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THE GLOBAL ENERGY LEGACY

Peter Tarana*

Ronald Stewart

Richard Perez

*Adirondack Community College
Queensbury, NY 12804

ABSTRACT

The Global Energy Legacy (GEL) is a mechanism designed to begin implementing the renewable energy generation systems which will mitigate long term global environmental and energy problems. By solicitation of public and private contributions, GEL will undertake to commission renewable energy systems through a public service not-for-profit corporation. GEL will proceed to directly re-invest revenues from energy production into new renewable energy systems - effectively serving as a renewable energy breeder. Using conservative technical and economic assumptions it is shown that a one-time contribution of $1 million toward a photovoltaic system will generate a legacy increasing beyond 1 megawatt of generating capacity. Yearly contributions of $100 million would yield over 7,000 MW in 50 years while also preventing the production of CO_2 equivalent to that absorbed by 40,000 square miles of mature forests.

KEYWORDS

Photovoltaics; wind; economics; funding mechanisms; environment.

1. BACKGROUND

Environmental and energy concerns are associated with many of the issues that find their way into today's headlines. However, behind the headlines are two fundamental underlying facts: (1) the global pollution of the biosphere, and (2) the growing demands on our finite fossil fuel resources. Although questions remain as to the urgency of these two problems, many symptoms are quite apparent (e.g., oil spills, CO_2 increase, recurrent international crises).

Energy conservation, as well as renewable energy resources such as solar and wind energy, are generally perceived as long term solutions to these concerns. However, although renewable resources have a very large potential, and have achieved a practical level of development and reliability, their implementation has been, and continues to be, only marginal.

The reason for this is an economic one; with large up-front capital costs, some renewable energy systems are at a disadvantage to compete with other forms of energy generation given current financing practices.

In particular, when a "bottom line" decision is made for investing in a new energy generating plant, little importance is given to the following:

(1) Environmental impact: External environmental costs are only beginning to

be considered today. Still, we are faced with considerable debate before legislation truly reflective of all impacts becomes established and implemented.

(2) Long-term fuel availability: Only short term fuel cost projections, which often prove inaccurate, are considered. Long term fuel availability is not taken into account at the decision making level (nor can it be, as we have little control over long term availability).

(3) Lifetime: Since standard financing procedures rely on a discount rate as a benchmark to measure profitability, and since this discount rate is generally selected higher than inflation, any cash flow in the distant future is effectively discounted and has negligible present value. As a consequence a system lifetime extending much beyond twenty years has very little value in the decision making process.

Some renewable energy options score highly on these three benchmarks but unfortunately are given little weight in the short term decisions that shape our energy future.

As a result, the markets available to the solar industry are growing more slowly than they should. These markets are crucial to a steady development and improvement of the renewable technologies and a maturing and strengthening of the industry.

2. THE GLOBAL ENERGY LEGACY (GEL)

The Global Energy Legacy (GEL) was conceived as a mechanism to start implementing **today** the renewable energy generation systems that will mitigate long term global environmental and energy problems.

2.1 The GEL Approach

By solicitation of public and private contributions, GEL will undertake to commission clean, renewable energy systems through a public service not-for-profit corporation. This service will aid educational facilities as well as utilities and industry. This effort will have two immediate beneficial global consequences for the environment and our long-term energy situation:

(1) directly, by displacing polluting, non-renewable energy, and

(2) indirectly, by expanding the markets available to the solar industry (hence triggering lower costs leading to more applications and more fuel displacement).

But more importantly, the key component of the GEL approach will be to **directly re-invest revenues from energy production into new energy systems**. This mechanism will have the effect of perpetuating and increasing initially donated systems: each renewable energy system implemented through GEL will act as a renewable energy **"breeder"**, providing a growing legacy of clean energy for the next generations.

2.2 An Example Case Study

The renewable energy breeding potential can be demonstrated through a case study simulating the long term energy and environment impact of a system implemented through GEL.

Let us illustrate the impact of a one-time $1 million contribution made in 1991 to GEL toward a photovoltaic electricity generation system.

The assumptions of this case study are of three types: (1) technical assumptions pertaining to the considered photovoltaic system, its current and projected cost, its energy yield and its useful life; (2) energy/environment assumptions reflecting the current and projected value of energy produced by the system, and (3) assumptions pertaining to the operation of GEL.

Note (*) that all cost figures given below are in constant 1991 dollars.

Technical Assumptions

(1) Cost per installed peak Watt in 1991: **$7.50***
(2) Real (after inflation) photovoltaic cost reduction through maturing of industry: **5% per year**
(3) Minimum achievable installed cost per peak Watt after industry maturation: **$1.75***
(4) Ideal PV energy yield per installed Watt: **1.75 kWh per year** (conservative)
(5) System availability: **85%** (hence actual energy yield equals 1.49 kWh per year per installed Watt)
(6) System energy output degradation over time: **-1% per year**
(7) Systems are discarded after: **35 years**

Energy/Environment Assumptions

(1) Current value of energy produced by system: **$0.11* per kWh** -- we assume that the photovoltaic system is a demand-side system that could contribute to meeting the load requirements of summer peaking utilities in the U.S. (see refs. 1 & 2). The selected figure is well in line with demand side rates for many such utilities.
(2) Real (after inflation) energy value increase over time: **1.5% per year**--this conservative figure reflects the gradual penetration of environment externalities in the cost of electrical energy and is certainly below recent trends.
(3) Maximum energy value achieved: **$0.16*** (we conservatively assume that after a gradual increase, energy value will reach a ceiling).

GEL-Related Assumptions

(1) GEL overhead on public and private contributions: **20%**
(2) GEL operation and system O&M costs as a percentage of energy production proceeds: **40% (i.e., 60% of proceeds are reinvested into new energy systems).**

Through straightforward simulation, it is possible to calculate, based on these assumptions, the evolution of the considered photovoltaic system as energy proceeds are reinvested into adding new photovoltaic capacity.

Figure 1 illustrates the evolution of the installed photovoltaic capacity resulting from a one-time $1 million contribution. The fact of the matter is that a **one-time contribution will generate an unending and growing flow of renewable energy:** Starting at 100 kW for a $1 million investment may sound uneconomical as judged by current financing practice. However, this translates into a legacy of almost 1 MW installed capacity 50 years in the future at a time when environmental and energy demand considerations may have become paramount. A comparable "profitable" investment in a conventional energy plant will not achieve this result.

To further put the impact of the one-time $1 million donation in perspective, it is possible to review the environmental and energy conservation benefits resulting from the system's operation over the years. Table 1 reports these benefits through a set of illustrative benchmarks. These benchmarks are:

(1) The cumulative energy produced by the growing GEL PV system
(2) The cumulative amount of CO_2 saved by not producing this electrical energy with coal fired plants
(3) The number of mature trees that would be required at any point in time to displace as much CO_2 [3]
(4) The cumulative amount of various pollutants saved by not burning coal [4]
(5) The number of barrels of oil saved by not producing the equivalent electrical power with oil burning turbines
(6) The number of electrical cars (12,000 miles per year) that could be supplied 100% by electrical energy produced yearly by the one-time $1,000,000 GEL system [5]

The numbers included in Table 1 demonstrate the dramatic long-term impact of a renewable system installed today using the GEL structure.

Further, extrapolating the one-time $1 million case to yearly contributions equivalent to a small fraction of U.S. public and private contributions, one obtains figures which demonstrate the long-term, large scale global potential of implementing GEL today. Table 2 reports such figures based on yearly contributions of $100 million amounting to <u>only two tenths of one percent of U.S. oil imports</u> [6]. The numbers are quite impressive: Using the mature tree equivalent benchmark, we would exceed the CO_2 removal capability of 40,000 sq. miles in 50 years and, with an installed PV capacity of 250 GigaWatt, we would exceed the 1,000,000 sq. mile mark in 100 years. In terms of electrical cars supplied 100% from renewable energy, we would supply over 2 million cars in 50 years and over 75 million cars in 100 years.

As a final remark on this case study, we stress again that the technical, operational and energy/environment assumptions taken are conservative. In this respect, note that the fundamental concept of GEL, that is the renewable "energy breeding" legacy, would be maintained even if drastically more conservative assumptions had been taken. For instance, discarding PV systems after only 15 years, paying as much as $20 per installed Watt today, or using a minimum achievable PV cost of $5.60 would still produce system growth over time. Conversely, estimates in Table 2 would be doubled by using only slightly less conservative assumptions, such as a ceiling energy cost of 18 cents instead of 16 cents.

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Based upon 7 million bbl imported daily at $20/bbl.

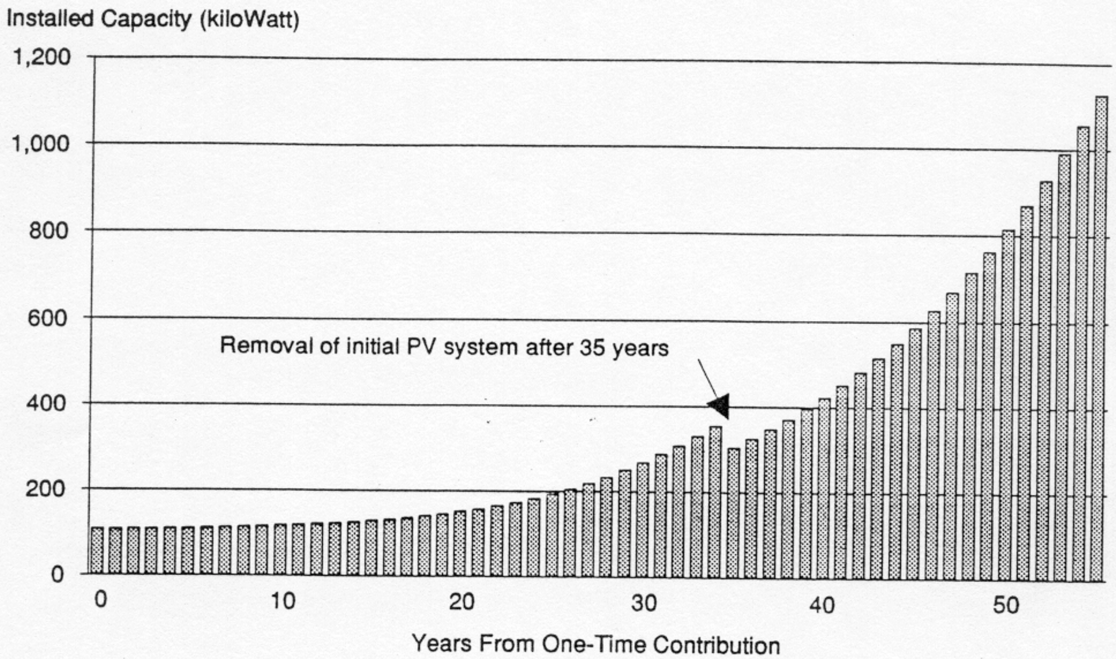

Figure 1: Growth of installed photovoltaic capacity resulting from a one time $1 million contribution to GEL

Table 1

RESULT SUMMARY -- one-time $1 million contribution --							
	Installed Capacity kWatt	Cumul. Energy MWh	Cumul. CO2 1000Xlbs	Mature Trees X 1000	Cum. Co, Nox, So2 TSP, O3 and other toxic (1000Xlbs)	Cum. Oil Barrels X 1000	Elec. car Yearly Supply
year 1	107	159	476	37	4	0	32
year 25	193	5,075	15,224	66	123	12	67
year 35	304	9,177	27,532	104	223	22	90
year 50	815	21,133	63,399	280	514	50	242
year 75	3,991	98,174	294,523	1,370	2,386	234	1,187
year 100	19,439	472,782	1,418,346	6,673	11,489	1,126	5,783

Table 2

RESULT SUMMARY -- yearly $100 million contributions --							
	Installed Capacity (MW)	Cum. GWh	Cum. CO2 10^8 lbs	Mature Trees (million)	Cum. Co, Nox, So2 TSP, O3, other toxics (million lbs.)	Cum. Oil Million Barrels	Elec Car Supply X 1000
year 1	11	16	0	4	0.39	0	3
year 25	805	10,894	327	276	264.74	26	240
year 35	2,202	32,984	990	756	801.51	79	655
year 50	7,377	133,935	4,018	2,532	3,254.61	319	2,195
year 75	44,519	937,070	28,112	15,282	22,770.80	2,231	13,244
year 100	253,777	5,571,967	167,159	87,114	135,398.80	13,267	75,499