Energy management for plastics processors
- Dr Robin Kent

Energy Management in Plastics Processing
Dr Robin Kent
Tangram Technology Ltd.

This is where we work:
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This is how long we have been doing this:

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The new words:

- Global warming.
- Greenhouse effect.
- Carbon management.
- Carbon footprint
- Sustainability.
- Life-cycle analysis.
- Corporate social responsibility.
- Stakeholders.
- Energy efficiency.
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The old word (and the most important)

Money

- I am not a ‘tree-hugger’.
- I am in this for the money.
- The new words are important but without the money none of us would be here.

We have saved companies:

- > 700,000,000 kWh
- > 361,000 tonnes of CO₂e
  @ 1 kWh = 0.45 kg CO₂e
  (*36,000 families. Average for Western world is 10 tonnes/year.)
- > €70,000,000
  (Conversion rate of 1 kWh = €0.10)

Which attracts your attention most?
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Energy use (kWh)

- Blow Moulding: 408,000,000 kWh
- Thermoforming: 867,000,000 kWh
- Molding: 95,000,000 kWh
- Others: 38,000,000 kWh

Netherlands

Total energy use: 4,339,000,000 kWh

Energy cost (€)

- Blow Moulding: €41,000,000
- Thermoforming: €77,000,000
- Molding: €9,000,000
- Others: €3,000,000
- Film Extrusion: €23,000,000

Netherlands

Total energy cost: €433,900,000
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- Carbon emissions (tonnes)
  - Blow Moulding, 202,861
  - Thermoforming, 421,896
  - Film Extrusion, 424,872
  - Other, 647,950

The future for world energy supplies

- It doesn't matter if you believe in ‘man-made global warming’.
- Motives don’t matter – survival does.
- Energy supplies are increasing precarious.
- Energy supply has driven major world political events and will drive more in the future.
EARTH FIRST!

We’ll drill the other planets later

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Energy management can:

- Reduce costs and improve profits.
- Improve competitiveness.
- Improve working conditions.
- Reduce carbon emissions and environmental impact.
- Reduce dependence on external energy sources.
- Reduce investment in generation capacity.
- Reduce the effect of new generation capacity.
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The two approaches:

- Reduce the cost of energy used through purchasing to reduce the £/kWh - a temporary fix.
- Reduce the amount of energy used through energy management to reduce the kWh/kg - a permanent fix.

The size of the gains

Energy costs can easily be reduced by up to 30%:

- Management - 10%
- Maintenance - 10%
- Technology - 10%

30% energy cost savings

What are you doing to control and reduce energy costs? Are you ready to ‘walk the walk’ instead of simply ‘talking the talk’ and ‘filling in the forms’?
How valuable are these savings?

Sales value of €1 saved by energy management

![Graph showing sales value vs. net margin](image)

It gets better!

- The cost of energy is rising faster than other costs.

Direct labour?

Energy?
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**How long does it take?**

- Management: 6-12 months
- Maintenance: 12-18 months
- Technology: 2-3 years

Typical results are 25-30% within 2 years but you have to be ready to ‘walk the walk’.
It will not happen if you simply want to ‘talk the talk’.

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**Starting out**

- Energy is now the second or third largest variable cost (and rising).
- Energy supplies are no longer assured and secure.
- Other countries and companies are already ahead of you.
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Where are our costs and where are our efforts?

**Our costs**

- Direct materials: 55%
- Overheads: 35%
- Direct labor: 10%

**Our efforts**

- 14%
- 10%
- 75%

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We have to change our model:

**Our real costs**

- Direct materials: 55%
- Overheads: 29%
- Direct energy: 6%
- Direct labor: 10%

**Our efforts**

- 14%
- 10%
- 75%

Energy use is controllable and variable
The barriers

- The fundamental disconnect:
  - Nobody needs approval to spend kWh
  - Everybody needs approval to save kWh

- The system does not reward energy saving because it is not allocated or accounted for.
- Energy usage is fixed and uncontrollable - therefore we will do nothing.
- There is no current method of assessment and performance management.

The simple questions:

- Do the time and resources allocated to control your energy costs reflect the relative spend?
- Do you spend any time or resources at all controlling energy usage?
- Who is responsible?

What is urgent is rarely important
What is important is rarely urgent (if it is then it is too late anyway)
This is not about lighting!

- Lighting: 5%
- Offices: 1%
- Heating: 2%
- Water pumps: 5%
- Chillers: 11%
- Compressors: 10%
- Polymer Processing: 66%

THE TOP TIPS
(proven actions and technologies)
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1. Energy management
   - Measurement leads to management but only if it is on the agenda.
   - Get the whole company involved by:
     - Setting a policy.
     - Making someone responsible.
     - Showing the results.
     - Rewarding the results.
     - Using the experience of the workforce.
     - Training the workforce.

2. Read the bills and the contracts
   - Read the bill and check it against the meters.
   - Monitor consumption and use the trends to save energy.
   - Look for reactive power charges and implement Power Factor correction if necessary.
   - Look for unexplained charges.
   - Always check the bill carefully.
   - Reduce Available Capacity and Maximum Demand.
3. Develop a site energy map

- Count the motors.
- Count the heaters.
- Count the lights.

The Energy Map gives the directions and targets for management and improvement.

4. Get the use numbers

- Put numbers on usage.
- Without information you are blind.
5. Start to measure and record

- Most of the key data is probably being measured already (or very easily available):
  - Energy used - preferably by sub-area.
  - Production volume - preferably by machine.
  - Operating hours - preferably by machine and service.
- Record the data and start to turn it into management information.

Data is not the same thing as information.

6. Report the results

- Create a simple report to show the key information.
- Publish the report monthly.
- Distribute the report widely.
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7. Billing data
   - Read the bill and check it against the meters.
   - Monitor consumption and use the trends to save energy.
   - Look for reactive power charges and implement Power Factor correction if necessary.

8. Calculate the base load and the process load

   Performance Characteristic Line (PCL)
   \[ \text{KWh} = 1.5751 \times \text{Production volume} + 152,440 \]
   \[ R^2 = 0.9397 \]
9. Calculate the base load and the process load

- The equation is the Performance Characteristic Line (PCL). For the example:
  \[ \text{kWh} = 1.5751 \times \text{Production volume} + 152,440 \]

This shows:

- The factory has a ‘base load’ of 152,440 kWh/month. This means it costs them €15,244 per month to open the doors (@ €0.10/Kwh).
- The factory has a ‘process load’ of 1.5751 kWh/kg. This means it costs €0.157 to process every kg of material.

10. Calculate the base load and the process load

- The equation is the Performance Characteristic Line (PCL). For the example:
  \[ \text{kWh} = 1.1245 \times \text{Production volume} + 124,422 \]

This shows:

- The factory has a ‘base load’ of 124,422 kWh/month. This means it costs them €12,442 per month to open the doors (@ €0.10/Kwh).
- The factory has a ‘process load’ of 1.1245 kWh/kg. This means it costs €0.1245 to process every kg of material.
11. Monitor performance

<table>
<thead>
<tr>
<th>Production volume (kg)</th>
<th>Predicted energy use (kWh)</th>
<th>Predicted cost (£/month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>152,440</td>
<td>152,440</td>
</tr>
<tr>
<td>50,000</td>
<td>231,195</td>
<td>231,195</td>
</tr>
<tr>
<td>100,000</td>
<td>309,950</td>
<td>309,950</td>
</tr>
<tr>
<td>150,000</td>
<td>388,705</td>
<td>38,870</td>
</tr>
<tr>
<td>200,000</td>
<td>467,460</td>
<td>46,746</td>
</tr>
<tr>
<td>250,000</td>
<td>546,215</td>
<td>54,622</td>
</tr>
<tr>
<td>300,000</td>
<td>624,970</td>
<td>62,497</td>
</tr>
<tr>
<td>350,000</td>
<td>703,725</td>
<td>70,373</td>
</tr>
<tr>
<td>400,000</td>
<td>782,480</td>
<td>78,248</td>
</tr>
</tbody>
</table>

Energy use is controllable and variable

12. Predict use from sales

<table>
<thead>
<tr>
<th>Month</th>
<th>Forecast production volume (kg)</th>
<th>Forecast energy use (kWh)</th>
<th>Forecast energy cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>150,000</td>
<td>388,705</td>
<td>£38,871</td>
</tr>
<tr>
<td>February</td>
<td>200,000</td>
<td>467,460</td>
<td>£46,746</td>
</tr>
<tr>
<td>March</td>
<td>250,000</td>
<td>546,215</td>
<td>£54,622</td>
</tr>
<tr>
<td>April</td>
<td>240,000</td>
<td>530,464</td>
<td>£53,046</td>
</tr>
<tr>
<td>May</td>
<td>235,000</td>
<td>522,589</td>
<td>£52,259</td>
</tr>
<tr>
<td>June</td>
<td>225,000</td>
<td>506,838</td>
<td>£50,684</td>
</tr>
<tr>
<td>July</td>
<td>235,000</td>
<td>522,589</td>
<td>£52,259</td>
</tr>
<tr>
<td>August</td>
<td>248,000</td>
<td>543,065</td>
<td>£54,307</td>
</tr>
<tr>
<td>September</td>
<td>267,000</td>
<td>572,992</td>
<td>£57,299</td>
</tr>
<tr>
<td>October</td>
<td>287,000</td>
<td>604,494</td>
<td>£60,449</td>
</tr>
<tr>
<td>November</td>
<td>210,000</td>
<td>483,211</td>
<td>£48,321</td>
</tr>
<tr>
<td>December</td>
<td>160,000</td>
<td>404,456</td>
<td>£40,446</td>
</tr>
<tr>
<td>Totals</td>
<td>2,707,000</td>
<td>6,093,076</td>
<td>£609,308</td>
</tr>
</tbody>
</table>
**13. Warning: kWh/kg is fatally flawed!**

Do not use kWh/kg as a short-term measure!

**14. Benchmark your site externally**
15. Benchmark your machines externally

![Graph showing SEC for injection moulding machines](image)

**Hydraulic machines**:
SEC = $14.45 \times \frac{\text{Production rate}}{1.79}$
Sample size: 223 machines.

**All-electric/hybrid machines**:
SEC = $3.41 \times \frac{\text{Production rate}}{0.58}$
Sample size: 25 machines.

16. Buy the right machines

- Buy energy efficient machines, services and systems. They may cost more but will pay back in the long term (and sometimes in the short term).
- Energy efficiency must be in the capital expenditure proposal.
- Energy efficiency must be part of the assessment procedure for all processing machines and ancillaries (dryers, chillers and compressors).
16 (cont). **Buy the right machines**

- The initial cost of a machine will be less than the cost of energy used during its lifetime.
- Use ‘whole life costing’ for new machines (include energy costs).
- New generation machines have improved energy efficiency.
- Get the right machine for the job.

17. **Motors**

- Minimise the demand and then optimise the supply.

Minimise the demand

- Step 1: Turn it off
- Step 2: Reduce the load at source
- Step 3: Reduce transmission losses

Optimise the supply

- Step 4: Improve the motor efficiency
- Step 5: Slow the motor down

Stage 1

Stage 2
18. Motors - Turn it off!

- The best way to save energy is to turn machines and ancillaries off when they are not needed.
- Shut down machines, conveyors, heaters and chillers when they are not being used.
- Link downstream machines to the main machine so that when the main machine is not operating then other machines are not operating too, e.g. sequence conveyors to the machine.
- Look for ‘hidden’ equipment such as regranulators!

Typical IMM energy use over the cycle
26 seconds cycle time
18 (cont). Motors - Turn it off!

- Only 5 - 10% of the energy used is input to the polymer, 90 - 95% is used to operate the machine.
- Machines will use between 52 and 97.5% of the running energy when idling.
19. Motors - Slow it down

- Use VSDs for fans & pumps.
- A.C drives are fixed speed. Slowing a motor down with a VSD saves money.
- Take a signal from the temperature or flow rate.

![Graph showing energy savings](image)

Decreasing the speed of an AC motor by 20% saves 49% of the energy.

19 (cont). Motors - Slow it down

- Compressors.
- Cooling tower fans.
- Chilled water pumps.
- Cooling water pumps.
- Exhaust fans.
- Vacuum pumps.
- Air handling units.
- Any other pump or fan.
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20. Insulate, insulate, insulate

- If it is hot to touch - it probably needs insulation.
  - Insulate hot surfaces to prevent heat losses.

- If it is cold to touch - it probably needs insulation.
  - Insulate cold surface to prevent heat gains.

21. Insulate hot surfaces

- Injection moulding machines
  - Barrels.
  - Tooling: from machine.
  - Tooling: from atmosphere.

- Extruders: areas forward of the screw tips
  - Dies
  - Transfer pipes.
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22. Insulate cold surfaces

- Chilled water piping.
- Cooling water piping.

23. Compressed air is not free

- Minimise the demand and then optimise the supply.
- Most of the cost of a compressor is in the energy it uses.

Minimise the demand

Step 1
Reduce leakage

Step 2
Reduce usage

Optimise the supply

Step 3
Reduce generation costs

Step 4
Reduce treatment costs

Step 5
Improve distribution

Stage 1
Stage 2
24. Reduce compressed air leakage

- 20-40% of compressed air is lost in leaks.
- Test the system to locate and seal the leaks.
- Use an ultrasonic tester to find leaks in a noisy factory.

25. Reduce compressed air use

- Look for poor use of compressed air:
  - Bowl feeders.
  - Product movement
  - Product ejection.
  - Cooling.
  - Air guns.
- Remove poor use of compressed air.
26. Reduce compressed air generation costs

- Reduce compressed air pressure:
  - Do not set the pressure at 7 – 8 bar because that is what you have always done?
  - Decrease the system pressure slowly until the minimum pressure is found.
  - Set the pressure at the minimum needed for the system.
- Reduce inlet air temperature.
- Make sure compressors are set correctly and operate to meet the demand.

27. Chilled water is not free

- Most of the cost of a chiller is in the energy it uses.
- Set up a chilled water management programme.
28. Reduce heat gains

- Insulate cold surfaces to prevent parasitic heat gain on chilled water piping.
- Increase flow temperature to get the same temperature at the point of use.
- A 1°C increase in set point will decrease the cost of operating a chiller by 3%.

29. Increase chilled water temperatures

- Increase the system set point slowly until the maximum temperature is found.
- A 1°C increase in set point will decrease the cost of operating a chiller by 3%.
30. Decrease cooling costs
- Air blast cooling as full or retro-fit for chilled water.
  - VSDs for cooling tower fans (motors).

31. Decrease distribution costs
- VSDs for chilled water pumps (motors).
- VSDs for cooling water pumps (motors).
32. Machine start up and settings

- Start up machines in the right sequence.
- Isolate machines that are not in use.
- Shut down machines and services when they are not productive.
- Use start up and shut down procedures.
- Adjustment of machines (to get more production) causes more lost time and energy than almost any other cause.
- Get machines set right, record the settings and do not change them unless absolutely necessary.

33. Auditing

- Start auditing today!
- Carry out an energy ‘walk-around’.
- Find hidden energy use!
- Look for energy use that not productive.
- Issue ‘Non-conformance Reports’ and police them.
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34. Staff training.

The signs are clear. The pressures are there. The only thing left is action.

You can save 30% of your energy usage and costs
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