ENERGY CONSCIOUS INTERNET USERS :Stop the ExaWatthours growth

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Abstract: Coherently challenging both the “Information Society” and “Sustainable Society”, let us (naively?) question ourselves, a few scientists out of 1 billion users -: can we yet close our eyes when facing the continuous, and apparently unlimited, growth of the Internet electricity demand? That purpose being our guideline, the present tutorial is organized as follows: a brief historical survey, starting with the second half of the XXth century, of the SETIT’s increasing growth and their impact on the electricity demand, both locally and globally, is firstly presented in a second part, through recent case-studies and results, some ways and means are suggested to increase scientist’s concern for energy and environmental impact. Particularly important when their own research is regarded, such purpose aims to include that impact as one (out of many other) main specifications when proposing new hardware manufacturing, improving existing technologies, not ignoring the purchase of equipment, ...

Finally, we propose a few comments in order to answer, in part, to the following question: not ignoring the SETIT’s electricity demand, how can we contribute, in such framework to a more sustainable Internet future.

Introduction

Before, during and after World War II, the SETITs were not existing, mainly restricted to develop, improve and operate those analog devices that are in use for the telecommunications requirement, the so-called “Radioelectricity” end-use sector. Actually the whole circuitry was built through vacuum bulbs and discrete resistors and capacitors aiming to comply with the telecommunications requirements. Among other important specifications, the efficient-use of electricity could not be, however, ignored at that time, in particular to power RF² emitters. Also an increasing need for digital equipment had to be soon recognized, due to the very rapid (an “exploding” one!) expansion of the nuclear physics and its related applications. Then, appears a trend to decrease both the size and the electricity consumption of the vacuum bulbs in use, for at least one main reason: improving the systems liability. Nevertheless, it became obvious that, unless a technology gap occurs, the modern equipment would result in bigger and bigger, soon unaffordable machines, quite unable to satisfy a growing number of applications in the booming economy.
Invented during the 1950’s decade, the transistor has permitted such expected revolution. Awarded with the Nobel Prize in 1956, W.B. Shockley, J. Bardeen, W. H. Brattain have actually created a new science “Electronics”, which is now diversified in many branches or technology fields perfectly represented by members of the SETIT community. This is the first milestone of the present “Information Society” a potential source of benefits remaining, however, unknown and non-profitable to a large share of the humans to-day. Billions of people continue to be waiting for more significant progress in terms of cost, availability, larger dissemination of vital equipment, … Is it another story ? Not really, but a commitment of the “Sustainable Society” to the present lecture main guideline.

Facing that challenge, let us ask ourselves a (possibly naive) question: can we stay yet ignoring the continuous, and possibly unlimited, growth of the Internet electricity demand? With that purpose in mind, the present tutorial is organized in two parts. First, beginning in the 1950’s, a brief historical survey of the SETIT’s impact on the electricity demand, both locally and globally, is presented and also analyzed within the energy context of the period. In a second part, some ways and means are suggested through recent case-studies and results: aiming to increase their own concern for energy and environmental impact, particularly when their own research is regarded, it is suggested to SETIT’s scientists and researchers to include such goal as one among all other main specifications when proposing new hardware technologies, purchasing new equipment, improving existing technologies, …

Finally, regarding energy issues, nobody ignores neither those dramatic changes that are reminded in figure 1, nor the resulting deep consequences into the world economy.

1. Energy and Setit : Interactive links

Before, during and after World War II, as told here above, the word “Electronics” being not widely used, the Radio is altogether service, application and science. However the need for surpassing the overwhelming limits of the vacuum bulb techniques is at once emerging. Invented during the 1950’s decade, the transistor was more than welcome to permit such technology gap. Awarded with the Nobel Prize in 1956, W.B. Shockley, J. Bardeen, W. H. Brattain have created a very stimulating, science: “Electronics”, so wide that only a few branches or technology fields are to be discussed during the present SETIT-09 Conference.

In Table 1, the main milestones of the SETIT’s growth, having occurred during the last past half-century are summarized (more details being given during the oral presentation). When appropriate, a few data in link with energy issues (from Figure 1) are also shown. In that brief survey, four steps are suggested as follows:

- 1956-1968 : Transistor Era
• 1972-1992: PC Era
• 1993-2002: Internet Era
• 2003 - .... Information Society Era

When presenting, about 22 years ago, our preliminary data regarding the potential energy savings of a PC\(^4\,5\), we were not surprised. Any ironical comment was our common welcome: “Are you kidding? It’s peanuts". By chance, the US Presidential election campaign was started in the US, in coincidence, while independently of course, with the WSSD/SMDD (Rio-da-Janeiro 1992). Environmental issues becoming key priorities, time was then to propose a new Energy Efficiency Label to the US-Environmental Protection Agency (US-EPA). In June 1992, a meeting in San José (California) has been specially devoted to the official announcement of the US-EPA Energy Star\(^6\) label. Organized by J.P. Harris, LBL (UC-Berkeley) scientist, that meeting was attended by commercial engineers of the computers industry and, of special interest, by research engineers from Californian electric utilities. Also deeply concerned, as active in similar studies in their own country, 3 European scientists\(^6\) were invited: B. Aebischer (ETH Zurich), O. Molinder (Nutek Stockholm) et J. Roturier (University of Bordeaux), one of them (J.R.) having presented the first in-built device turning automatically to a stand-by mode a PC or a printer device\(^7\).

On both sides of the Atlantic Ocean, the R-D effort has been continuing altogether on a national and European basis:

• Leading European countries in the National Efficient-Energy Policy field were, at that time, Sweden and Switzerland, strongly involved in a national voluntary policy targeting the most Energy Efficient technologies, including ICT’s. At University Bordeaux 1, a way different of the Swedish (Nutek’s “1 Watt in 1 Year” programme) and Swiss (Target Values programme) Top-Down strategy, was operated. In a first step, Abdeljalil Elkari as part of his Ph.D.thesis\(^6\), has analyzed the ways permitting any equipment (PC and peripherals) to be automatically turned into a stand-by mode while the main issues related to the equipment end of life (the so-called 3R : Reduce-Reuse-Recycle rules), have been preliminarily discussed. In a second step, the ICT’s impact on the electricity demand in very large office buildings in the Paris area (including one new building of the French Ministry of Finances) has been the main theme of a thesis submitted in 1996 by Leila Ben Ali\(^8\). In a third step, this aspect was part of another thesis, submitted to University Bordeaux 1 also in 1999: Patrick Faucher, analyzed the PC stock of several teaching and R-D Departments, their consumption, the ways used to control the power load. … ; then, the author’s main conclusion was clear : most computers managers refuse to let any stand-by way coming into their own field of activity!

• Simultaneously, the European Commission through the SAVE/PACE Programme has funded the initiatives OT3E\(^9\) and MACEBUR\(^10\) aiming to analyze, EU-wide, the ICT’s electricity demand, forecast the evolution and suggest the best ways to go towards a more affordable and sustainable use. The key result was then the start of a negotiating procedure into the EU members and secondly with the US federal government through its EPA. Being achieved after a few years, not without some difficulties, but with at least one significant result : the EU and US-EPA negotiation has resulted in a partnership\(^11\), started in mid-90’s, negotiated for several years and finally in force since July 2001

Some hope was set into the UN World Summit on Information Society (WSIS/WSIS) \(^12\), held in two phases: in Geneva (hosted by the Government of Switzerland Dec. 2003) and in Tunis (hosted by the Government of Tunisia, Nov. 2005). The Tunis Agenda for the Information Society is given in: http://www.itu.int/wsis/docs2/tunis/off/6rev1.html. However, again unsurprisingly, the energy and environmental ICT’s huge impact were not given key priorities in spite of many documented studies. Such a challenge is however known to be of the greatest importance in poor “Southern” countries. Oppositely, the IPCC/GIEC & V.P. Al Gore Nobel Prize in 2007 has been very successful from our viewpoint, the boost given to the environmental policies being not ignored by any scientist to-day! For that reason, at least, no doubt that every scientist is totally convinced to be (as soon as possible) a proactive builder of a fully integrated Sustainable and Information Society. If each of us is 1 in his/her field, Consciousness and Synergy would hopefully be the keywords of the next decade.
### TABLE 1. The 4-steps path from Transistor’s Invention to SETIT

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<thead>
<tr>
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<tbody>
<tr>
<td>1956</td>
<td>Transistor Era</td>
<td>19</td>
<td>SUEZ Canal Shutdown</td>
</tr>
<tr>
<td>(1956-68)</td>
<td>• Nobel Prize to: W.B. Shockley, J. Bardeen W. H. Brattain (2)</td>
<td></td>
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<tr>
<td>1961</td>
<td>TTL invention (3)</td>
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<td>1968</td>
<td>Microprocessor invention (4)</td>
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<tr>
<td>1973</td>
<td>• PC invention (5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1979</td>
<td>• New concepts derived from µP: OA, FA, HA, …</td>
<td>40</td>
<td>2nd Oil Shock</td>
</tr>
<tr>
<td>1985</td>
<td>• 50 millions PCs worldwide</td>
<td>20</td>
<td>Oil price collapse</td>
</tr>
<tr>
<td>1988</td>
<td>• First study of PC’s impact on electricity demand: (6a)</td>
<td>20</td>
<td>50 10^7 PCs consume (6b): 12.5 TWh. (Peanuts, did you say?)</td>
</tr>
<tr>
<td>1992</td>
<td>• Energy Star® by US-EPA (7a)</td>
<td></td>
<td></td>
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<tr>
<td>1993-2001</td>
<td>1993-2002: Internet Era</td>
<td></td>
<td>Estimated PCs Power load the EU : 10 GW</td>
</tr>
<tr>
<td>1994 –96</td>
<td>• Internet invention (8)</td>
<td></td>
<td></td>
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<tr>
<td>2001</td>
<td>• OT3E &amp; MACEBUR Task Forces (SAVE/PACE EU Programme) (9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002 - 05</td>
<td>• Energy Star® : EU &amp; US-EPA partnership (10)</td>
<td></td>
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<tr>
<td>2007</td>
<td>Information Society Era</td>
<td></td>
<td>Sustainable Society Era ???</td>
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<tr>
<td>2008</td>
<td>WSIS/SMSI: Geneva &amp; Tunis (11)</td>
<td>145</td>
<td>IPCC/GIEC and V.P. Al Gore Nobel Prize (12)</td>
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<tr>
<td>2009</td>
<td></td>
<td>40</td>
<td>3rd Oil shock &amp; World Crisis</td>
</tr>
<tr>
<td>2009</td>
<td></td>
<td></td>
<td>Oil price : New collapse</td>
</tr>
</tbody>
</table>

**References:** Table 1

1. “Oil Price History and Analysis” see for instance: [http://www.wtrg.com/]
2. nobelprize.org/nobel_prizes/physics/laureates/1956/index.html “for their researches on semiconductors and their discovery of the transistor effect” A story tells how French and German scientists were involved in the discovery of the transistor effect. See i.e.: [http://www.avandormael.net/](http://www.avandormael.net/)
4. [http://www.ideafinder.com/history/inventions/microprocessor.htm](http://www.ideafinder.com/history/inventions/microprocessor.htm)
5. see [http://en.wikipedia.org/wiki/Micral “...According to the Computer History Museum, the Micral N was the earliest commercial, non-kit personal computer based on a microprocessor and http://en.wikipedia.org/wiki/Kenbak-1](http://en.wikipedia.org/wiki/Kenbak-1) (6a) See Ref.4, 5 (6b) Average annual time-of-use: 2,500 h/yr. – Average power load: 200W/PC – Diversity ratio - 0.5 (7a) [http://www.energy.gov/](http://www.energy.gov/) (7b) [http://www.un-documents.net/locf-02.htm](http://www.un-documents.net/locf-02.htm) “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts (1) the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and (2) the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.”

(9) OT3E and MACEBUR See Ref. 9, 10 (10) [http://www.eu-energystar.org/](http://www.eu-energystar.org/)
(11) [http://www.itu.int/wsis/index.html](http://www.itu.int/wsis/index.html) (12) [http://nobelprize.org/nobel_prizes/peace/laureates/2007/index.html](http://nobelprize.org/nobel_prizes/peace/laureates/2007/index.html) “for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change”

2. **Case-Studies Suggesting a Few Ways and Means**

Not often conveniently addressed to (or received by) the scientific community, many efforts are however aiming to fill the gap between the Information Society Era and the Sustainable Society Era, the latter being unable to exist without the former and vice-versa! Three examples of such research, regarding both the environmental issues and the energy ones, are now presented:
2.1. Energy Conservation in Ad hoc Mobile Networks

As far as a clear definition may be given here, any ad-hoc network is a network specially created through a reunion of mobiles not having any pre-existing joint infrastructure. Such networks are of great interest when facing a sudden situation that calls for an immediate action (emergency). In the study briefly introduced here, the authors propose a list of mechanisms and actions to be implemented when a more energy-efficient operation has to be achieved, i.e. to improve the life of batteries used to power the equipment.

1. Adequate management of both disk and processor
2. Proper allowance to the memory
3. Better transmission power control
4. Turn-Off any unused interface
5. Use of directional antennas
6. Implementation of a more efficient routing protocol

A precise analysis of such measures being beyond the scope of the tutorial, a single comment is given here: actions 1 to 4 are typical of any conscious use of techniques derived from the SETITs while 5 and 6 are relevant of that issue. Of course, the identification of the most convenient “sustainable” attitude, is solely the responsibility of those promoters any other technique or equipment.

2.2. Data Centers: Telecoms Utilities are concerned with Energy Efficiency too …

Even during the “pre-historic” times of the radio, a better Energy Efficiency was a commitment for the suppliers of equipment, in particular for the emitters and those “mobile” telephones that share with the to-day’s one the need for a longer battery life! Since the beginnings of the transistor era, such commitment is yet stronger, for one main reason: reducing the inner temperature of the system largely increases its liability. That evidence has made the computers industry initially hesitant always when our team of scientists has suggested to negotiate the Energy Star® label. Some of us also heard this several years by people remaining reluctant to turn PCs into a stand-by mode even when the energy costs were high (1970’s and early 1980’s), particularly most computers managers from both commercial sector … and certain universities! Most, not all! Even at that time, the banks have rapidly pointed out a possible improvement – a decrease – of their electricity demand management that would be highly profitable. More recently, other sectors possibly boosted by the Greenhouse Gas (GHG) challenge, has entered the group of conscious users. Among these are the Telecoms utilities now extremely concerned with the larger and larger energy demand of their Data Centers (DC): the electricity consumption of the existing ones in EU countries is (2008 data) 40 TWh : in France, it is estimated to be 1% of the total electricity demand. This phenomenon is illustrated by 2 maps representing worldwide and European Google DCs (Figure 2-a and 2-b) that also clearly demonstrate the so-called “numeric gap” ….). Such data being commonly found on the Internet, it is not intended here to remind or summarize all those news that the general public may also find in daily journals or weekly magazines.

A few years ago, B. Aebischer and J. Roturi have previously underlined the fact that the ICT’s electricity impact cannot been analyzed through the final user’s vision only, the related infrastructures being more and more intensively electricity consuming. From a R-D viewpoint, it is more important to illustrate the Telecoms utilities policy in that field. Their need for a comprehensive knowledge of such electricity demand is essential, in particular to conveniently analyze the investment costs.

Figure 2a. Google World Wide Data Center
2.2.1. French Telecoms utility case-study

Now cited, recent data obtained in a French Telecom R-D lab, are a typical example of an action prior to preparing a voluntary programme. In her work, Laetitia SOUCHON, the author the study has compiled and analyzed data from her own in-site electric measurements and other data previously collected to define a bottom-up strategy. Some results are shown here:

2.2.2. Electricity demand per user

The telecommunications services having been analysed in great detail, the related electricity demand per customer is calculated in KWh/yr.-client (Figure 3): on a per user basis, a typical total demand is in a range 150-200 kWh/yr.
2.2.4. Correlation between the traffic and the power demand of a server

During 6 days, in January 2007, both traffic and electric power demand were metered. A very weak correlation is shown: both traffic and power load are simultaneously changing while the relative percentage of variations is much smaller for the power load than for the traffic due to very high stand-by nominal power. That results in a significant electricity savings potential and, consequently, the need for improving the power management.

2.2.5. Scenario of the evolution of the electricity demand (2007-2012)

From her analysis, L. SOUCHON suggests a probable scenario of the evolution of the electricity demand (2007 data) over the 5 next years. Two main features are to be observed:

- total annual demand is about 1.4 TWh.
- When estimated similar data from other French Telecoms utilities are added, 2 TWh
- total annual demand is not expected to grow; on the contrary, after a peak demand in 2010, a decrease may happen
2.3. The META Initiative

Out of other certainly existing initiatives, it may be useful to introduce here an interesting technology initiated by a start-up company from Bordeaux (France), the META Initiative, whose objective is to build a computing network for small enterprises. In the context presently discussed by the author, it is the splendid conclusion that is hoped since many years.

2.3.1. Data Facts and Goals

The problem is the IT’s impact on the Environment, far from having been sustainably solved in spite of a technology, more than 35 years old. This is an evidence possibly due to its fast growth, however not neglecting the lack of any environment policy in most industrialized countries, the market was entirely unconscious of the end-of-life issues! Waste management is now a worldwide problem, another perfect example of the numerical gap (the rich pay the poor to do the dirty job!)

Now, let us remind a few facts. Furthermore, when regarding the CO₂ emissions, IT's share is, at the moment, 2% of global production. It may be known, too, that the manufacturing process of a desktop requires, on average, 10 times its weight in fossil fuels chemicals. More globally a PC ecological footprint represents 100% of one human allocation. Facing these trends and evidences, it may be noted that there are only very limited efforts up-to-now mostly for notebooks (less consumption means more autonomy) and servers in order to decrease air conditioning bill.

The main goal being, as noted in §2, to "fill the gap between the Information Society Era and the Sustainable Society Era", an entirely new PC architecture would be designed and be constructed through a project management built around a few smart, and simple ideas:, easy construction and maintenance thanks to a limited number of components, free software availability through a form of partnership to be negotiated. Facing the present market behaviour, this is uncommon. Actually, IT's market is mostly leaded by video games not primarily by most office's users. For example, many professional IT's users (office activities) have no need for: 3D optimised graphic card, CD/DVD burner (software installation by network), being operated through a battery or using Wifi, … Not also ignoring that non-graphical work doesn't need “large” screen, 15,6" in 16/9 format being as large as standard 17” and lower power load. Finally, always working at the same place don’t need mobile laptop-like technology. To speak clearly, ITs market is much more leaded by video games players than white-collars real needs.

2.3.2. Available technologies

Several ways are now available that are in the right direction. Both the choice of a metal like aluminium recycling alike and a limited number of parts used in the manufacturing process would permit a cheap (possibly) cost-effective. While there is no real need for any CD/DVD burner, 3D graphic processor or wireless device, local storage may be done through using Solid State Drive (SSD) and mass storage by the network server. Regarding the energy efficiency, ultra Low Voltage (ULV) processors being compliant with most office tasks, a 15,6" low consumption flat panel and a high efficiency power supply are perfect.

2.3.3. To-day’s State-of-the Art

META prototype is shown in Figure 7. Its main specifications as achieved to-day are:

- Frame and mechanical parts: through the aluminium local industry knowledge and resources, a convenient recycling circuit is found, less than 20 pieces for a fully integrated desktop computer (screws and wires not included.) being used;

2.3.4. META Initiative

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- SSD hard-drive and fanless cooling system. Then the equipment is 100% noiseless;
- Power consumption: 32 W max. and "True" 0 W consumption when turned-off;
- 6 years life cycle.

2.3.4. Trends for to-morrow’s

Two examples (1) a more energy-efficient power supply (common yield is 60-70%) would permit to reach a 20 W power load (2) it is proposed to future users to explore local industry knowledge and resources as local use sustainably means local manufacturing.

3. CONCLUSION

The path is yet quite long. One example, the bad news, that have been widely discussed as given in a recent paper aiming to inform the general public: “Second Life Avatars Consume As Much Electricity As Brazilians” nothing but a horrible illustration of the "numeric gap" clearly demonstrated by Figure 2-b. But the good ones are more vital: your presence to-day and the initiatives supported by a new generation of conscious scientists.

ACKNOWLEDGEMENTS

The present tutorial having been suggested by Pr. Mohamed Salim BOUHLEL General Co-Chair of SETIT 2009, it is with both a great pleasure and gratefulness that I underline such more appreciable mark of honour. My thanks also go towards my Maghreb students, Leila Ben Ali and Abdeljalil ELKARI, the first in the world to have been graduated with a Ph. D. in that field, more than 15 years ago. I had also the great opportunity to work with Leatitia Souchon (formerly R-D FT Grenoble) and to have a contact with Abderazek SEBA (Algiers University) and to meet the META team (Bordeaux) particularly Michael de Muro: I appreciate the permission they gave me to use their work. Finally, the series of SETIT Conferences I had the privilege to attend, had resulted in a source of very fruitful discussions with many colleagues, both from Tunisia and other countries. Let me tell them my friendship and my very sincere thanks.

Appendix 1

LIST OF ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>CPU</td>
<td>Central Processor Unit</td>
</tr>
<tr>
<td>ETH-Zurich</td>
<td>Eidgenössische Technische Hochschule Zürich (Technical University of Zurich)</td>
</tr>
<tr>
<td>GIEC/IPCC</td>
<td>Groupe Intergouvernemental sur les Changements Climatiques</td>
</tr>
<tr>
<td>ICT’s</td>
<td>Information and Communication Technologies</td>
</tr>
<tr>
<td>IPCC/GIEC</td>
<td>International Panel on Climate Change</td>
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LRL Summit - A (communication privée, "Ener 98 Bordeaux 1 Report (Jan. 1994) «Energy programme, known as "Enveloppe SOLEAU" is then protected under the French legislation by a INPI to University Bordeaux 1 by Abdeljalil ELKARI (1993), OT3E Workgroup see Ref 8

6 BODLUND, R.M. WILLIAMS Planning Implications edited by T.B. JOHANSSON, B. End Trends and Technology in ELECTRICITY : Efficient Office Technologies in Europe

RF : Radiofrequency
SETIT : Sciences de l’Electronique, des Technologies de l’Information et des Télécommunications
SMDD/WSSD : Sommet Mondial pour le Développement Durable
SMISD/WSSI : Sommet Mondial sur la Société de l’Information
US EPA : United States Environment Protection Agency
TWh : TeraWatthours
UC-Berkeley : University of California at Berkeley
WSIS/SMSI : World Summit on the Information Society
WSDD/SMDD : World Summit on Sustainable Development
WWW : Who/When/Why or WorldWideWeb

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1 ExaWatthours : 10^18 TWh. See a conversion table : http://www.convertunits.com/from/joule/to/exawatt+hour
2 A list of acronyms is given in Appendix 1
4 Our preliminary results were presented in 1988 by J.P. Harris (ACEEE Summer Study – Asilomar California – Aug. 1988) and J. Roturier (Energy 88 Conference – Barcelona – Spain)
6 These 3 scientists have been active members of the OT3E Workgroup see Ref 8-a
7 That device, invented as part of a thesis work, submitted to University Bordeaux 1 by Abdeljalil ELKARI (1993), is then protected under the French legislation by a INPI programme, known as “Enveloppe SOLEAU”