# ENERMAR SYSTEM

# Kobold turbine in the Strait of Messina

*Appraisal of Environmental macro/micro economics*
*Realizing wider socio-economic benefit*

*Ponte di Archimede S.p.A. – 2007 Report*

## CA-OE WP5: Environment, Economics, Developments Policy and Promotion of Opportunities.

***Task 5.1 Appraisal of Environmental macro/micro economics***
***Task 5.4 Realizing wider socio-economic benefit***

## Developer: Ponte di Archimede nello Stretto di Messina
## Device: Kobold Vertical axis turbine in tidal current.

### *Preface*

Ponte di Archimede (PdA) developed a tidal energy device, Kobold, already tested as full-scale proto-type inside Strait of Messina (Italy). Nowadays, PdA is interested in exporting knowledge of its device; thus Kobold is going to be applied in Indonesian seawaters, Chinese ones and Philippine ones. This is an additional sign as Europe is one of front-leaders in renewable energy technologies and it is working to assure its leader-position on competition market at worldwide level.

The project for Indonesian coast is partially supported by UNIDO Funds. There are several aims linked with this project, such as:

- helping developing countries – as Indonesia – to get electricity energy in a clear way, to improve its economy assuring more independence on energy market, to create new job-position and with new skills;
- helping PdA to test device in new location and to learn more and consequently to get a faster learning rate to decrease future cost of technology;
- helping a sustainable world's growth;
- creating and stimulating interests for ocean energy sectors.

A research has been ordered to Dr. Veronica La Regina, hosted at PdA premises of Messina. The study has been prepared during a ToK (Transfer of Knowledge) experience, with financial support of CA-OE (6th Framework Program).

The study has developed an ex-ante Socio-economic Impact Assessment (SIA) of this project at macro-economic level -multiplier effect of Investments on local Gross Domestic Product (GDP), job-creation according with the relation between new power installed and GDP, financial multiplier-, and at regional level according with methodology of regional economy - base economic multiplier of each industrial sectors involved with supply chain of technology-. It has also considered the Net Present Value (NPV) of the project, which gives information on financial pay-back period and identifies the technology cost and learning curve where the area of learning investment required for break-even point for a commercial status can be seen.

In the present report, a summary of the most important issues is given. For further information some references are available at the end.

## ***Introduction: Italian Technology to Indonesia***

A full scale Kobold device is being built in Indonesia. A joint-venture company, Kobold Nusa PT, between PdA and the Indonesian company Walinusa Energy PT was created in May 2006 to build and implement this technology in Indonesia.

This project is going to transfer the PdA "know-how" with the aim to improve the local community and to help the economy of a developing country, just to know that there are other places in the world and without being conquerors.

In the project, partially supported by UNIDO Funds, there is a clear intend to help a developing country to "import" innovation and technology, linked with Kobold, and on the other side there is willing of PdA to obtain new knowledge of its device in a sea-environment different from its previous experience in Italy.

The project is going to be implemented, according to their previous experience in Italy and to some new amendments linked with new socio-economic settlements of Indonesia, is described in figure below. Figure 1 is showing the quota-weight relative to each step of project according with its costs. Then, from this we are going to consider the socio-economic impact inside Indonesian economy.

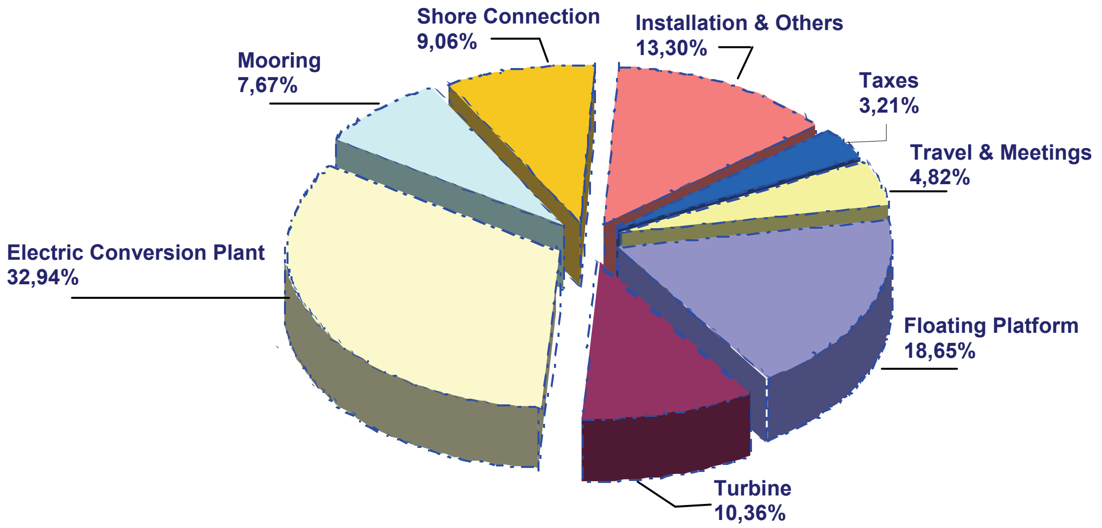



*Fig. 1 Sectorial dimension of project*

## ***Learning Curve***

Operating in competitive markets make individuals, enterprises and industries do better. This fact is at the heart of the experience-curve phenomenon. Price is the most important measure of performance for new energy technologies.

Experience curves provide a simple, quantitative relationship between price and the cumulative production or use of a technology. There is overwhelming empirical support for such a price experience relationship from all fields of industrial activities, including the production of equipment that transforms or uses energy[1].

Anywhere along the line, an increase by a fixed percentage of the cumulative production gives a consistent percentage reduction in price. In the literature, comparisons between different experience curves are made by doubling the cumulative volume; the corresponding change in price is referred to as the *progress ratio*.

The observation that costs decrease with adoption, or cumulative production, has been formalised in so called experience curves. They describe how the unit cost, *c* decrease with cumulative production, *S*.

$$c = c_0 \left( \frac{S}{S_0} \right)^{\beta}$$

$$S = S_0 \left( \frac{c}{c_0} \right)^{\frac{1}{\beta}}$$

where $c_0$ is the initial unit cost and $S_0$ the initial cumulative production at time $t_0=0$ and the experience index β:

$$\beta = \frac{\ln(r_p)}{\ln(2)}$$

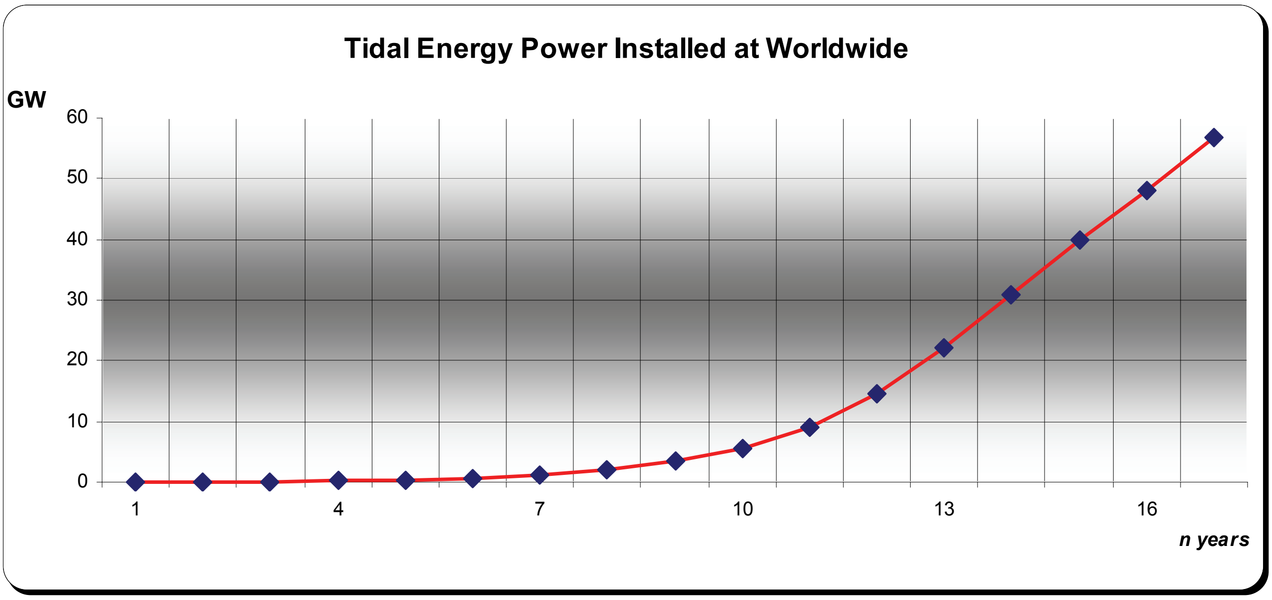
where $r_p$ is the so called progress ratio. A progress ratio of 0.80 means that costs decrease by 20% for each doubling of cumulative production (Argote-Epple, 1990).

The logarithmic representation emphasises the steady and continuous improvements in performance, but underlines that these improvements always should be seen relative to previous achievements.

[1] Abell and Hammond (1979).

Here, it is considered a forecast of tidal-energy power installed at world-wide level as declared by EPRI (Electric Power Research Institute), see Figure.2.

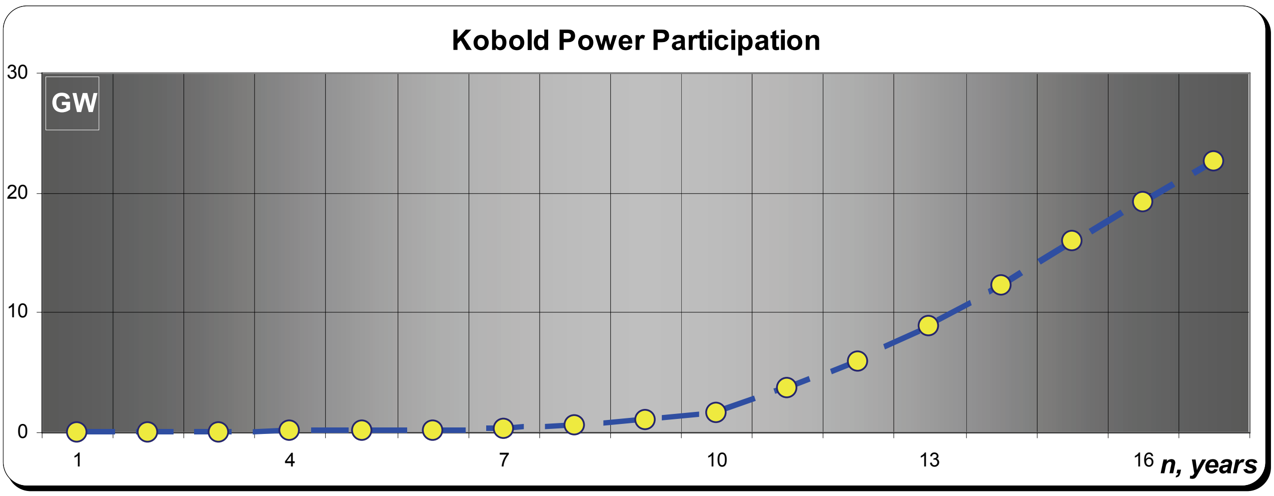
*Figure. 2: Forecast of Tidal-Energy at worldwide, EPRI-2006*




*Source: EPRI, 2006*

From it, it is assumed a variable quota of participation of Kobold system that is able to assure following hypothetical scenario as shown in figure 3. The scenario proposed is constructed according with actual status development of technology, hold deal of further in installations, testing and demonstration results and degree of understanding of its working.

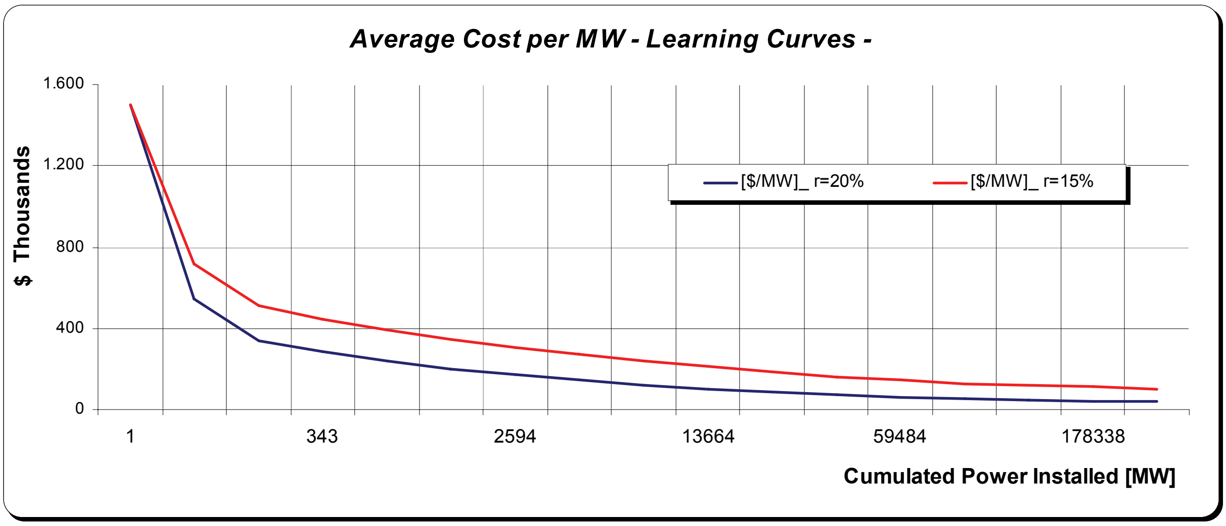
*Figure. 3: Power Installed as Kobold system at worldwide*




*Source: elaboration by VLR.*

This scenario is able to get a decreasing cost per MW as provided in Figure 4, where it is shown effect of different learning rates (constant 20%, constant 15% and variable one from 20% to 13%). It is easy to understand that with only a cumulative power installed around of 24 MW the cost of an additional MW is already three times less expensive than the initial MW, which has been evaluated 1.500.000 US$.

***Figure. 4: Learning Curves with different learning ratios***




*Source: elaboration by VLR*

Here, decreasing cost curves are shown with three different learning ratio, then it has been choice of authors to consider the constant 20% one in further sections.

The cost of a MWh can be calculated considering an annual ratio of 1.600 MWh/MW. It starts from 938 US$/MWh (1.500.000/1600) and is decreasing at 69 US$/MWh at a cumulative power installed around of 14.000 MW.

## ***Net Present Value -NPV-.***

NPV indicates the difference between the present value of cash inflows and the present value of cash outflows. It is used in capital budgeting to analyze the profitability of an investment or project. NPV analysis is sensitive to the reliability of future cash inflows that an investment or project wild yield.

The concept of Net Present Value (NPV) is used, as defined below:

$$NPV = -I_0 + \sum_{k=1}^{n} R_k \left( \frac{1+e}{1+d} \right)^k - \sum_{k=1}^{n} C_k \left( \frac{1+g}{1+d} \right)^k$$

with $R_k$ revenues per time *k*; $C_k$ costs per time *k*; *e* energy inflation ratio; *g* general inflation ratio; *d* discount ratio; *n* plant life time. *NPV* is like a "synthetic index" of opportunities' investments.

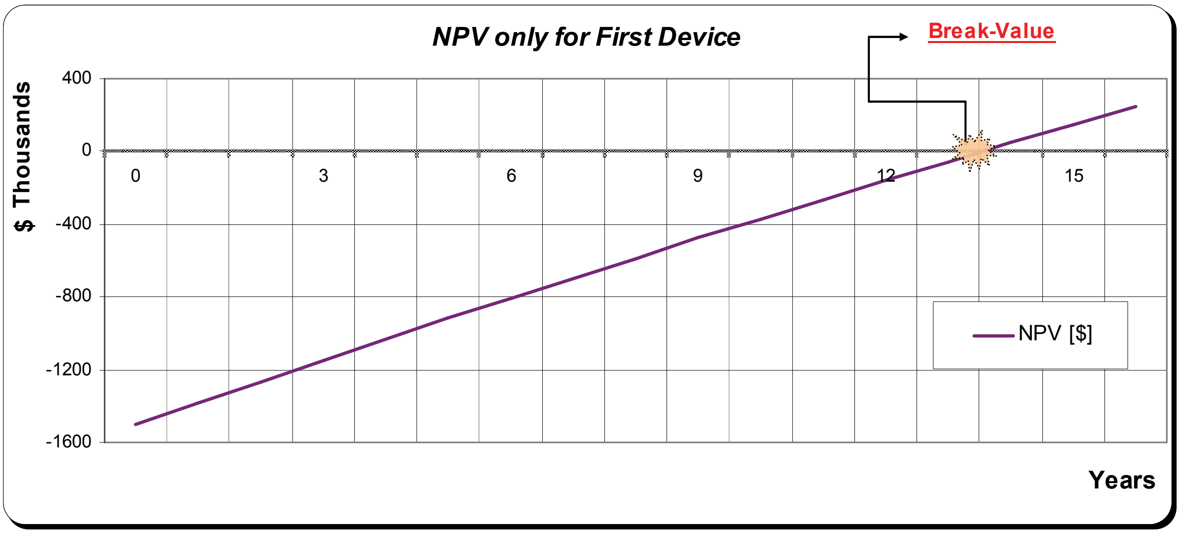
According with Indonesian economic settlement, data considered are:

- $I_0$ =1.500.000 US$/MW;
- *e* = 6,8%;
- *g* = 6,6%;
- *n* =25 years;
- *d* = 8%.

In addition, revenue *R* is coming from electricity price of 42US$/MWh, electricity production is coming from an annual ratio of 1.600 MWh/MW. Costs *C* are evaluated 3,4% of initial cost

Now, it is shown NPV of single project a Kobold system in Indonesia as described in figure below:

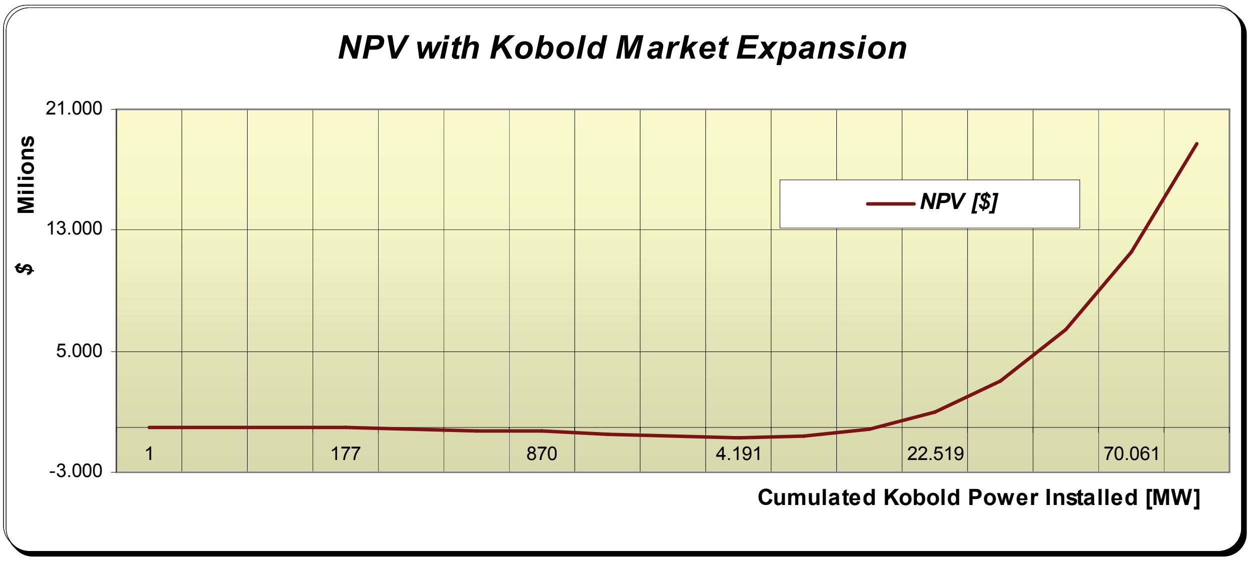
***Figure. 5: NPV of a single project in Indonesia***




*Source: elaboration by VLR.*

In Figure 6, it is considered NPV with a growing expansion of Kobold system as described in previous section.

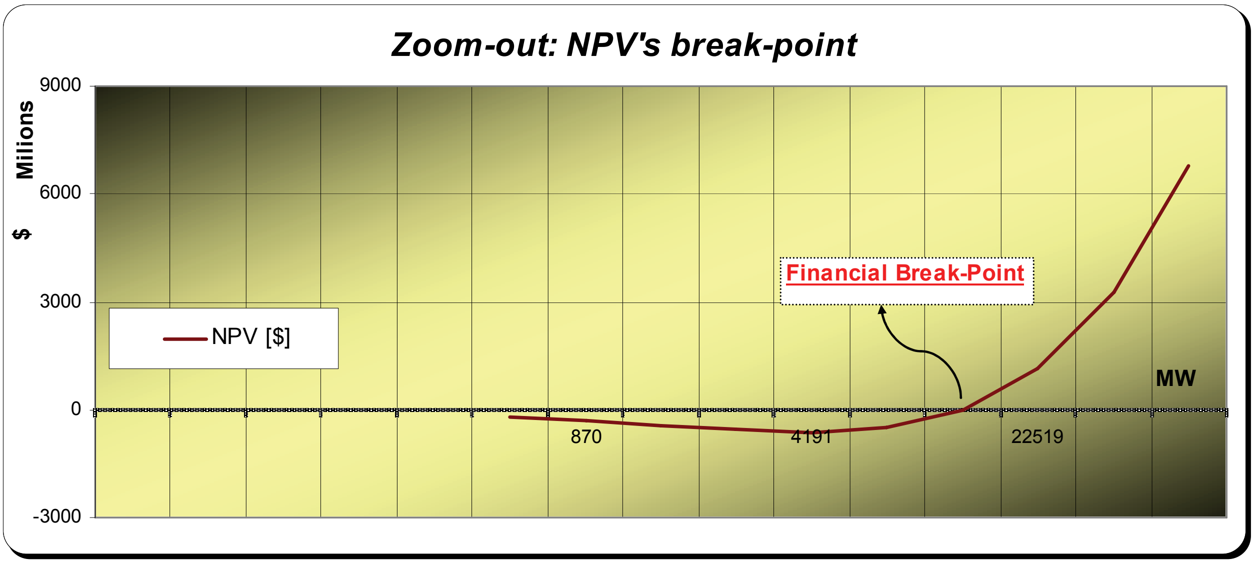
*Figure.6: NPV with a project considering Kobold expansion in Indonesia*




*Source: elaboration by VLR*

A zoom-out of the region with NPV positive is shown in Figure 7:

*Figure.7: Zoom-out of Figure 6*




*Source: elaboration by VLR*

***SIA at macro-economic level***

Previous experience in Indonesia from the biomass energy industry has shown promising potential for such systems in providing job opportunity and income for unemployed. The project included a training component for the manager and technicians from the local people to enable them to construct, operate and manage the facility. The main difficulty encountered was due to the limited access of working capital to purchase raw products and continuous guarantee to market outlet.

In order to accelerate economic recovery, Indonesia has given high priority in making use of its marine resources by effectively applying renewable energy technology. This approach can be considered as a sound and rational strategy since the potential renewable energy sources are also available close to the availability and supply of marine resources. Renewable energy can be utilized to improve quality of life of rural household. Tidal energy is an environmentally friendly technology.

In addition, it is also important source of energy supply for empowering small and medium industries to process high value cash commodities. The rapid depletion of oil reserve with R/P (Reserve/Production) of 18 years will force Indonesia to find alternative energy supply to sustain its economics development. Indonesia still extracts natural gas for the next 34 years and coal for more than 150 years.

The directorate general of electricity and energy development has estimated that the total energy consumption will increase with an increasing ratio of 26%. The highest energy demand is expected to come from the transportation sector while the household sector will remain at the third place.

In line with the above government policy, renewable energy projects are with aim to help the rural people with facility to increase value added of their products, provide job opportunity and source of income.

Another issue, usually discussed in association with the introduction of new technologies and innovation, is the relation and/or the dimension of job losses and job creation. Presently we are not able to have dimensions of job creation nor job destruction with a new project.

The method of 'Employment multiplier' is often used in such calculations, as a factor regarding the (additional) jobs created in related industries. These multiplier values are specified by executive officers for various industries' sectors. As the tidal energy industry is very new, there is no existing employment multiplier for this industry so it is necessary to take the employment multiplier for the closely related industries and find a representative mean value between them.

Additional jobs will arise in two categories, indirect and induced. Indirect jobs are those required to support the main workers, induced ones are those caused by the increased economic prosperity when the new employees increase their consumption in other areas such as entertainment.

At present, a unique supply chain of a marine energy farm is not easy to describe; thus proportion of each production sector is unknown. Instead, the value of an employee inside its country-economy in terms of MW is considered.

The most studies showing relation between MW power installed and number of jobs, consider only the absolute potentiality of the type of technology for job creation. Here, a different approach is followed; the interesting issue is to know how many jobs a country's economy can make when additional MW power are installed.

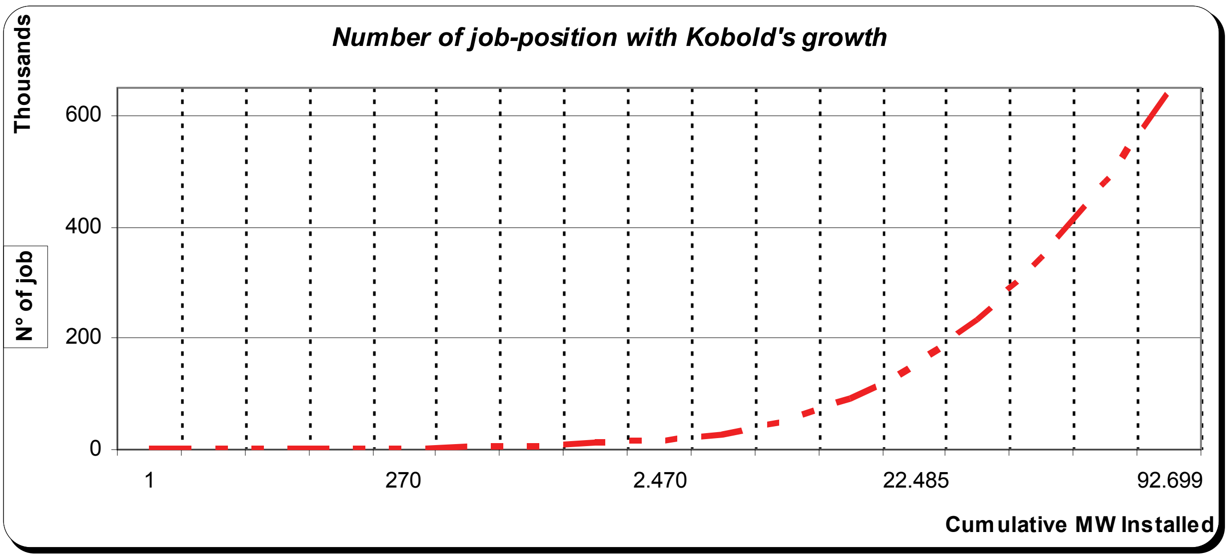
A MW power installed is a "special good" like money, because a MW does not have the same potentialities and values in each country-economy and in addition it does not have a level of pleasure saturation. We never find a country refusing additional MW even if it is rich!

GDP - Gross Domestic Product - in MW units ($GDP_{MW}$) is considered as distributed over production sectors (Industry and Services); then we consider GDP per sector over the number of employees ($GDP^{E}_{MW}$) for each sector. Consequently, we obtain:

$$GDP^{E}_{MW}$$

Then, it is considered the resulting relation of value per employee with its forecasting according Indonesian time series. From these results, numbers of jobs, linked with further MW power installations in the country, are estimated. Indonesia's economy is able to get a coefficient of employee per MW around of 0,17 to 0,14. Situation, according with the hypothetical scenario presented beforehand, is showed in Figure below:

***Figure. 6: Number of job-position in Indonesia with Kobold's expansion***
*Coefficient Employee/MW from 0,17 to 0,14*




*Source: Data from WDI, 2005; Elaboration by VLR.*

These estimations show how many jobs each economy can sustain with new MW power installed.

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