Better ROI and Lower Emissions
– Smart Decisions Based on Energy Efficiency Facts
Reduce the Emissions and Improve Your OPEX –

Albert Bossart

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Today's world has many obligations; the energy consumption in general must be reduced, the emissions as per Kyoto protocol should be reduced to the 2005 level and there should be a shift from coal fired and nuclear power plants into renewable energy sources. Also the management in industry starts to request energy savings to compensate the high energy costs. Now, as by the end of 2011, the new ISO 50,001 Energy Management System shall be implemented for systematically saving the precious energy while reducing the greenhouse gas emissions. The world needs will soon be fundamentally changed. This ambitious goal must be achieved in less than 20 years. Each one of us is asked every day to save energy and resources and it all depends and starts with each human being.

For maintaining our quality of life and for the production of our goods we need electrical energy also in the future. We can not waste it as careless as we have done in the past.

The following presentation/article we will show ways in saving electrical energy in a sustainable way.

In most WtE (Waste to Energy) resp. Power Plants, between 6 to 20 % of the generated power never makes it beyond the plant gate and is consumed by its many pumps, fans and other auxiliary consumers. We will show you ways to reduce this house load consumption by 10 to 30 % while increasing the overall availability of your plant. These power savings are considered as real green energy and can be sold at premium rates while not having any impact on nature. No additional CO or NOX emissions will be produced – every saved kWh is green energy and every kWh sold will remarkably influence your balance sheets and pay the premium investment in a very short time.

We show you ways for your future investment decisions so you can fully benefit from this know how.

Every decision taker is requested to carefully specify his requirements for any new plant in respect of energy efficient transformers, motors, drives, etc. together with its proper sizing.
of all sub processes. Only when applying the modern integrative engineering approach, the plant achieves its planned high availability with lowest production costs. We show the important criteria and ways for selecting the right systems/equipment and which are the sustainable benefits for the operator of his plant.

1. Challenges in todays world

We are all aware that over the next 20 years the energy consumption will increase by another 30% to 50% while the CO₂ emissions must be drastically reduced and maintained at 1995 level. Only then the world will remain livable and human beings will not have to fear any harm and be safe. Even so today the technology is there, up to 80% of the energy is lost from its source (coal mine, oil/gas well, hydro or WtE (waste to energy) to its consumers. All our effort must be put into the amelioration and improvement of the production, transport and consumption.

By the end of 2011 the new ISO 50,001 Standard for the effective Energy Management will come into force. This will assure a high level of compatibility with the ISO 9,001 for Quality Management and ISO 14,001 for Environmental Management and will allow companies to save energy in a sustainable manner. These savings of energy will not only reduce operating costs and consumables, they are the easiest, fastest and most sustainable way to reduce the greenhouse gas emissions to the targeted 1995 level. The decarbonization of the power mix with carbon capture and incentives for renewable energy will not be enough to bring us back to that 1995 level as requested in the Kyoto protocol. So the society and industry must get forced to accept the benefits of implementing energy efficiency measure. The premium of the additional investments for the high quality energy efficient systems will be more than compensated with the much lower operating costs and reduced maintenance work.
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Figure 2: Contribution of different measures to cut CO₂ emissions
Quelle: IEA, World Energy Outlook 2009

All power plants, including WtE plants are not only generating electricity, but it are also a big energy consumer. Through the proper selection of the best in class equipment, together with careful sizing of the systems with an integrative engineering approach, the requirement of the houseload for the plants own consumption will vary massively. It can be in the range of 6 % to 20 % of the generated electricity. Assume, a reduction of 20 % or even 30 % of the own consumption can be achieved; this savings on energy will help all of us. Everybody will benefit on this savings:

- the plant operator needs less energy and can reduce his operating costs
- the plant operator can sell more energy to the Utility and increases his profits
- the Utility can sell this real green electrical energy for a premium to its consumers
- each saved kWh helps the environment with reduced CO₂ emissions

Let`s assume there is a WtE plant with a generator capacity of 15 MVAel. The houseload will be either at an optimized 8 % respectively 14 % for a not well engineered plant which is supposed to operate for 8,200 hours per year. With a 6 % better efficiency it shall be possible to sell an additional 900 kVA per hour resp. about 900 kWh per hour. With a remuneration of 10 Cents/kWh the customer is able to receive an additional 90 EUR per hour – or 738,000 EUR per year for the additional energy sold to the Utility.

Where can this potential with energy savings be tapped? In the following chapters detailed information about the relevant equipment/systems will be shared.

2  Transformers
3  CT & VT for Measurement and Protection
4  Motors & Drives
2. Transformers

The Utilities know that the installed transformers are big energy consumers because 2% of all electrical energy is lost in transformers. Therefore they keep a very close eye on the transformers in their distribution network. Standard transformers under normal working conditions in a utility network are in average loaded with only about 20% while transformers in factories or industrial sites are loaded with about 70%. Both situations have something in common, the so called No-Load Losses or Iron Losses occur anyway and with the same amount. No-Load Losses are there as soon as the transformer is energized and they make up about 0.6% of the transformer rating. When a transformer is loaded with less than 40% of its rating then the No-Load Losses are predominant. Above that loading, then the so called Load Losses, Short Circuit Losses or Copper Losses will heavily increase since they follow the Ohmsche Law (I^2 R) with the power of 2. At full load rating of the transformer then the No-Load Losses are almost negligible.

With state-of-the-art technology in transformer development, the losses can be remarkably reduced, both the No-Load Losses as well the Load Losses can be lowered. For a reduction of the Load Losses the manufacturer needs to use a better winding material with a bigger winding diameter and the windings needs a better arrangement and geometry. These improvements help to reduce the losses by 0.5-1.0%. ABB has developed a new sheet metal material with amorphous metal. The amorph metal is produced by rapid solidification from the liquid status while rolling it as a film or foil. The amorphous metal structure is therefore a snapshot of the disordered liquid structure at the moment of the solidification. The film/foil has only a thickness of about 25 µm, which is a big difference to a regular sheet metal. So far there is only a single global manufacturer for this amorphous metal.

This film/foil metal with its very disordered atomic structure requires only about a third of the energy for the magnetization of the transformer. This new material is a major breakthrough in distribution transformer application, especially for the low loaded transformers which are very common in utility networks. With this technology an efficiency rating of 99.5% can be achieved and this is very much appreciated by the Utilities.
With this knowledge it is possible to build high efficiency transformers for high power loading, like Resibloc$^{99\text{plus}}$ with an efficiency rating of about 99.2 % or the super efficiency transformer for all loading applications, like the EcoDry$^{\text{Ultra}}$ with an efficiency rating of about 99.5 %.

The EU is requesting today that the losses for all transformers must be reduced by 20 %, as per DIN 42523 or Cenelec HD 538. The mentioned Resibloc$^{99\text{plus}}$ and the EcoDry$^{\text{Ultra}}$ are exceeding these requirements by 30 % resp. more than 40 %. The new ISO 50’001 requirement will guide all users and investors into the same direction => to improve efficiency and save energy. Each not produced kWh will protect and save our environment while reducing the CO$_2$ emissions (1 kg CO$_2$ per 1 kWh).

The manufacturers of transformers are today producing 3 to 4 different quality grades of transformers. As previously mentioned, the main quality differences which are reflected in the efficiency rating of the equipment can be found in the Iron Core for the No-Load Losses (e-metal quality) and as well in the Windings for the Load Losses (winding diameter, arrangement/shape of coil, quality/purity of winding material). With relatively little additional costs on the equipment for the material and the assembly/handling, the efficiency rating on the transformers can be improved.

Utilities have developed some valuation tools for the quantification of the losses. With a rule of thumb they are able to pretty accurately evaluate the Total Cost of Ownership (TCO) for a transformer. When knowing the Load Losses or Short Circuit Losses (P$k$) and the No-Load losses or Iron Losses (P$o$) then we can quickly calculate the costs for the losses...
resp. the TCO. This simple rule of thumb is sufficient for a first view. If really needed there are complicated formulas to find out the costs for the losses more accurately by considering the Net Present Value (NPV). For this you find in the literature the A-factor which allows defining the costs for the No-Load Losses, respectively the B-factor for the Load Losses in EUR/Watt.

The A – factor (No-Load Loss capitalization factor) EUR/W

\[
A = \frac{8,760 \cdot d \cdot \left(\left(1+\frac{p}{100}\right)^n-1\right) \cdot 100}{\left(1+\frac{i}{100}\right)^n \cdot p}
\]

with

d = costs of energy and CO₂ of the customer in EUR/W

i = average annual inflation (%)

p = annual increase in energy cost rate (%)

n = expected life time of equipment (years)

The B – factor (Load Loss capitalization factor) EUR/kW

\[
B = \frac{l_{eqinit}^2 \cdot 8,760 \cdot d \cdot \left(\left(1+\frac{z}{100}\right)^2 \cdot \left(1+\frac{p}{100}\right)\right)^n - 1}{\left(1+\frac{i}{100}\right)^n \cdot \left(1+\frac{z}{100}\right)^2 \cdot \left(1+\frac{p}{100}\right) - 1}
\]

z = average increase in loading current per year (%)

l = average loading current in first year

TCO = Price + [A (EUR/W) • No-Load Loss (W)] + [B (EUR/W) • Load Loss (W)]

TCO = \(K_i + A \cdot P_o + B \cdot P_k\)

\(K_i\) = initial investment costs

\(P_o\) = No-Load Losses (W)

\(P_k\) = Load Losses (W)

Total Cost of Ownership (TCO) method takes future operating cost of a unit over its lifetime brought back into present day cost to be added to its purchase price to arrive at TCO. The TCO provides true economics where lower losses result in a cost avoidance derived from the elimination or deferral of generation and capacity additions.
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The following facts and figures will help understanding the principles of above complex formulas respectively the use of the thumb rule. We take again some assumptions from practice;

- loading factor of transformer with 20 % (Utility Distribution) and 70 % (Industry)
- life time of operations 25 years
- internal interest rate/discount factor 7 %
- sales price for electrical energy 0.1 EUR/kWh
- rated power of transformers 1 MVA

With above formulas we get the following A & B factors for the different transformer loadings

<table>
<thead>
<tr>
<th></th>
<th>20 % loading</th>
<th>70 % loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-factors (No-Load Losses)</td>
<td>11.3</td>
<td>11.3</td>
</tr>
<tr>
<td>B-factors (Load losses)</td>
<td>0.4</td>
<td>5.4</td>
</tr>
</tbody>
</table>

In a transformer data sheet or in a submitted offer we find the values for the losses of the different transformer types, with

\[
P_0 = \text{No-Load Losses} \\
P_k = \text{Load Losses at 100 % loading}
\]

For a first quick estimation of the capitalization costs of transformers there is a simple thumb rule. The indicated factors are valid for a distribution transformer in an industrial plant with 50 % – 70 % loading for an operating period of 25 years. Taking the difference of the losses of 2 transformers and then multiply it with the capitalization factor, then we find a first indication of what to expect.
Table 1: Capitalization costs for different 1 MVA transformers

<table>
<thead>
<tr>
<th>Average loading %</th>
<th>Einheit</th>
<th>Standard HD538</th>
<th>20</th>
<th>70</th>
<th>100</th>
<th>20</th>
<th>70</th>
<th>100</th>
<th>20</th>
<th>70</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Investment costs EUR</td>
<td>22,000.00</td>
<td>22,000.00</td>
<td>27,500.00</td>
<td>27,500.00</td>
<td>27,500.00</td>
<td>32,000.00</td>
<td>32,000.00</td>
<td>32,000.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No-Load Losses W</td>
<td>1,500</td>
<td>1,500</td>
<td>1,500</td>
<td>1,500</td>
<td>1,500</td>
<td>680</td>
<td>680</td>
<td>680</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>actual Load Losses at 75 °C W</td>
<td>350</td>
<td>4310</td>
<td>8,800</td>
<td>240</td>
<td>2,890</td>
<td>5,900</td>
<td>240</td>
<td>2,890</td>
<td>5,900</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total losses at 100 % loading W</td>
<td>10,300</td>
<td>10,300</td>
<td>10,300</td>
<td>7,400</td>
<td>7,400</td>
<td>7,400</td>
<td>6,580</td>
<td>6,580</td>
<td>6,580</td>
<td></td>
<td></td>
</tr>
<tr>
<td>yearly losses kWh</td>
<td>16,206</td>
<td>90,228</td>
<td>90,228</td>
<td>15,242</td>
<td>64,824</td>
<td>64,824</td>
<td>8,059</td>
<td>57,641</td>
<td>57,641</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest rate p = 7 %; Life time of transformer n = 25 y; Costs for electrical power 0,10 EUR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A – factor EUR/kWh</td>
<td>11.30</td>
<td>11.30</td>
<td>11.30</td>
<td>11.30</td>
<td>11.30</td>
<td>11.30</td>
<td>11.30</td>
<td>11.30</td>
<td>11.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B – factor EUR/kWh</td>
<td>0.40</td>
<td>5.00</td>
<td>11.30</td>
<td>0.40</td>
<td>5.00</td>
<td>11.30</td>
<td>0.40</td>
<td>5.00</td>
<td>11.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capitalization Costs EUR</td>
<td>39,090.00</td>
<td>60,500.00</td>
<td>138,390.00</td>
<td>44,546.00</td>
<td>58,900.00</td>
<td>111,120.00</td>
<td>39,780.00</td>
<td>54,134.00</td>
<td>106,354.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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\[ P_o \text{ factor } = \text{No-Load Losses} \quad 8 \text{ EUR/Watt} \]
\[ P_k \text{ factor } = \text{Load Losses at 100 \% loading} \quad 1 \text{ EUR/Watt} \]
with 50 \% – 70 \% loading 0.6 EUR/Watt

Difference of Losses between Standard trafo and EcoDry\textsuperscript{Ultra} at 70 \% loading

Capitalization of No-Load Losses = 1,500 W-680 W = 820 W \times 8 \text{ EUR} = 6,560 \text{ EUR}

Capitalization of Load Losses = 4,310 W-2,890 W = 1,420 W \times 0.6 \text{ EUR} = 852 \text{ EUR}

Total Capitalization costs for Standard trafo \rightarrow\text{ EcoDry}\textsuperscript{Ultra} = 7,412 \text{ EUR}

Total capitalization costs from calculation table (60,500-54,130) = 6,570 \text{ EUR}

We can see, we get very close and it proofs that the premium investment pays off. As we can see in the table above, the more the transformers are loaded, the bigger the difference in capitalization costs will be. The same will be applicable for higher rated transformers, eg. 2.5 MVA transformers. Then the difference of the capitalization costs will be about EUR 25,000.

It is therefore mandatory for a future investment to have a very close view on the losses of the different transformers. The savings will help paying and reducing the future operating costs (OPEX).

3. CT & VT for Measurement and Protection

Even though not very obvious, there are many little transformers, like Current Transformers (CT) and Voltage Transformers (VT) for Measurement and Protection purposes in any Medium Voltage Switchgear (MV) resp. High Voltage Switchgear (HV). Their main task is to ensure the safety for persons and the plant itself. These numerous little transformers are as well big consumers when adding up all their losses. The conventional CT and VT are built in a similar way like the big transformers and their operating principal is about the same and therefore their losses occur the same way.

ABB has recently developed a new generation of CT`s and VT`s with the aim of saving energy and built them therefore without a coil. Due to the working principle we can speak of a Current Sensor and a Voltage Sensor. To save space and time when installing them, the 2 types of sensors are available as a Combisensor. The new generation of sensors is based on the Rogowski Coil measuring principle. It is functioning without a conventional coil and therefore these sensors are functioning without the losses of a standard CT or VT. Their losses are as little as 1 Watt (W) per sensor, compared to about 15 W for a typical CT respectively 50 W of a standard VT.

Until today these losses in CT` s and VT` s are neglected, not measured and not capitalized. This is done only with their big brothers the regular transformers. Besides saving energy with these new sensors, they have further remarkable advantages, like:

- spare parts management \rightarrow only 1 type of Combisensor is needed for a plant
- no saturation of a coil \rightarrow no false measurement
- no ferroresonancy \rightarrow no disturbance of other systems in the plant
- linearity over full range \rightarrow correct measurement and hence functionality also with big load changes
The following example shall underline the sustainable benefit of Combisensors against the conventional CT’s and VT’s in respect of Energy Efficiency and Capitalization Costs. For this reason we compare the devices in a typical MV Switchgear of a WtE plant. We can expect that the initial investment costs for either concept/principal is about the same.

Figure 9:
Comparison between Combi-sensor <-> CT/PT in respect of saturation effect

Figure 10:
Principal operating diagram of Combisensor
MV switchgear  8 bays/cabinets
1 bay with CT / VT  3 x VT à 50 W each and 3 x CT à 15 W each (1 device per phase)
with Combisensors  3 x Combisensors à 2 W each
Cost of Energy  0.1 EUR pro kWh
Operating time/life span  8,760 hours over 25 years
Operating costs per year
Total losses  8 bays à 3 VT à (50 W-1 W) + 8 bays à 3 CT à (15 W – 1 W)
            1,176 W + 336 W = 1,512 W
Losses per year  1,520 W • 8,760 h = 13,245 kWh (reduced energy sales per year)
Operating costs per year  13,245 kWh • 0.1 EUR = 1,325 EUR/year
Costs for losses  25 years • 1,325 EUR = 33,125 EUR over operating period of 25 years
Or when using capitalization method (net present value) over 25 years = 37,455 EUR
Now we have proof that also little, not recognized losses add up to big numbers over the life time of the equipment.

### 4. Motors & Drives

Motors are the work horses in industry; they are the biggest energy consumers and take more than 60% of all electrical energy needed in industry. It concerns mainly motors for pumps and fans. The bigger the motors are, the more probably they operate 7/24. Until recently nobody had a closer look at them since they quietly operate and perform their task. Only when energy prices started to increase drastically, some customers approached the motor manufactures with the target to reduce the operating costs. This challenging task has many aspects; for improving the efficiency rating of a motor it needs new design

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![Sources of losses in a motor](image-url)
and materials. The results show that is possible to build those new motors with many new features and remarkably lower operating costs.

With the old classification used until 2010 the motors were distinguished with a naming like EFF1 for a high grade motor and EFF3 for the lowest quality equipment. ABB started working on improvements on the motors several years ago. Since we know about the sources for the losses in a motor, there is a way to improve the situation. As the overview in Figure 11 shows, the losses occur in many places.

It is not only the Iron- or the Copper Losses but also the Losses in the stator, the rotor, the bearings, the geometry of the windings. To take actions a few leading motor manufactures got together in a working group where they defined the new motor efficiency classes. As we can see in the IE class definition, the new classification got enlarged by a new Super Premium efficiency motor IE4. This is a step into the right direction and this grading is valid as from 2011. It was further decided that the lowest grade motors IE1 are not any longer permitted in new installations or replacements in Europe as from end of 2011.

The new IE4 motors class brings many features all industry was waiting for a long time. Not only the efficiency rating could be improved by up to 4% over the low efficiency motor, but because of using best available materials further improvements can be achieved:

- longer life time $\rightarrow$ best materials
- minimal noise $\rightarrow$ optimal assembly, better arrangement, better fan shape
- less maintenance $\rightarrow$ highest grade material, eg. better bearings, lower operating temperature
- lower heat losses $\rightarrow$ better winding material, high grade e-steel with thin lamination

$\rightarrow$ and as the result, the IE4 motor class is regarding energy efficiency in a new dimension. The additional investment cost for the better material and the new design (premium costs) will pay for itself.
Let’s assume we have to select a 18.5 kW motor. A cheap IE1 motor with an efficiency rating of only about 90% can be found, or for a European application an IE2 motor with 91.0%. As an attractive alternative we select a premium IE4 Motor with 94.2% efficiency rating. Between the 2 classes (IE4 – IE2) of the 18.5 kW motor there is a difference in efficiency of 3.2%. We assume that the motor is running for 8’200 hours (guaranteed plant availability) and the cost for electrical energy is again 0.1 EUR/kWh.

<table>
<thead>
<tr>
<th></th>
<th>Losses in 18.5 kW Motor</th>
<th>Premium Investment Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE4</td>
<td>94.2 % 1,073 W</td>
<td>2,260 EUR 34.5 % premium</td>
</tr>
<tr>
<td>IE2</td>
<td>91.0 % 1,665 W</td>
<td>1,680 EUR</td>
</tr>
<tr>
<td>Difference in losses</td>
<td>592 W 0.592 kW</td>
<td></td>
</tr>
<tr>
<td>Additional operating cost due to losses</td>
<td>485 EUR</td>
<td></td>
</tr>
<tr>
<td>Savings</td>
<td>485 EUR</td>
<td></td>
</tr>
</tbody>
</table>

With the savings of the reduced losses of EUR 485 we will find a **ROI of only 14 months** for the premium investment! When taking into account the reduced maintenance costs and the chance of the better availability then the premium gets even more attractive.
This is proof that the premium investment for a motor is more than worth its effort in investing into premium equipment. It pays in a very short time, not only its premium with its lower operating costs – it makes the plant more competitive and reduces the impact on our nature.

It is up to you as the future operator and owner of the new WtE or Power Plant to properly specify highest efficiency equipment such as the mentioned IE4 premium motor. It must be clearly expressed and stated that Energy Efficiency, Availability and Operating Costs are key criteria and must achieve certain values. It is important to know that the findings and savings are scalable – there about 500 motors spread out in a WtE plant. The motors consume > 60 % of the planned houseload and a saving of about 4 % is not negligible and can be achieved with only installing best quality motors.

Motor applications are generally oversized; 20 % and more are very common. This is still the heritage of the old and not flexible control devices, like throttling or dampening. Today a Frequency Converter or a Variable Speed Drive (VSD) should be a must, since the VSD is able to reduce the effect of the system oversizing – however it can not be fully eliminated. The cost implications of an oversized system can be seen throughout the plant with; bigger transformers, thicker cables, bigger switchgear, bigger motors and drives remain and must be paid and the additional space required must be allocated.

Under normal operating conditions a motor is running at only 60 % to 70 % of its rated power. There is no need to dimension it at 110 % or 120 % or even more. A modern VSD can run today for a limited time at up to 125 % of its rating, so the argument for the safety margin in the motor application is not valid any longer. Today a VSD should be equipped with a low harmonic filter for reducing and limiting the harmonics to below 4 % and with a direct torque control (DTC) feature. With the DTC a controlled ramp up of the speed without a current surge up to nominal load is achieved and it further prevents the hammering in the process environment (protection of pipes and tubes). With the help of a VSD it is also possible to adjust and compensate the reactive power. This helps to save the investment costs for a compensation capacitor bank and further prevents the penalties from the Utility for producing reactive power.

5. Summary

What can we learn from this article? Energy is a very valuable resource since its availability is more and more limited. A high percentage is getting lost from its source (coal mine, oil/gas field, waste bag, hydro scheme, etc.) to its consumers. There are many inefficiencies, not only in the equipment itself, but also in selecting the most adequate and efficient solution or in oversizing the process due to limited process and engineering skills. These many shortcomings lead to the very high losses of up to 80 % along the way to its consumers.

We have shown some simple ways in reducing the houseload of a WtE respectively power plant, like with transformers by 1 %, with motors by 2 – 5 %, with protection/measuring by 0.5 %, with drive applications by 10 % or with oversizing of a system with 5 – 10 %.

This know how can easily be applied in a new plant and the savings result in very green renewable energy and remarkably lower operating costs (OPEX). After a short time this smart investment will be a cash machine. This potential savings should not be lost due to careless planning or a not sufficient tender specification. Only a precise requirement specification brings the adequate systems with the sustainable benefits for the future operator.
For a better understanding of this effect, we will have a close look at a typical WtE plant with a generating capacity of 15 MWel and an expected service life span of 25 years. The availability is guaranteed with 8,200 hours. When selecting best energy efficient systems and the planning is done with a thorough integrative engineering approach then the operating hours will increase by a further 50 hours. With this approach the houseload or the own plant consumption will decrease from 12.5 % to 10 %, which is a remarkable improvement on the electrical energy efficiency of 20 %. The remuneration for the electrical energy is 0.1 EUR while the production / operating costs for the electrical energy are 0.07 EUR.

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy savings 2.5 % (12.5 % – 10 %) on 15 MW</td>
<td>375 kW</td>
</tr>
<tr>
<td>Addl. Power to be sold per year (8,200 h à 375 kW)</td>
<td>3,075,000 kWh</td>
</tr>
<tr>
<td>Addl. Income on this power to be sold (3,075 MWh à 0.1 EUR)</td>
<td>307,500 EUR</td>
</tr>
<tr>
<td>Addl. Benefit for not using fuel and consumables (8,200 h à 0.03 EUR à 375 kW)</td>
<td>92,250 EUR</td>
</tr>
<tr>
<td>Addl. Operating hours (50 h à (15 MW – 10 % houseload) à 0.1 EUR)</td>
<td>67,500 EUR</td>
</tr>
<tr>
<td>Total operator benefit with best energy efficiency per year</td>
<td>467,500 EUR</td>
</tr>
<tr>
<td>Expected savings over the life span of the plant with 25 years</td>
<td>11,687,500 EUR</td>
</tr>
</tbody>
</table>

This proofs that energy efficiency is getting a very serious business for Operators who are able to consider and evaluate the operating costs. OPEX is the key for the future success of a plant; even so CAPEX shall not be neglected. A typical example everybody can easily verify in his own premises – a motor. The energy bill of a motor which is running 24/7 is after only about 40 days as high as the initial investment cost. When considering the investment costs with the maintenance costs and the energy costs over the 25 years life span of a motor, then the energy costs will exceed > 90 %, while the maintenance costs and the initial investment costs are both below < 5 %. Therefore an improvement on the energy efficiency pays off in a short time and will help you reducing further the operating costs (OPEX).

The full involvement and commitment in the early tender phase with the requirement for better Energy Efficiency and higher Availability will reward the plant operator despite the premium investment in the high quality equipment and the adequate integrative engineering.

6. Literature reference

[2] EcoDry: Ultra-efficient dry-type Transformers
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