Investments in energy efficiency. A case study.

MIHAI CRUCERU, ADRIAN GORUN, BOGDAN MARIAN DIACONU
Energy Department
University “Constantin Brancusi” from Targu-Jiu
Eroilor 30, Targu-Jiu, Gorj, RO-210152
ROMANIA
e-mail: cruceru@utgjiu.ro, http://www.utgjiu.ro

Abstract: - In Romania, one of the main barriers that inhibit the development of energy efficiency projects is the lack of funds. The paper analyses an energy efficiency project in which an Energy Services Company was committed to access funding in order to purchase equipment, to own, to put in service and operate the host facility. The costs, the benefits and the impact of the project are briefly described.

Key-Words: - Energy services company, energy efficiency project, costs, benefits

1. Introduction
Efficiency is delivered in many ways, but most of us are familiar with two predominant mechanisms – public programs and private contracts (including internal company decisions). In both of these cases the relevant decision makers seek to calculate the cost and benefit of the efficiency investment. Investment decisions under uncertainty are a common problem that is well addressed in the economic and financial literature. On the energy supply side, there are a number of tools available that collectively comprise the energy risk management industry. Despite some setbacks to the industry, the use of financial risk management tools such as forward contracts, long-term contracts, options and swaps is growing worldwide and is an accepted form of risk sharing. Tools for managing risk on the supply side help to dampen, but not eliminate volatility of demand side estimate for the value of “negawatts”. The simple fact is that when one makes an energy efficiency investment, there is often very little chance of knowing what the actual value of savings will be more than a year or two hence.

Ignoring this uncertainty, as most energy efficiency planners do now, does not make it disappear. In fact, when energy efficiency is allowed to compete directly with other sources of supply in terms of value and risk, it can often provide a more attractive investment.

In private contracts for energy services, the parties must allocate the responsibility for energy asset purchase, maintenance and long term energy use. A common form of energy service contracting involves a host facility and an Energy Services Company (ESCO) under an agreement called an Energy Savings Performance Contract (ESPC).

The Energy Service Provider Companies (ESPCs) are companies providing energy services to final energy users, including the supply and installation of energy-efficient equipment, the supply of energy, and/or building refurbishment, maintenance and operation, facility management, and the supply of energy (including heat), as They may be consulting engineers specialised in efficiency improvements, equipment manufacturers, energy suppliers or utilities. ESPCs provide a service for a fixed fee or as added value to the supply of equipment or energy. ESPC may have some incentives to reduce consumption, but these are not as clear as in the ESCO approach. Often the full cost of energy services is recovered in the fee, so the ESPC does not assume any risk in case of underperformance. ESPCs are paid a fee for their advice/service rather than being paid based on the results of their recommendations. Principally, projects implemented by ESPCs are related to primary energy conversion equipment (boilers, CHPs). In such projects the ESCP is unlikely to guarantee a reduction in the delivered energy consumption because it may have no control or on-going responsibility over the efficiency of secondary conversion equipment (such as radiators, motors, drives) and over the demand for final energy services (such as space heating, motive power and light).

Energy Service Companies (ESCOs) also offer these same services. ESCOs are fundamentally different from ESPCs and the ESCO activities can be distinguished from ESPCs’ activities in the following ways:

• ESCOs guarantee the energy savings and/or the provision of the same level of energy service at a lower cost by implementing an energy efficiency project. A performance guarantee can take several forms. It can revolve around the actual flow of energy savings from a project, can stipulate that the energy savings will be sufficient to repay monthly debt service costs for an
efficiency project, or that the same level of energy service will be provided for less money.

- The remuneration of ESCOs is directly tied to the energy savings achieved;
- ESCOs typically finance, or assist in arranging financing for the installation of an energy project they implement by providing a savings guarantee;
- ESCOs retain an on-going operational role in measuring and verifying the savings over the financing term.

Therefore ESCOs accept some degree of risk for the achievement of improved energy efficiency in a user’s facility and have their payment for the services delivered based (either in whole or at least in part) on the achievement of those energy efficiency improvements.

2. Case study

Eneas Bucharest is an energy services company (ESCO), whose beneficiary is the company CARMOLIMP Ucea de Jos, Barşov county, currently one of the largest meat processing companies in the region. Founded in 1993, based on a family business, CARMOLIMP operates two natural gas-fired steam boiler type Panini and two hot water boilers. The steam is used for technological needs, heating and hot water. In 2006, the natural gas consumption was 360,604 Nm³ and the electricity consumption 1,131 MWhe. The company purchased the entire quantity of electricity needed.

Business development perspective estimated an increase of electricity consumption of 169% and a heat consumption increase of 63%. Consequently, CARMOLIMP decided to install a cogeneration unit to produce electricity and heat, being helped by an energy services company founded in 2007, Eneas Bucharest. The reason of such cooperation was to limit the growth of energy bills by purchasing electricity and heat (thermal energy produced by recovering heat from the exhaust and cooling system cogeneration facility) cheaper than electricity purchased from regional operator and heat generated in the boiler of the company respectively. In order to overcome the disadvantages of lack of information on the achievement of such a project and removal of any obstacles related to technology transfer and establishing a scheme for financing, and technological and financial risks, CARMOLIMP decided to work with energy services company Eneas Bucharest by a BOOT-type arrangement (Build-Operate-Own_Transfer). In such a framework, Eneas is committed to access funding in order to purchase equipment, to own, to put in service and operate the cogeneration unit. CARMOLIMP was supposed to benefit from electricity and heat produced in cogeneration with lower costs than initial and, after the return on investment, free to take ownership held by Eneas. Collaboration between Eneas and CARMOLIMP materialized through a shared savings contract type, in which Eneas guaranteed cheaper energy than resulting from the production and purchasing of the same amount of energy as the original conditions. If it had continued to produce heat, CARMOLIMP should use an annual quantity of natural gas 486,240 Nm³/year to generate MWh 3,186 per year to cover a part of the necessary heat and should purchase extra MWhe 2,304/year to meet electricity demand.

After the project implementation, the total consumption of natural gas increases to 657,660 Nm³/year, while electricity consumption would remain unchanged, ie 2,304 MWh / year and thermal energy production MWh 3,186 per year (ie 2,740 Gcal/an). In conclusion, CARMOLIMP will consume more natural gas but will purchase less electricity (from 3,200 MWh/year to 896 MWhe/year) and will cover a part of the thermal energy from waste heat produced virtually for free (63% average). Co-generation unit has a rated electrical power of 384 kW and a heat output of 531 kWt. At full load, electrical efficiency is 37.0% and thermal efficiency is 51.0%. Total project cost was 623,000 USD. Energy savings are estimated at 574,464 Nm³/year (equivalent to 462 toe per year), maintenance and personnel costs will be nonexistent as long as Eneas operates the unit and handles the maintenance, refurbishment and repair.

The financial analysis was conducted both for the project and for the Energy Services Company. Cash flow analysis considered a normal life time of the cogeneration unit of 10 years and the costs for electricity and natural gas in 2007. The discount rate considered is 12%. To analyze the cash flow generated by the project only the benefits of energy savings achieved for an operating time of 6,000 hours per year (defined as the minimum shared savings contract) were considered; financial benefits were estimated at 332,144 USD/year. Gross term recovery (VAT included) is 2.2 years, the net present value is 1,135,000 USD and the internal rate of return is 44%. For cash flow analysis conducted by Eneas, were considered only the minimum annual income, guaranteed savings contract type (176,219 USD/year). Recovery for the entire term of gross investment (VAT included) is 4.2 years, the net present value is about 254,000 USD and internal rate of return is 20%. Shared savings type contract is in force five years from the starting of co-generation unit and revenue share varies with the number of operating hours per year. Thus, the executive Eneas decided to invest 623,000 USD to install a co-generation unit in CARMOLIMP location for providing heat and electricity at lower prices. As an investment in energy efficiency achieved by an energy service company,
Eneas has applied for a loan of 499,000 USD (80%), the remaining 124,000 USD (20%) representing its contribution. Loan maturity is 4.5 years, including a grace period of three months. Refunds are made quarterly in equal payments as Eneas requested.

3. Analysis of the project
Currently, two Panini type steam boilers with natural gas and two hot water boilers are working at CARMOLIMP. No 1 boiler produces 1 t/h of steam at a pressure of 9 bar and a temperature of 170 °C. No. 2 boiler produces 1 t/h of steam at a pressure of 7 bar and a temperature of 160 °C. The steam is used for technological purposes, heating and hot water consumption. In 2006, the annual natural gas consumption was 360,604 Nm$^3$ and electricity consumption was 1313 MWhe. Compared with 2006 in 2005 the values differ slightly.

The electricity is purchased from Electrica Transilvania Sud. The imminent development of productive capacities decided by CARMOLIMP will increase the energy consumption (electricity and heat with 169% and 63% respectively). In such a perspective, CARMOLIMP asked Eneas to install co-generation unit (gas engine - generator - heat recovery) at Ucea de Jos unit. The reason envisaged by the executive decision was to limit the energy bills by purchasing electricity and heat (recovered from flue gases), with lower costs than those associated with electricity supplied by the regional operator and the heat produced by the existing boilers.

Continuing to operate the existing conditions, the increasing of CARMOLIMP capacity would lead to an annual consumption of 486,240 Nm$^3$/year natural gas to produce 3186 MWht and to purchase an annual quantity of electricity 2304 MWhe to cover electricity consumption. After the project implementation, the total natural gas consumption will increase to 657,660 Nm$^3$/an, while electricity consumption will be 2304 MWhe/year and thermal energy production 3186 MWht/year (ie 2.740Gcal/an). Inferior calorific value of natural gas was considered in the calculations 8050 kcal/Nm$^3$ (equivalent to 33.688 kJ / Nm$^3$).

In conclusion, CARMOLIMP will consume more natural gas but will purchase less electricity (from 3200 MWhe/year to 896 MWhe year) and will cover a part of thermal energy needs by virtually free waste heat (about 63%).

Co-generation unit (Figure 1 and 2), is equipped with an engine type MAN E 2842 LE312 and a standard electric generator HCI 534 E. The nominal input power is 384 kW electricity and 531 kW thermal energy.

At full load, electrical efficiency is 37.0% and thermal efficiency is 51.0%, resulting in a total return of 88.0%.

Operation and control are provided by Eneas until full recovery of investment and transfer the ownership of the unit to CARMOLIMP.

Figure 1 Co-generation unit equiped with MAN E 2842 LE312 and a generator HCI 534 E at CarmOlimp Ucea de Jos (source: http://www.free.org.ro)

Figure 2. Co-generation unit equiped with MAN E 2842 LE312 and a generator HCI 534 E at CarmOlimp Ucea de Jos (source: http://www.free.org.ro)

3.1. Project purpose
The project goal is to ensure sustainable development of CARMOLIMP business by promoting high efficiency cogeneration, based on a collaboration with an energy services company.

The main advantages of the project are:
- Reducing energy consumption: by installing of co-generation unit, CARMOLIMP will consume more natural gas but less power. How electricity is produced...
from the national natural gas based on lower yields, equivalent gas savings will be achieved.

- Reduced environmental impact: reducing energy consumption will reduce emissions of pollutants, especially CO$_2$.

### 3.2. Project Costs
Installing cogeneration plant by Eneas in the Ucea de Jos CARMOLIMP started in May 2007 and it was finished in approximately five months. Commissioning and start-up took place in late September 2007. Investment costs were 623,438 USD.

### 3.3. Project Benefits
Estimated energy savings and financial benefits obtained after the investment are:

- Natural gas: exploiting co-generation facility will result in savings of 574,464 Nm$^3$/year (about 462 toe/year), equivalent to 332,144 USD/year;
- Maintenance operations: in relation to the situation, Eneas will cover all operating costs, maintenance and repair, which in the context of high reliability and automation will be insignificant.

### 3.4. Financial evaluation
Cash flow analysis was performed in the first case, for investment and for Eneas Bucharest in the second case. In both cases, the analysis was conducted over a period of 10 years, based on energy prices during 2007.

To analyze the cash flow generated by investment, it has been considered only the financial benefits of 332,144 USD/year from energy savings achieved for an operating time of 6,000 hours per year (defined as the minimum shared savings contract type).

Financial analysis for investment is presented in Table 1.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Year (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0 1 2 3 ... 9 10</td>
</tr>
<tr>
<td>CF$_h$</td>
<td>-742 333 333 333 ... 333 333</td>
</tr>
<tr>
<td>$S_h$</td>
<td>-742 -77 256 ... 2,251 2,584</td>
</tr>
<tr>
<td>FA$_h$</td>
<td>1.00 0.80 0.80 0.71 ... 0.36 0.32</td>
</tr>
<tr>
<td>SA$_h$</td>
<td>-742 -180 57 ... 1.030 1.137</td>
</tr>
<tr>
<td>TRB</td>
<td>2.2 ani</td>
</tr>
<tr>
<td>TRA</td>
<td>2.7 ani</td>
</tr>
<tr>
<td>VNA</td>
<td>1,13 thousand USD</td>
</tr>
<tr>
<td>RIR</td>
<td>44%</td>
</tr>
</tbody>
</table>

Financial analysis in the case of Eneas Bucharest investment at CarmOlimp Ucea de Jos

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Year (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0 1 2 3 ... 9 10</td>
</tr>
<tr>
<td>CF$_h$</td>
<td>-742 176 176 176 ... 176 176</td>
</tr>
<tr>
<td>$S_h$</td>
<td>-742 -389 -213 ... 844 1,020</td>
</tr>
<tr>
<td>FA$_h$</td>
<td>1.00 0.80 0.80 0.71 ... 0.36 0.32</td>
</tr>
<tr>
<td>SA$_h$</td>
<td>-742 -444 -319 ... 197 254</td>
</tr>
<tr>
<td>TRB</td>
<td>4.2 ani</td>
</tr>
<tr>
<td>TRA</td>
<td>6.2 ani</td>
</tr>
<tr>
<td>VNA</td>
<td>254 thousand USD</td>
</tr>
<tr>
<td>RIR</td>
<td>20%</td>
</tr>
</tbody>
</table>

### 3.5. Investment Analysis
Compared with annual revenues in 2006 of 21,934,621 USD (exchange rate 2.5632 lei/USD), starting in 2007, by expanding production capacity, the annual revenues of CARMOLIMP will increase to 28,925 USD, respectively 7,991,107 USD/year.

In 2006, annual natural gas consumption was 360,604 Nm$^3$ and electricity 1313 MWhe. How in December 2006, electricity prices, including the value added tax was 189 USD/MWh and natural gas prices, including value added tax was 450 Nm$^3$/USD1000, the annual energy bill in 2006 was about 410,429 USD (the same exchange rate of 2.5632 lei / USD).

Continuing to operate the existing conditions, the increasing of CARMOLIMP capacity would lead to an annual consumption of natural gas of 486,240 Nm$^3$ and to purchase an annual quantity of electricity of 3,200 MWhe to cover electricity consumption.

For the same price in December 2006 and at the same rate of 2.5632 lei/USD, the annual energy bill would be about 823,608 USD.

After the investment in cogeneration unit, the annual natural gas consumption will raise to 657,660 Nm$^3$ and
the quantity of electricity purchased will fall to 896 MWhe per year.

For the same price in December 2006 and at the same rate of 2.5632 lei/USD, the annual energy bill will be about 491,464 USD, respectively 81,035 USD/year higher than in 2006 but 332,144 USD/year less than if the investment were not realized.

In relation to these data, the informations needed for the investment analysis, consisting in installation, commissioning and operation of co-generation unit of a third party are presented in synthesis in Table 2.

From the above data, prior to installation and commissioning of the cogeneration plant, the energy intensity IE1 has the value of 0.0187 USD energy/ USD revenue.

After installation and commissioning of the cogeneration facility, the estimated energy intensity IE2 could be 0.0170 USD energy/ USD revenue.

If the production capacity expansion would have occurred without the installation of cogeneration unit, the energy intensity of the IE2 value of 0.0285 had clearly higher energy intensity than initial, as shown in figure 3.

The decrease of energy intensity in the two phases 1 and 2 is shown in figure 3. The variation of energy intensity 1-2* would increase the energy intensity in terms of heat production by CARMOLIMP and purchasing electricity from the regional electricity supplier.

The analysis shows that, after installation and commissioning of the cogeneration plant, the virtual productivity is higher than one and its value is 46.3971 USD income /USD capital investment.

It follows that the share in obtaining benefits after the investment is connected with the sales growth due to expansion of production capacity, meantime the energy bill increases as a result of lower consumption of electricity and natural gas consumption growth.

Regarding the specific investment, IS1 and IS2 values can be determined if one takes into account the present value of the initial investment on which the old technology equipments were purchased and operated.

If IS1 should be equal to 1 USD investment/USD energy, IS2 investment would have the value 1.8770 USD investment/USD energy.

### 3.6. Project Financing

Eneas executive chose to increase efficiency of natural gas using by producing electricity and heat simultaneously, in order to reduce, accordingly, the CARMOLIMP energy bill.

As an investment in energy efficiency achieved by an energy service company, Eneas called on a third party financing, getting a loan of 499,000 USD (80%), the remaining 124,000 USD (20%) representing its contribution.

Loan maturity is 4.5 years including a grace period of three months.
4 Conclusion

The Energy Services Companies guarantee the energy savings and/or the provision of the same level of energy service at a lower cost by implementing an energy efficiency project.

The CARMOLIMP business development perspective estimated an increase of electricity consumption of 169% and a heat consumption increase of 63%.

CARMOLIMP executive decided to install a cogeneration unit to produce electricity and heat and to involve an Energy Services Company, Eneas Bucharest, in the project. Eneas was committed to access funding in order to purchase equipment, to own, to put in service and operate the cogeneration unit.

The investment allows significant financial benefits from energy savings.

The estimated savings are 574,464 Nm$^3$/year of natural gas (ie 462 toe / year).

The natural gas savings will lead to a reduction in CO$_2$ emissions, by approximately 1101 tons / year.

References:


