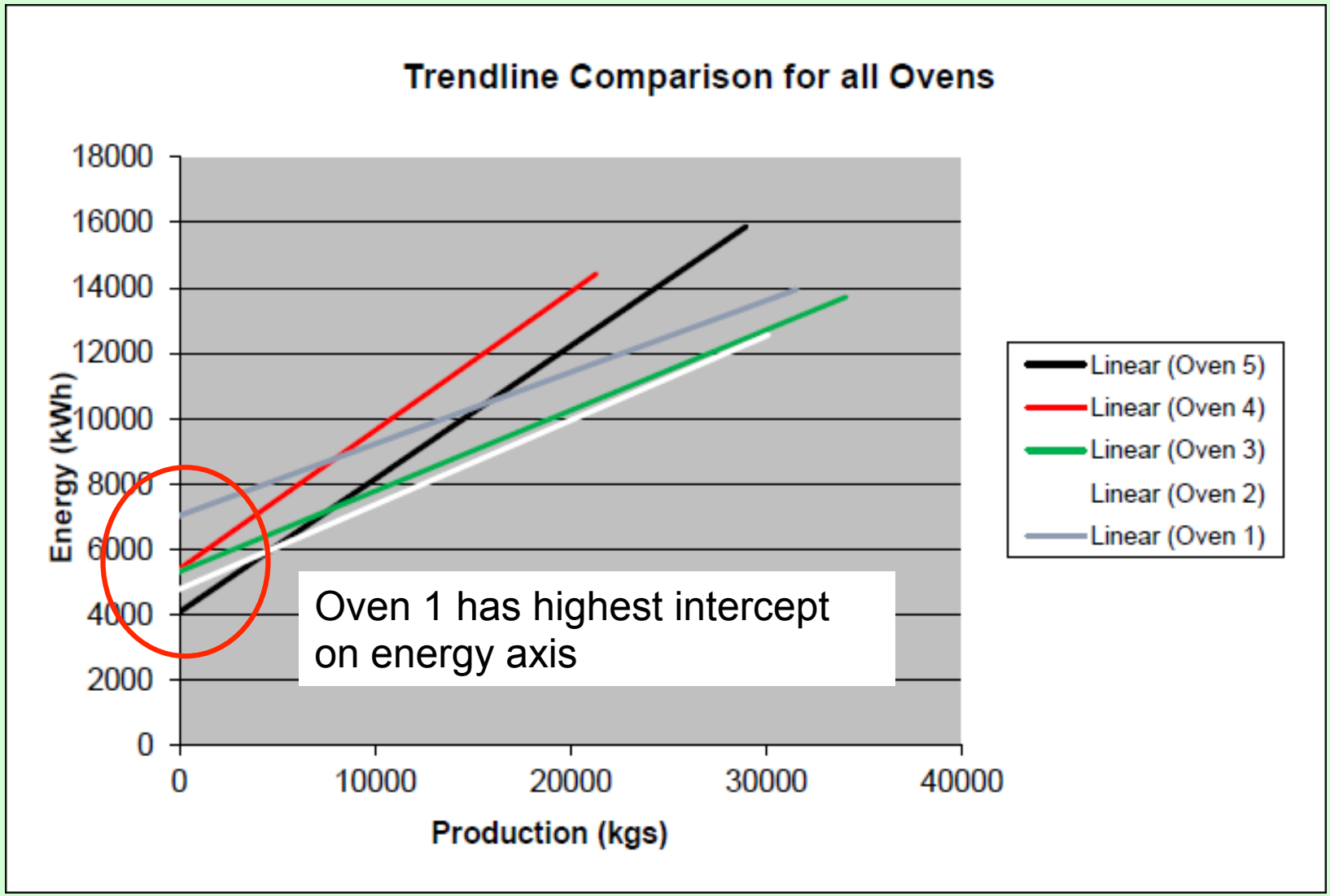
Gas use by ovens at Company A



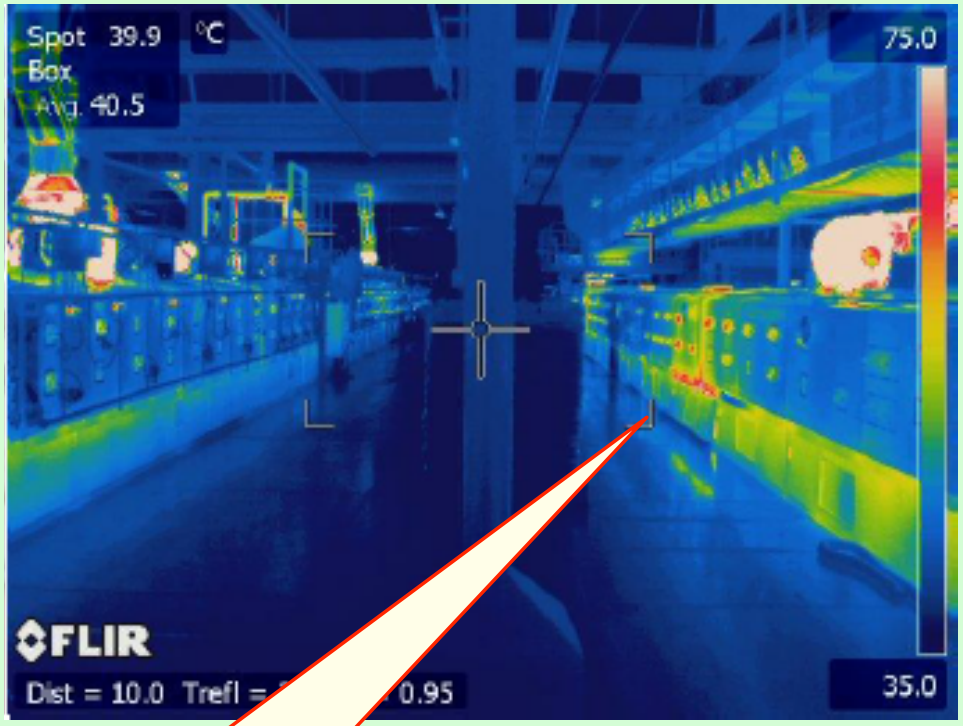
Reasons for scatter:

- Variety of recipes
- Weather effects
- Different operator attitudes to energy efficiency
- Old ovens with different characteristics

Comparison of gas ovens at Company A



Thermal image of gas ovens at Company A



Missing or damaged insulation

Foundry industry

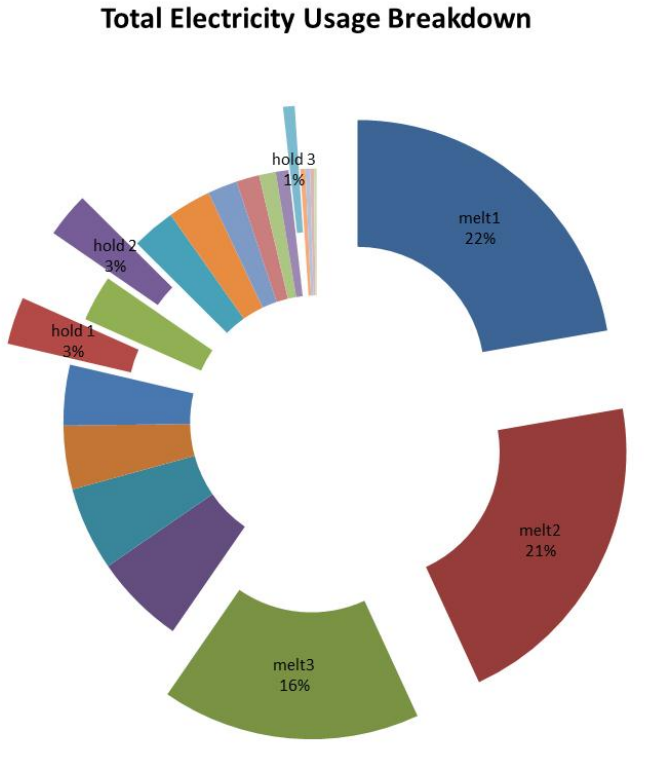
- Highly energy intensive sector
  - But small production volume compared to continuous casting
- Induction furnaces
  - Melting is ~55% of energy use
- Main charge is scrap metal
  - Carefully chosen alloys
  - Mixed with other materials to produce desired properties
- Company B specialises in austempered ductile iron (ADI) products
- Energy is part of S.H.E. Manager's role

Company B electrical energy data

- Half-hourly data from utility
  - Almost 10GWh in 2011 at cost of €1150
- Sub-metering on 23 circuits
  - Obsolete system was broken
  - First task was to fix it
- Analysis of historical data:
  - 839,526 kWh sub-metered
  - 872,184 kWh on fiscal meter
  - Difference of 4% represents average power of 36 kW

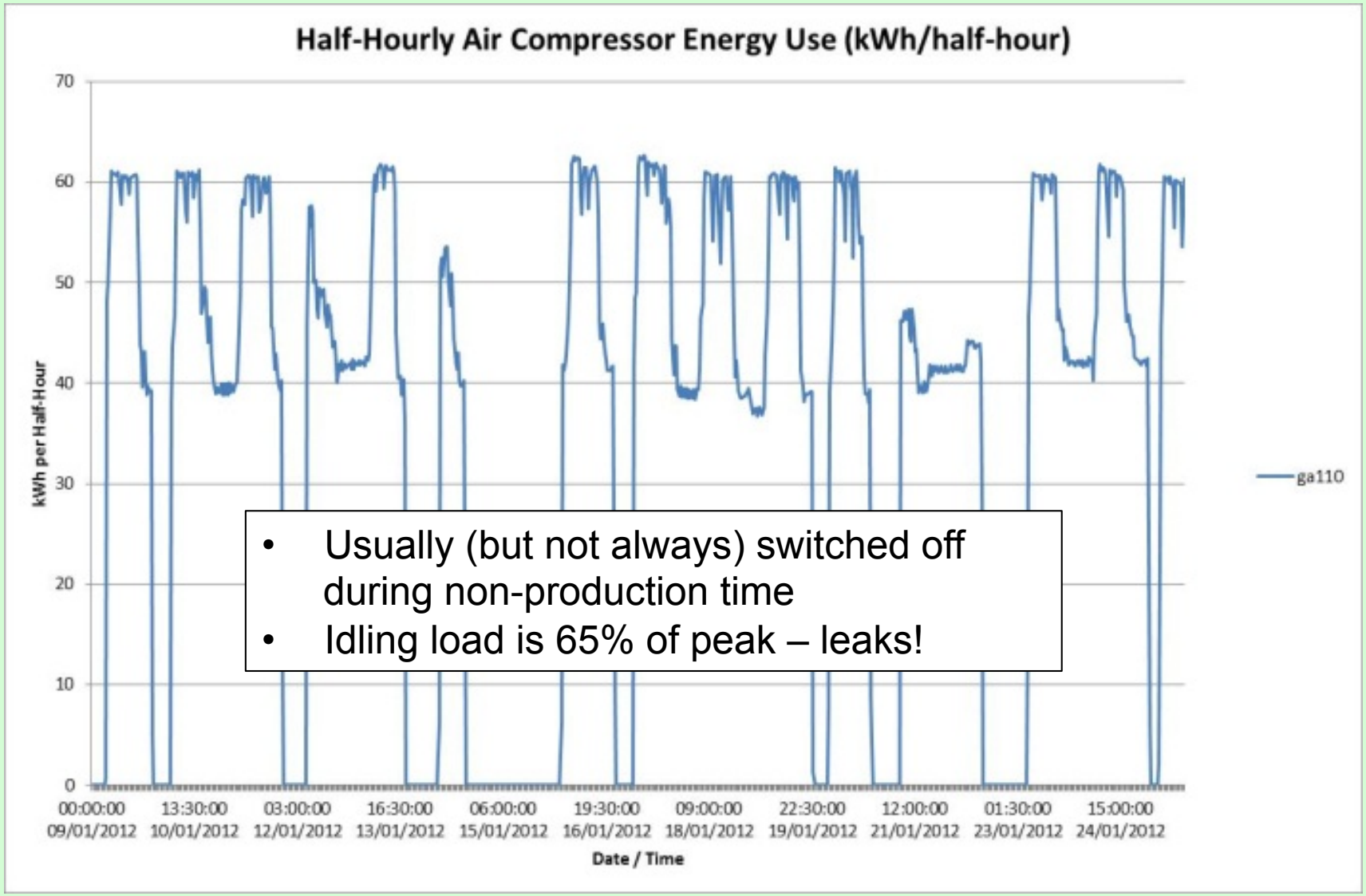
Analysis of electrical data at Company B

- Furnaces use most energy
  - 59% of total load to melt
  - 7% of total load to hold
- Typical for industry
  - Furnace upgrade not an option
  - Focused on other areas
- Remaining electrical load
  - Compressors (20% of non-melt)
  - Heat treatment (14%)
  - Input 22 (10%)
  - Hold 1,2,3, shot-blasting, fans, mould handling, etc.

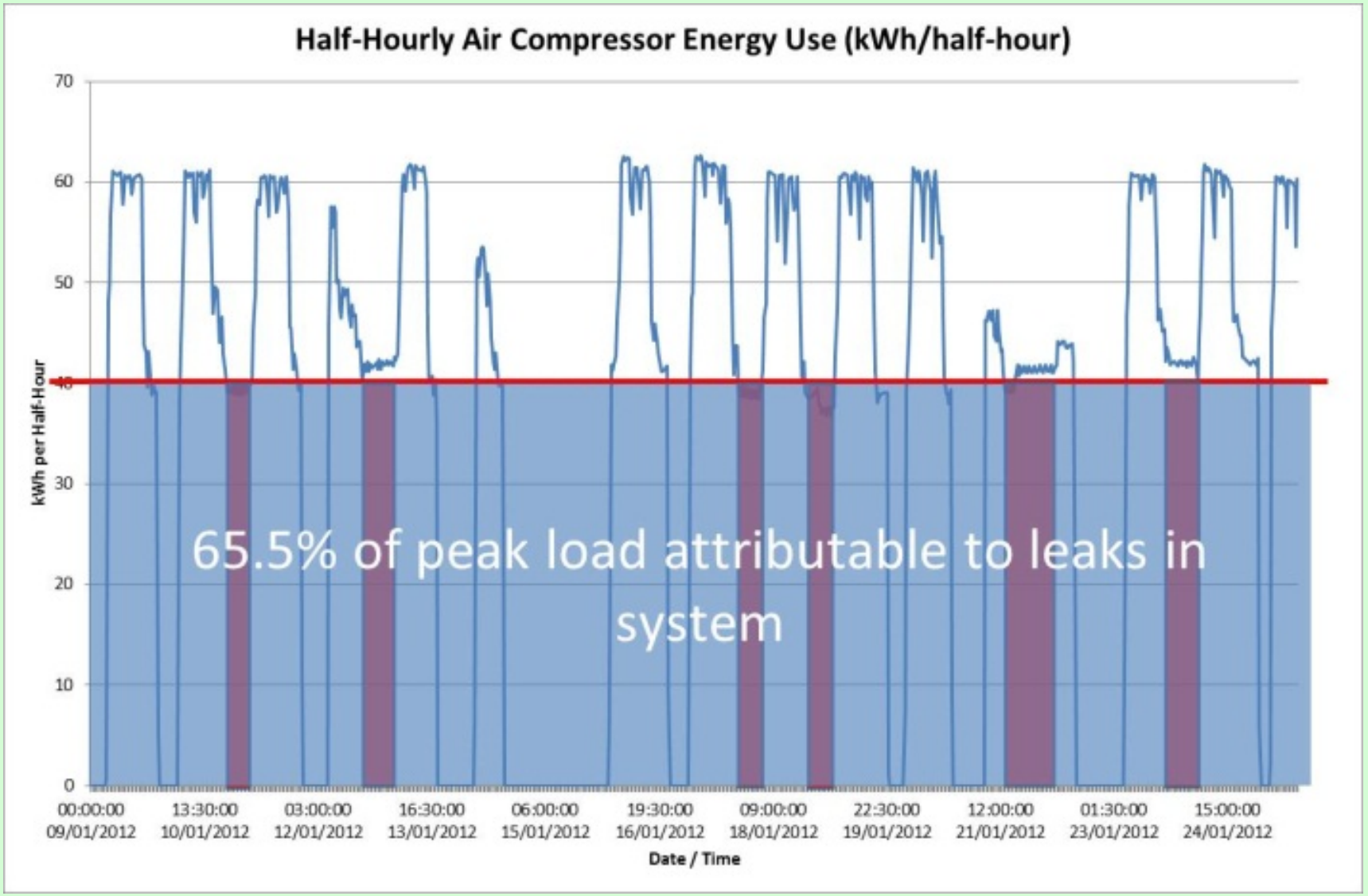


Melt, hold and remainder

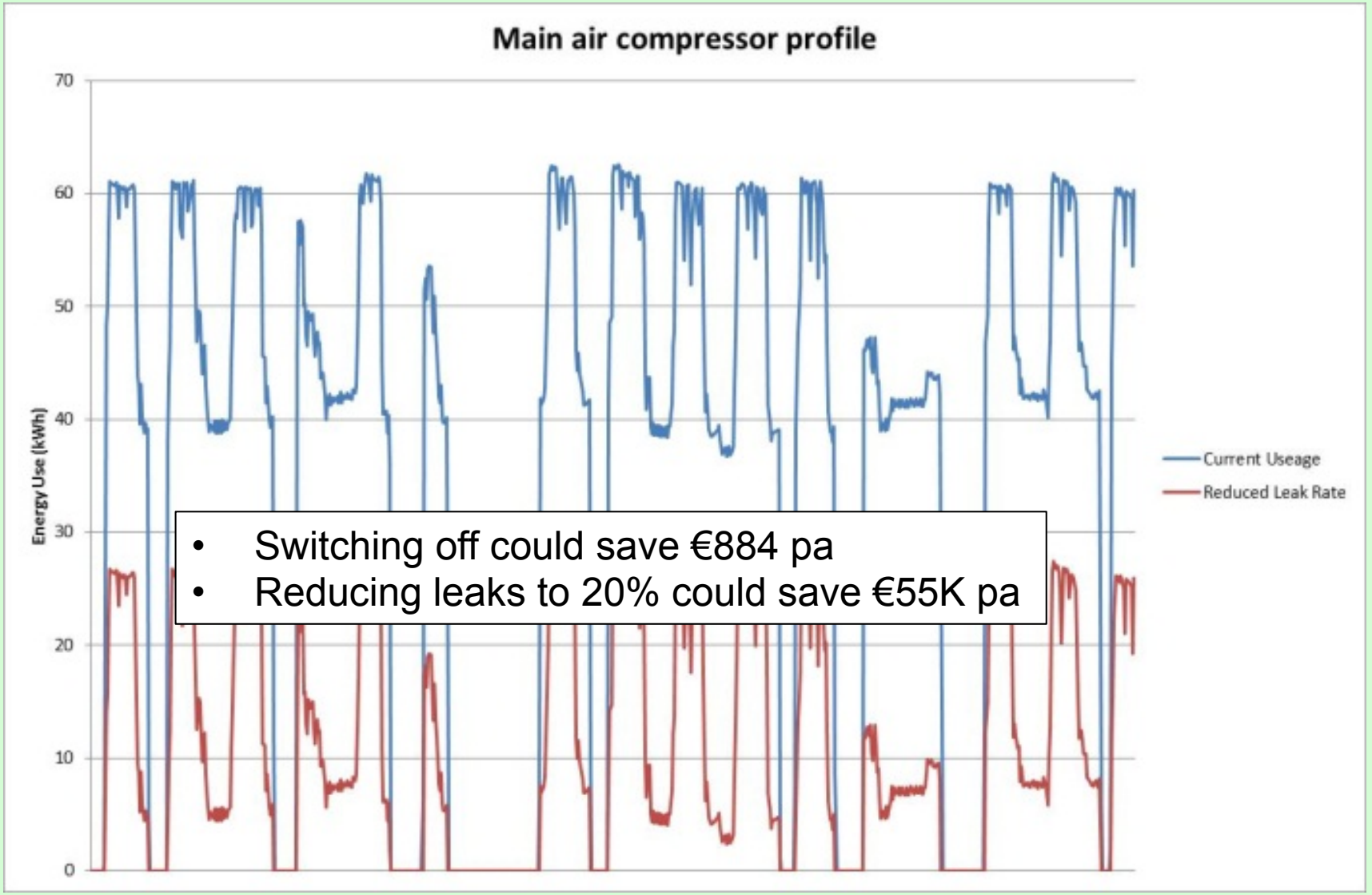
Compressed air use pattern at Company B



Compressed air leakage at Company B

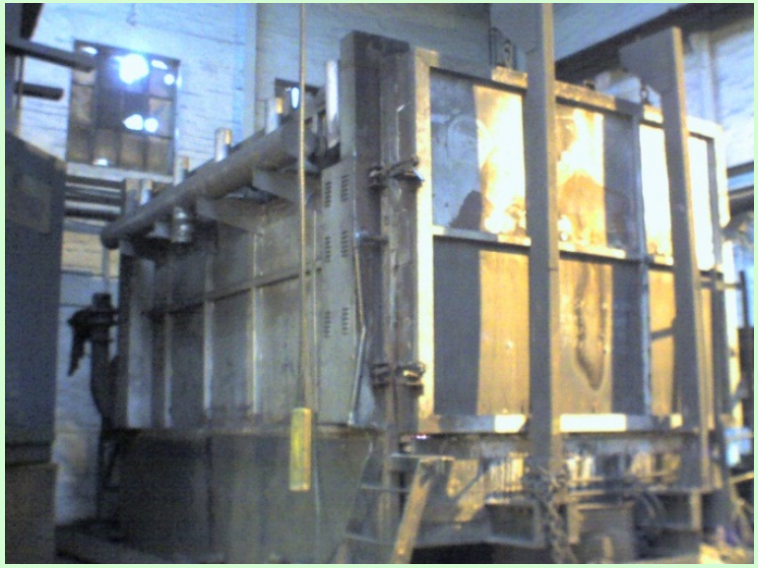


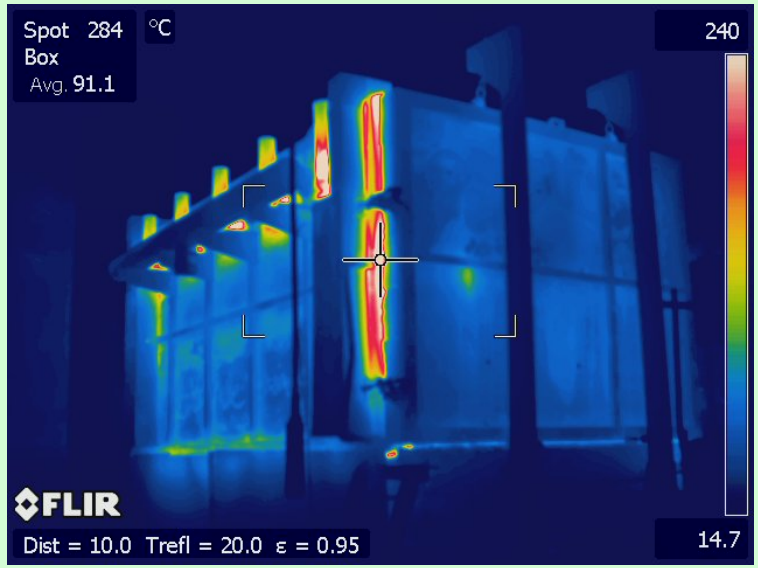
Reducing leakage at Company B



Thermal imaging at Company B

- Heat treatment oven used 6% of total energy
- Felt hot in factory...
- Thermal imaging used
  - Damaged or missing insulation
  - Faulty door seal
- Both had been suspected
  - Images gave powerful evidence





Conclusions

- Two different companies but:
  - Both companies need to improve maintenance and operation of compressed air systems
  - Neither had dedicated energy manager
  - Both had invested in energy management equipment that was either unused or faulty
- Managers at both were highly motivated to make financial savings:
  - Did not easily connect these with energy saving
- Little or no evidence of ‘energy awareness’ information on notice boards