TAKING A FEW ENERGETIC STRIDES TOWARD A SUSTAINABLE FUTURE

by
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The purpose of this paper is to address the conference question: "Can the Last Frontier have a sustainable future?" However it is only possible to address a few aspects of that issue, and I will apply my experience and expertise to demonstrating the physical/energy dimensions of a sustainable Alaska. Since I have recently returned from a German Fulbright Summer Study (June 5-26, 1999) on the theme of "Alternative Energy and Environmental Protection", there is much "political spice" and interesting international examples which can add credibility and demonstrable feasibility to my message. I will, in the short space of this paper, try to show how quite feasible is a renewable energy future for Alaska. And also, there are ongoing efforts and developments in Alaska (although not nearly enough!!) which lend further credibility and hope to the renewable energy prospects for Alaska.

WIND

First, a look at the wind energy prospect. Because of the huge disparity in electric prices, the continuing policy of P.C.E., the Power Cost Equalization plan, and the lack of investment by the state and rural coop in wind (except for Kotzebue Electric), and the enormous wind resource available in coastal western, southern, and northern Alaska and the Aleutians, wind is, and has been an appealing option. Wind is particularly good as a renewable alternative, because it is synchronous with the electrical loads: wind energy potential, as measured in average wind speed, is consistently higher in the winter months, when energy needs are higher. See figures 1 and 2, from the "Wind Energy Resource Atlas of the United States. Shown are the maps (2-16 and 2-22) for Alaska, indicating the annual average wind resource estimates and the winter wind resource. In the original color coding it is clear that wind is a maximum in the winter, hardly a new insight to those who live on the coast.

But the implications of a winter peak are instructive. First, wind is a good match to move to wind/diesel hybrids, especially for peak load capacity. And second, as economics hopefully brings photovoltaics into contention for electrical supply, there is then a complimentarity for a wind-photovoltaic hybrid system to supply an electrolyzer with electricity to produce hydrogen by electrolysis. Why suddenly hydrogen? Many reasons lead to a path which utilizes hydrogen as an energy carrier. It can be used for most energy applications: fuel for transportation, even aircraft, snow machines, and autos and trucks. It can supply onsite fuel for home heating, domestic hot water, showers and washeterias, and it can be burned in a fuel cell to produce electricity with added prospects of useful waste heat from this process.

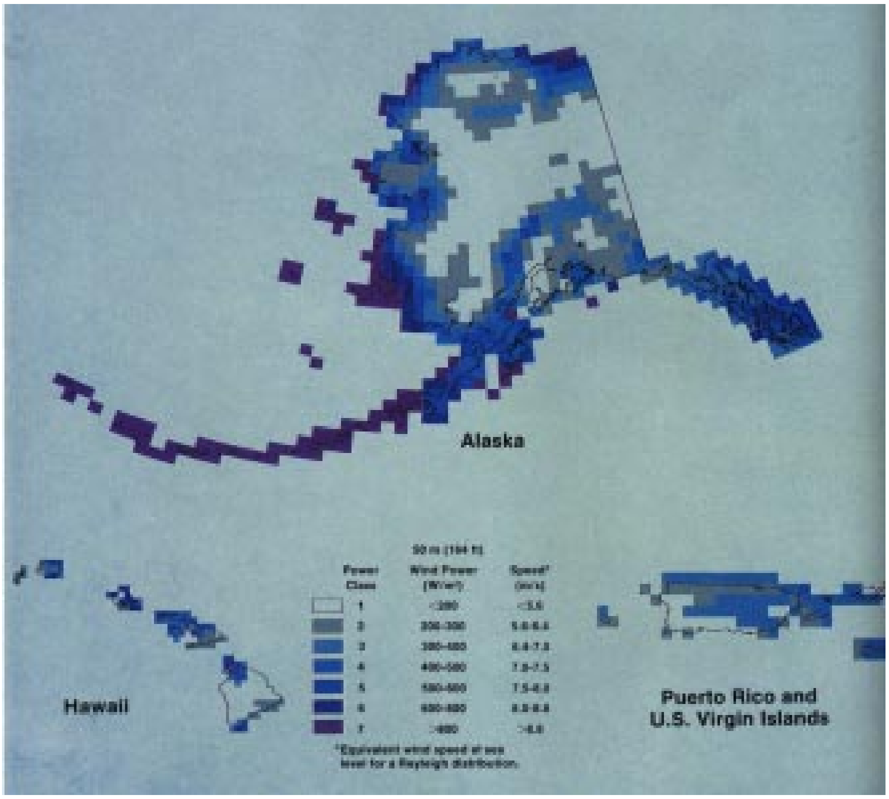


Figure 1. Annual average wind resource estimates in Alaska, Hawaii, Puerto Rico, and Virgin Islands.

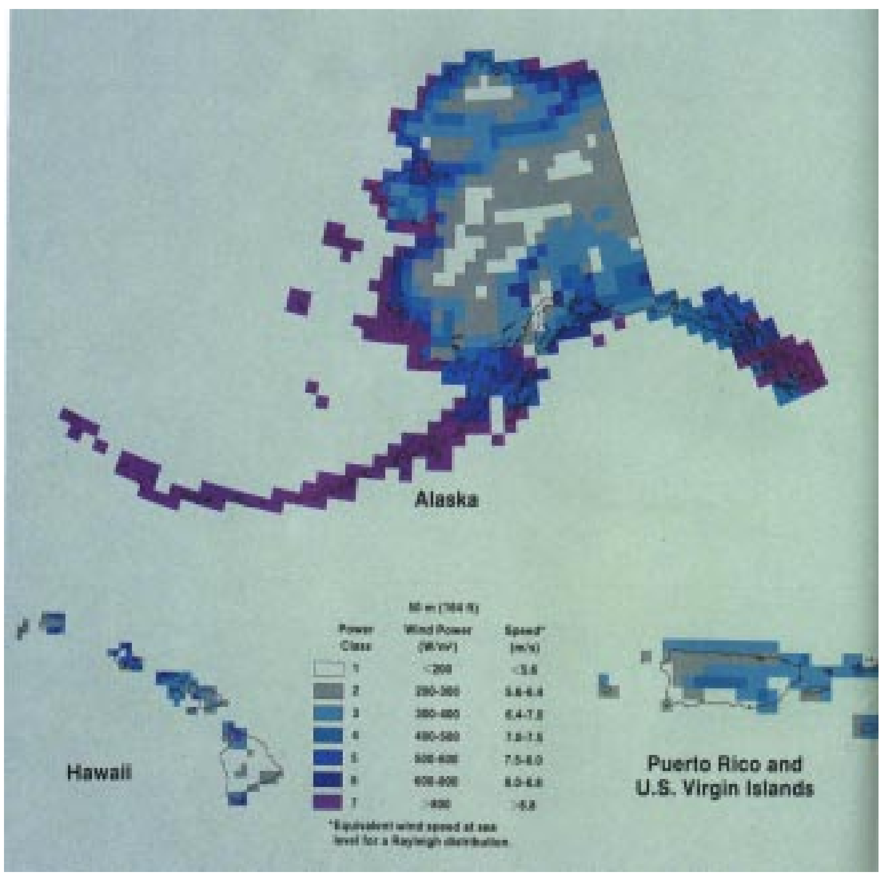
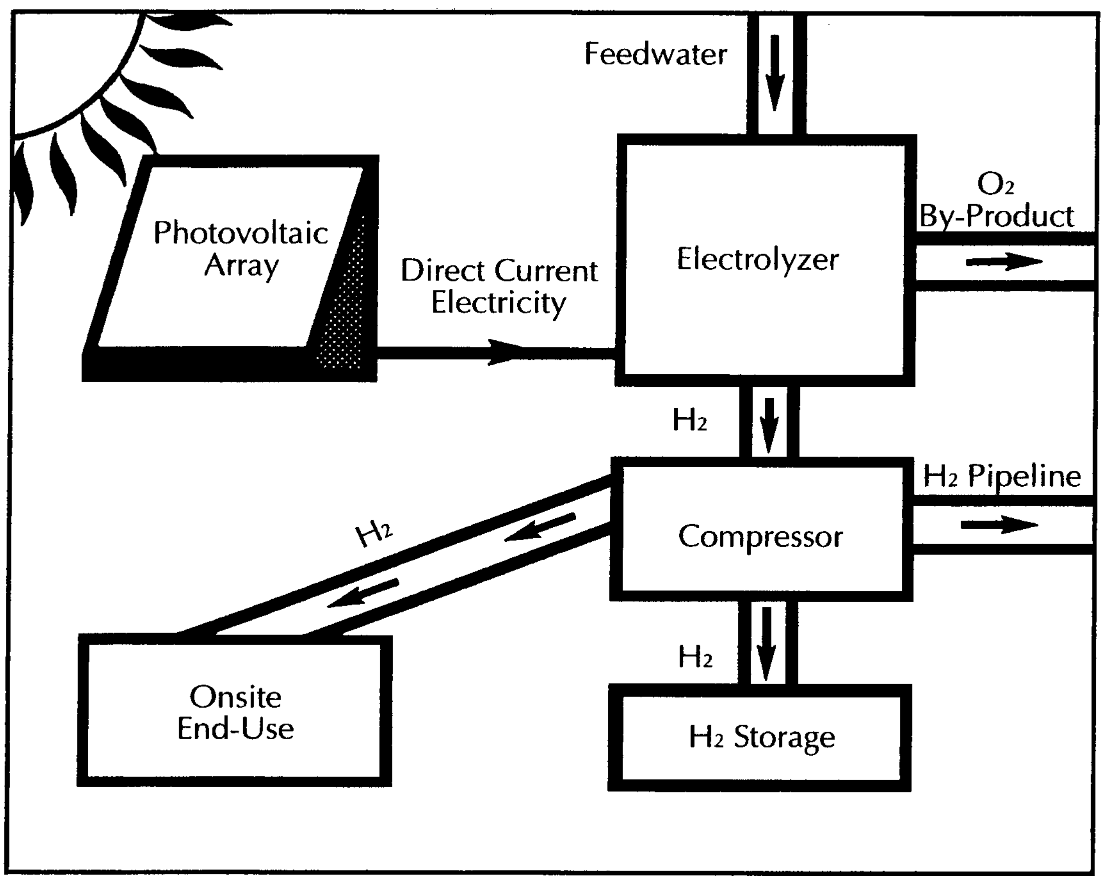


Figure 2. Winter wind resource estimates in Alaska, Hawaii, Puerto Rico, and Virgin Islands.

Figure 3, from Ogden and Williams, shows a schematic of how such a component system might work. The pipeline of H_2 is hypothetical for a large grid system and would not be relevant to Rural Alaska sites. Also, only a photovoltaic array is indicated as feeding direct current electricity to the electrolyzer, but obviously a wind generator could do the same when wind was available. The earlier mentioned fuel cell, in the Alaska conception, is in the onsite end-use block. Fuel cells have great possibilities, and they are being actively researched by the engineering department at UAF for rural application in the future. A conference discussing these efforts is planned for UAF in mid-August.

Fuel cells, utilizing stored hydrogen, take a big problem out of the equation for small off-grid electrification systems: batteries disappear!! Batteries are the nemesis of small electric systems requiring electricity storage: they are heavy, often made with highly toxic materials, have a high cost and relatively short life. Getting rid of batteries solves myriad problems, economic, technical and environmental. Hydrogen as an energy storage medium is better on most accounts, and eliminates fossil carbon use for electricity productions. Clearly this process is worthy of our attention for a sustainable paths for Alaska's energy supply.

A Solar Photovoltaic Electrolytic Hydrogen System



A PV array converts sunlight into DC electricity, which powers an electrolyzer, splitting water into its constituent elements, hydrogen and oxygen. A compressor pressurized the hydrogen for storage, onsite use or pipeline transport to distant markets.

Figure 3.

How to fund this? Several suggestions come to mind. Capital investment in rural electrification should be a joint effort of rural utilities, the state industrial development authority (AIDEA), and perhaps native corporations and municipalities. The Kotzebue Electric model is yet to clearly emerge, as to how their experience might be spread, purchased, maintained, owned. Politics will determine much, but should not foreclose new or unusual coalitions for funding rural energy systems. If they can't be sustainable, then the aspiration is a hollow one.

Before leaving wind, let me show figure 4, a series of photos from a wind power "farm" of sorts in the former East Germany. Shown are two views of the 1.5 MW Enercon German wind machines, which could be viewed by some as lovely kinetic sculptures. They are certainly not noisy. But not everyone thinks windmills of this size and type are an aesthetic improvement of the landscape.

Figure 4.

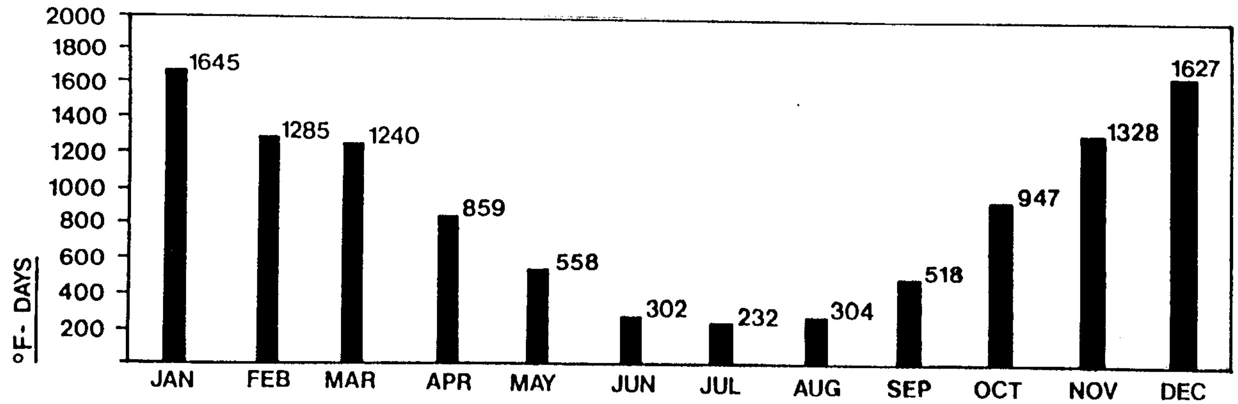
So in order to add an astute human dimension, and to develop a personal tie between the wind machines and the community, the owners of this "farm" got the local schools involved in adding a theme-based painting (up to 40 feet high up the tower base). Each school range class from ages 8-16 got their chance to permanently paint a machine. The one with the sea creatures has a "Protect the Oceans" theme, and the lower left one has a very interesting "Lebensbaum" theme, meaning "Living tree, tree of life". This is adapted from a matriarchal African fable, feminist really, of linking us all through our ancestors in an organic life supporting social and biological structure. In this way the wind machines become art, and environmental icons for the community, certainly a fabulous political aid to their acceptability. This dimension of helping people to imagine, first, and aesthetically and personally accept renewable energy seems like an elegant lesson which should not be lost in our sometimes overly technical approach.

An additional political note is also important. Lebensbaum is an adversarial, alternative allusion to Hitler's use of the term "lebensraum", meaning living space, breathing room, which he used as justification for Anschluss(s) in Austria and the Sudetenland, that Germans needed more "living space". So there is much more than simply meets the eye to these artistic windmills.

SOLAR AND PHOTOVOLTAIC (PV)

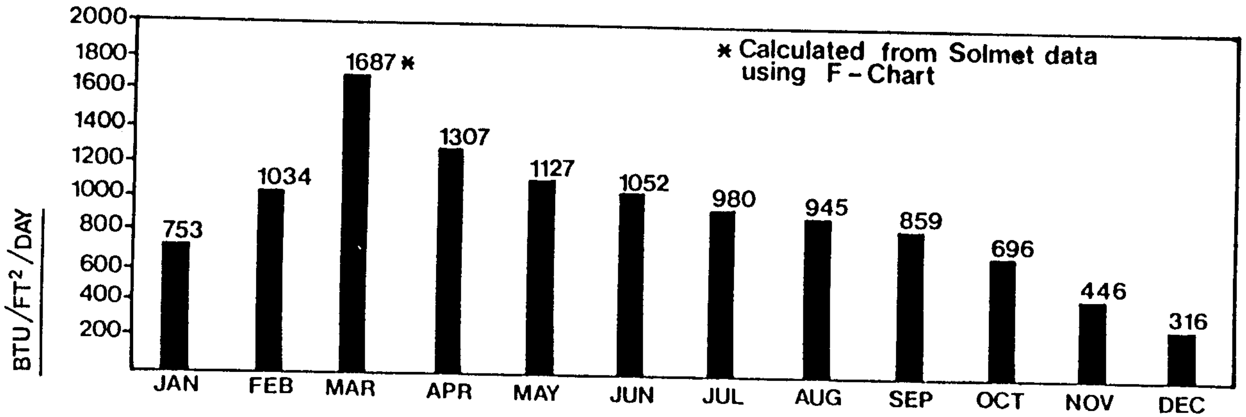
Let's move quickly to the solar and photovoltaic alternatives. Alaska's low sun angles provide a very interesting opportunity for solar architectural thinking. Figure 5 (from Seifert, 1981) makes this point clearly. It is the annual solar radiation (the bottom graph), of the average solar radiation on a *vertical south-facing surface*. This can simply be construed as the south wall or facade of a building. Because of our annual climatic conditions, cloud cover, and snow cover over the winter and spring, this plot has some rather counter-intuitive information. The one shown is for Palmer (Matanuska). Radiation on the south surface peaks in March, and then declines all the way through December, quickly building again through January and February. February and March are typically two of the months with the most clear weather in the year, a fact which adds greatly to this information. So clearly building facades, particularly south faces, and roofs, get a lot of solar radiation. So what might they yield if we in fact, built them to collect energy? Figure 6 and 7 show photovoltaic building facades precisely designed to be aesthetic, provide shade (Figure 6) and at the same time, produce electricity. Both are from the Ruhr Valley of Germany, an area not highly regarded for its solar potential.

What follows is an order of magnitude calculation to get an idea of how much photovoltaic electricity could be produced if we were to promote photovoltaic roofs and facades in Alaska. The federal D.O.E. has initiated a "Million Solar Roofs" initiative which has no funding and is stalled and doing nothing at the moment. Figure 8 shows a humorous interpretive advertisement done by Siemens Solar GmbH, and run in every major magazine and newspaper in Germany.



Average Monthly Heating Degree Days

Matanuska, Alaska



Average Solar Radiation on a Vertical South Facing Surface

Matanuska, Alaska

Matanuska heating degree days and average solar radiation. These graphs illustrate that the annual heating degree days (which are an indication of a building's heating requirements) are not in phase with the solar radiation on a south-facing vertical surface. This has positive implications for passive solar heating. The solar gain is highest in March and April when heating is needed. Data are from Kusuda and Ishii (1977).

Figure 5.

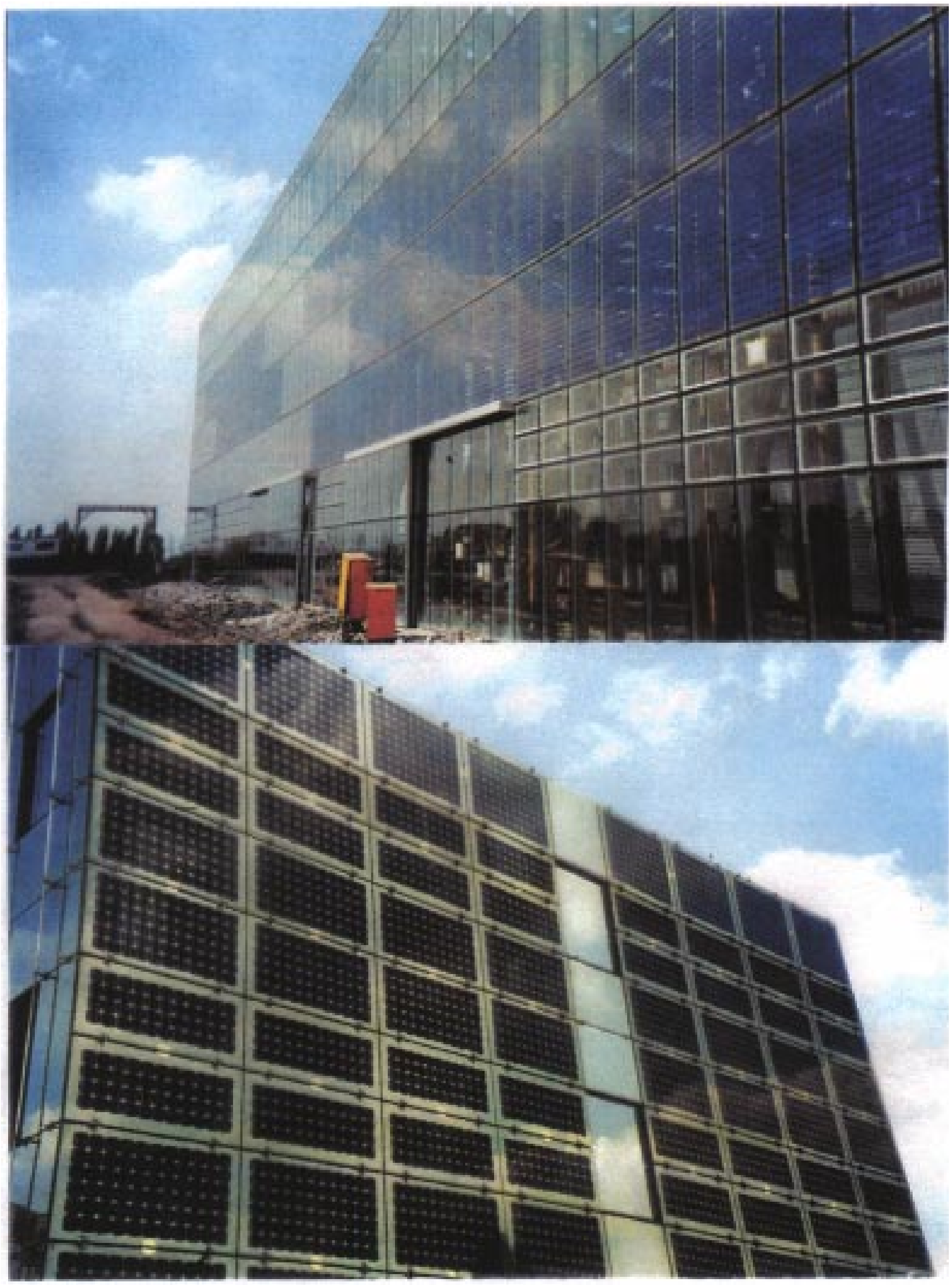


Figure 6 and 7.

SIEMENS

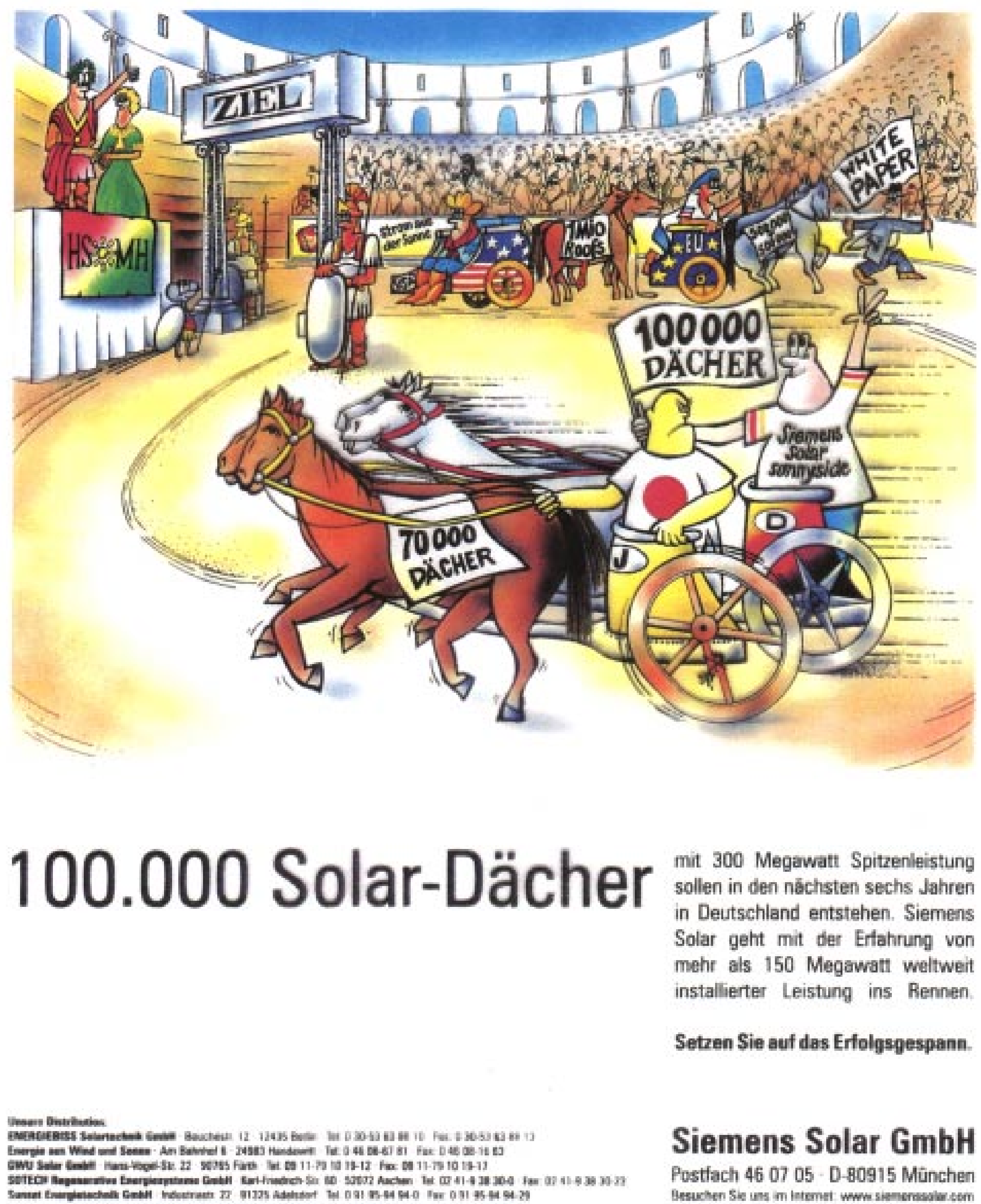


Figure 8.

A QUICK CALCULATION OF THE AMOUNT OF SOLAR COLLECTION AREA AVAILABLE ON ROOFS OF BUILDINGS IN ALASKA:

First: Estimate how many residential buildings there are, their average roof area, and aspect suitable for solar collection:

As a ratio, the Fairbanks NS Borough has 24,000 residences for a population of 95,000 (1990 census numbers). This number is somewhat distorted by the military population.

This is a rate of: 252 residences / 1000 persons

If we apply this rate to Alaska statewide, the population base is 610,000. At 252 residences / 1000, this yields 153,720 residences.

If we conservatively assume that 50% (one half) of the residences have appropriate exposures and roof slopes or vertical surfaces to allow for solar collection, (we'll use photovoltaic for this estimate) and further that each of the residences has 110 square meters of roof (1200 ft^2), but only half that area is south slope, we get the following suitable area for photovoltaic electricity production on roofs in Alaska: (residential only!!)

$$76{,}860 \text{ residences} \times 55\ {}^{m^2}\!/_{\text{residence}} = 4{,}227{,}300\ m^2 \text{ collection area.}$$

How much solar electricity could this produce?

For 10% efficient PV systems, and assuming an annual solar radiation level equal to that for Palmer, Alaska (selected because it is a solid number in the middle of the largest population density in Alaska):

$$830\ {}^{BTU}\!/_{FT^2\bullet Day} \times 365 \text{ Days} \times {}^{1\ KWH}\!/_{3413\ BTU} = 88.76\ {}^{KWH}\!/_{FT^2}$$

$$\times\ 10.9\ {}^{FT^2}\!/_{m^2} = 967\ {}^{KWH}\!/_{m^2}$$

Only 10% of this energy is available assuming a PV system efficiency of 10%, yielding 96.7 $^{KWH}/_{m^2}$

How many $^{KWH}/_{year}$ are available then from 50% of the residential rooftops of Alaska?

$$4{,}227{,}300\ m^2 \times 96.7\ {}^{KWH}\!/_{m^2} \cong 408 \text{ million KWH per year.}$$

How much is this? If the average household uses at today's rate, about 8609 kwh/$_{year}$ (GVEA number, 1999)

Then the PV could supply about 47,479 houses, about one third of the residences. A clear message here is that PV could supply a much larger percentage if the average residential use were reduced. If it could be reduced by 2/3, the amount produced by PV from only one-half of the rooftops of one-half of the residences of Alaska, would provide an amount equal to the consumption of the entire housing stock (!!).

Perhaps most important is the close match (within a factor of 3) of the energy supplied by PV compared to the average household use today. Of course other complicating factors greatly affect the validity of this calculation, particularly the winter peak of electricity use versus summer peak of available electricity production from solar PV.

Other interesting insights from this analysis:

1. PV makes much more economic and physical sense if electrical demand is reduced by energy efficient lighting (CFL's) and appliances.

2. Demand side reductions and conservation, including energy efficient housing is also clearly a good idea, especially good public policy, and largely the model already exists in Alaska (Thermal Efficiency Standard, BEES, Energy rated mortgage incentives, ABSN, ACHP, and Alaska Cooperative Extension UAF housing education programs sponsored by USDOE and AHFC).

   These housing programs can be linked to utility incentive programs to enable consumers to buy energy efficient appliances through their utility and pay through its accounting. A good example of this practical, excellent idea is already in place with Homer Electric Association.

3. The PV analysis doesn't include any consideration of adding PV to the roofs and facades of commercial buildings. These have huge surface areas and when the economics are right, it completely changes the economics of commercial buildings and space. Suddenly rooftops and facades (south-facing) of commercial buildings can be used to produce electricity, perhaps even become net producers, adding an income stream to commercial space not presently even conceived of by most commercial property owners.

   This also may infer that new central power plants may NEVER again be needed, since any NEW production could come from residential and commercial surfaces with PV. The role of a utility and its grid system shifts radically in this conception, wherein the grid now serves as a battery and distribution system for new PV production, as well as its standard use of today.

THE HYDROELECTRIC ASPECT OF A RENEWABLE/SUSTAINABLE FUTURE FOR ALASKA:

Alaska's undeveloped hydroelectric potential is still a large prospect for electric power production, as well as being renewable, if not forever (due to reservoir siltation and other long term effects), at least for a hundred years or more. In the 1980s much attention was given and controversy raised over the anticipation of building the Devil's Canyon Hydroelectric Project on the Upper Susitna River. This project, with a minimum of 2 dams, could supply 1600 megawatts of electricity to the railbelt grid. Another, perhaps even more attractive hydroelectric prospect is the Chakachamna site, across Cook Inlet from Anchorage. Both of these alternatives have been intensively studied in a controversial past. (see U.S. dept. of the Interior, A.P.A., Devil's Canyon Project, Alaska, status report, 1976, and Malone and Rogers, Final Report, House Power Alternatives Study Committee, Alaska State Legislature, Sept. 1980).

Although a thorough review of the virtues of building large, significant hydroelectric projects for Alaska's future is beyond the scope of this paper, it is the opinion of the author that large hydro in the railbelt could now, and in the next 30 years, prove a wise, clean and reliable renewable energy source for Alaska to move to sustainability. While electricity is not what we need as an end use for service delivery, (transportation use is nearly 50% of energy end use in Alaska now, and you can't fly airplanes, run boats, or snowmachines on electricity, and electric cars certainly seem to have some considerable limitations), with the advent of fuel cells for use in hybrid or multifuel transportation modes, hydroelectricity in surplus over the base utility demand for electricity, could provide electrolytic hydrogen through use of electrolysis of water, and provide hydrogen fuel as a basis for transportation and domestic fuel use. This path of energy production allows a transition entirely away from fossil fuel use, taking fossil carbon out of the energy use sector. This would have enormous environmental and social benefits, not the least of which is minimum liability for worsening global warming. It is the intent here to mention it (hydroelectric development) as a positive future option and path about which Alaskans should reconvene a dialog.

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