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KEELING, SCHNEIDER AND HAWKING: GLOBAL WARMING THEORY (GWT)

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Abstract

Global Warming Theory (GWT) has come of age sine Swedish chemist Svante Arrhenius anticipated it around 1895. It is not quite as established as Einstein's theory of relativity or Weber's theory of political authority. It may comprise blunders like Einstein's cosmological constant or Weber's failure to distinguish between rule by law and rule of law. Yet, it scores high enough on systematic observational evidence and parsimony in order to be takes most seriously. It does not contradict established theory like the principles of thermodynamics. And it predicts dangers or catastrophes that mankind must avoid, even at very high costs for basic energy transformation. What is mission is a social science counter-part, a management theory of how to fulfill the UNFCCC goals in the Paris Treaty 2015.

Keywords: Management of decarbonisation: UNFCCC; COP21: GOALS: I, II and III, CO2 – Temperature; Ouarzazate size solar parks

INTRODUCTION

All forms of energy be measured, and these measures are translatable into each other – a major scientific achievement. One may employ some standard sources on energy consumption and what is immediately obvious is the immensely huge numbers involved (see Table 1).

Table 1. Energy consumption 2015 (Million Tons of oil equivalent)

	Total	%
Fossil fuels	11306,4	86,0
Oil	4331,3	32,9
Natural Gas	3135,2	23,8
Coal	3839,9	29,2
Renewables	1257,8	9,6
Hydroelectric	892,9	6,8
Others	364,9	2,8
Nuclear power	583,1	4,4
Total	13147,3	100,0

Source: BP Statistical Review of World Energy 2016

Sad to say, one bypasses the constantly increasing need for energy, the augmentation of air transportation, more cars and bigger engines, and first and foremost more human beings! The COP21's GOALII calls for decarbonisation entails a sharp reduction of fossil fuels up until 2030 in order to stabilize climate change, involving a 30-40 decrease in CO2 emissions, measured against the 2005 level of emissions. Coal must be eliminated completely by 2030! Let us here focus upon what this hoped for reduction of fossil fuels implies for the augmentation of renewable energy consumption, here solar power. The use of atomic power is highly contested, some countries closing reactors while others construct new and hopefully safer ones. I here bypass wind power and thermal power for the sake of simplicity in calculations.

Time has come for halting and reducing CO2 emissions by real implementation and not utopian dreams of a sustainable economy (Sachs, 2015). There is nothing to wait for any longer (Stern, 2015), as the COP23 in Bonn this fall must set of the promised Super Fund. No time for politicking in the UN any longer (Conca, 2015; Vogler, 2016). The COP21 project houses lots of reneging opportunities of various sorts, which will become clear as this CPR project moves forward. One major partner has already defected, which may trigger other governments to renege. The only way to control defection in this global CPR is to employ *selective incentives*, which is what the planned Super Fund could offer, if at all workable.

The COP21 objectives are: GOAL I: Halt CO2 increases by 2018-2020; some countries already have done so, but far from all; GOAL II: Reduce CO2 emissions by 30-40 per cent at 2005 levels, depending on how counts, by 2030 – an immense challenge; GOAL III: Complete decarbonisation by 2070-75.

GLOBAL WARMING THEORY (GWT)

The most recent addition to GWT is Stephen Hawking's ominous prediction about irreversibility. GWP has been known for some 200 years, but never harbouring such dramatic hypotheses. French mathematician Joseph Fourier discovered global warming in the early 19th century looking at its contribution to warming a too *cool* planet Earth. But the negative theory was developed by Swedish chemist Arrhenius around 1895, focusing on the risk of *overheating* the planet Earth. He calculated that a doubling of CO2 ppm would be conducive to a 5 degree increase in global average temperature, which is not too far off the worst case scenario for the 21rst century, according to UN expertise now. Not until Stephen Schneider published Global Warming in 1989 did the theory receive wide attention with his journal Climate Change, no doubt strengthened by the work of Keeling in measuring CO2 ppm globally. Moreover, techniques for viewing the CO2 layer were developed, increasing the attention to climate change. Now, the UN reacted with creating a few bodies to look into the changes going on, one of which was the COP framework.

The economists entered the GWP, worried about the future costs of this transformation of the atmosphere. On the one hand, Kaya and associates presented in 1997 a model that explained CO2:s with energy and energy intensity of GDP. On the other hand, Stern called global warming the largest externality in human history, calling for international governance in order to stem the growth of greenhouse gases. Stern outlined in 2007 a number of activities aimed at reducing CO2 emissions, promising also a Super Fund to channel money from rich advanced nations to poor countries and developing economies. As little has been done through the UN system of meetings and agencies – transaction costs - up to date, Stern 2015 asked: "What are we waiting for?", neglecting his promise of the *Super Fund* (Ramesh, 2015), to assist poor and developing economies with energy transition.

A scientific theory needs two things, namely diverse empirical underpinning as well as deductive support from other theories. One may say that we now possess a lot of empirical evidence that support GWT. It is a matter of quite diverse phenomena, difficult to explain outside of GWT:

a) Huge land losses along the costs;
b) Too high temperatures for men and women to work outside;
c) Food production decline;
d) Fish harvest decrease;
e) Droughts and starvation;
f) Lack of fresh water supply;

g) Drying up of rivers, affecting electricity supply;
h) Ocean acidification and species extinction;
i) Highly volatile climate with giant forest fires, storms, rainfall and tornados with tremendous damages;
j) Deforestation and desertification;
k) Transformations of the South and North Poles as well as the slow by constant diminution of glaciers.

In terms of deductive support, it has been claimed that GWT contradicts thermodynamic hypotheses – see debate in Skeptical Science. However, GWT satisfies Occam's razor, integration a large number of empirical findings by means of a few theoretical hypotheses, seemingly in agreement with principles of thermodynamics.

Actually, the dominant opinion in the social sciences and economics towards GWT was skepticism about its claims, if not outright rejection. On the one hand, political scientist Aaron Wildavsky linked GWT to environmentalism, which he regarded as the leftist ideology of an anti-capitalist movement: "Global warming is the Mother of environmental scares", declared Wildavsky (1997). On the other hand, Julian Simon (2002) questioned the economic foundation of GWT as well as environmentalism in general. If the ecologists were right, there would be scarcity of basic resources in the world. But prices on raw materials keep falling, noted Simon.
Today, one may speak of two currents of social science theory that are highly relevant for GWT: *Implementation theory*: In the discipline of public administration and policy-making, some ideas about the so-called "implementation gap" – *Wildavsky's hiatus* – are highly relevant to the COP21 project (Pressman and Wildavsky, 1973, 1984). The COP21 has three main objectives: halt CO2 increases by 2018-2020 (GOAL I), decrease CO2 emissions considerable by 2030 (GOAL II) and achieve full decarbonistion by 2070-80 (GOAL III).

But how are they to be implemented? No one knows, because COP21 has neglected what will happen after the major policy decision. The COP21 project outlines many years of policy implementation to reach decarbonisation, but which are the policy tools? *Game theory*: A CPR is vulnerable to the strategy of reneging, as analysed theoretically in the discipline of game theory. The relevant game for the CPR is the PD game, where the sub game perfect Nash equilibrium is defection in finite rounds of play of this game – backwards induction (Dutta, 1999). This is not recognized by Elinor Ostrom (1990) in her too optimistic view about the viability of CPR:s. It is definitely not the case that Ostrom has overcome Hobbes ("covenants are in vain and but empty words; and the right of all men to all things remaining"), as one commentator

naively declared when she was awarded both the Nobel prize and the Johan Skytte prize (Rothstein' website 2014). The COP21 project is a CPR that may well fail, either due to defection or lack of management resources and skills.

The giant common pool regime that the COP21 Treaty has created can only succeed by the use of *selective incentives*, like the promised Super Fund. The COP2 Treaty as a common pool regime (CPR) is weak, and subject constantly to the threat of defection. No time for politicking in the UN or the G20 any longer (Conca, 2015; Vogler, 2016).

KEELING CURVE AND TEMPERATURE RISE

One may attempt to calculate exactly how increases in greenhouse gases impact upon temperature augmentations. Take the case of CO2s, where a most complicated mathematical formula is employed:

(1) $T = Tc + Tn,$

Where, T is temperature, Tc is the cumulative net contribution to temperature from CO2 and Tn the normal temperature;

But when it comes to methane, it is not known whether the tundra will melt and release enormous amounts. But methane does not stay in the atmosphere long, like CO2s. For the other greenhouse gases, there is no similar calculation as for the CO2s: If humans could eat less meat from cows, it would mean a great improvement, as more than a billion cows emit methane. Food from chicken should replace beef meat and burgers. The general formula reads:

(2) $dT = \lambda * dF$

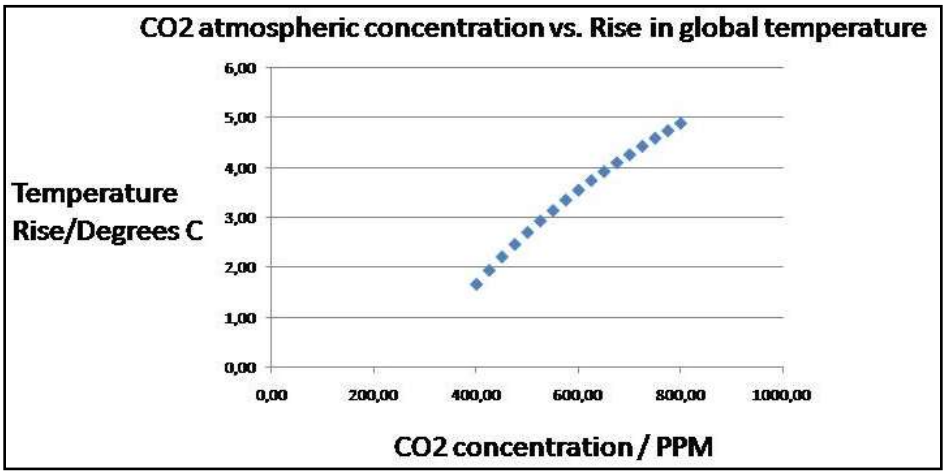
*W*here, 'dT' is the change in the Earth's average surface temperature, 'λ' is the climate sensitivity, usually with degrees Celsius per Watts per square meter (°C/[W/m2]), and 'dF' is the radiative forcing.

To get the calculations going, we start from lambda between 0.54 and 1.2, but let's take the average = 0.87. Thus, we have the formula (Myhre 1998):

Formula: 0.87 x 5.35 x ln(C/280).

Diagram 1 shows how CO2 emissions may raise temperature to 4-5 degrees, which would be Hawking's worst case scenario.

Diagram 1. CO2s and temperature rise in Celsius



What needs to be done to avert this scenario is to reduce fossil fuel consumption quickly and replace it with renewables, like e.g. solar power. Below, we give an example of what is involved in giant energy transformation to save Planet Earth, starting from the Paris 2015 COP 21 TREATY, with its major second GOAL II: reduction of CO2 emissions

RENEWABLES: Solar Power Parks

Consider now Table 2, using the giant solar power station in Morocco as the benchmark – How many would be needed to replace the energy cut in fossil fuels and maintain the same energy amount, for a few selected countries with big CO2 emissions?

Table 2. Number of Ouarzazate plants necessary in 2030 for COP21's GOAL II: Global scene (Note: Average of 250 - 300 days of sunshine used for all entries except Australia, Indonesia, and Mexico, where 300 - 350 was used)

Nation	CO2 reduction pledge / % of 2005 emissions	Number of gigantic solar plants needed (Ouarzazate)	Gigantic plants needed for 40 % reduction
United States	26 - 28[i]	2100	3200
China	none[ii]	0	3300
EU28	41 - 42	2300	2300
India	none[ii]	0	600
Japan	26	460	700
Brazil	43	180	170
Indonesia	29	120	170

Canada	30	230	300
Mexico	25	120	200
Australia	26 – 28	130	190
Russia	none[iii]	0	940
World	N/A	N/A	16000

Notes:

i. The United States has pulled out of the deal
ii. No absolute target
iii. Pledge is above current level, no reduction
iv. Upper limit dependent on receiving financial support
v. EU joint pledge of 40 % compared to 1990

If countries rely to some extent upon wind or geo-thermal power or atomic power, the number in Table 2 will be reduced. The key question is: Can so much solar power be constructed in some 10 years? Thus, the COP23 should decide to embark upon an energy transformation of this colossal size.

Solar power investments will have to take many things into account: energy mix, climate, access to land, energy storage facilities, etc. They are preferable to nuclear power, which pushes the pollution problem into the distant future with other kinds of dangers. Wind power is accused to being detrimental to bird life, like in Israel's Golan Heights. Geo-thermal power comes from volcanic power and sites. Let us look at the American scene in Table 3.

Table 3. Number of Ouarzazate plants necessary in 2030 for COP21's GOAL II: American scene (Note: Average of 250 - 300 days of sunshine per year was used for Canada, 300 – 350 for the others).

Nation	**Co2 reduction pledge / % of 2005 emissions**	**Number of gigantic solar plants needed (Ouarzazate)**	**Gigantic plants needed for 40 % reduction**
Canada	30	230	300
Mexico	25	120	200
Argentina	none[ii]	0	80
Peru	none[ii]	0	15
Uruguay	none[ii]	0	3
Chile	35	25	30

It has been researched has much a climate of Canadian type impacts upon solar power efficiency. In any case, Canada will need backs ups for its many solar power parks, like gas power stations. Mexico has a very favourable situation for solar power, but will need financing from the Super Fund, promised in COP21 Treaty. In Latin America, solar power is the future, especially as water shortages may be expected. Chile can manage their quota, but Argentine needs the Super Fund for sure.

Table 4 has the data for the African scene with a few key countries, poor or medium income.

Table 4. Number of Ouarzazate plants necessary in 2030 for COP21's GOAL II: African scene (Note: Average of 300 - 350 days of sunshine per year was used).

Nation	**Co2 reduction pledge / % of 2005 emissions**	**Number of gigantic solar plants needed (Ouarzazate)**	**Gigantic plants needed for 40 % reduction**
Algeria	7 - 22[IV]	8	50
Egypt	none[II]	0	80
Senegal	5 – 21	0,3	3
Ivory Coast	28-36[IV]	2	3
Ghana	15 – 45[IV]	1	3
Angola	35 – 50[IV]	6	7
Kenya	30[IV]	3	4
Botswana	17[IV]	1	2
Zambia	25 – 47[IV]	0,7	1
South Africa	none[II]	0	190

Since Africa is poor, it does not use much energy like fossil fuels, except Maghreb as well as Egypt plus much polluting South Africa, which countries must make the energy transition as quickly as possible. The rest of Africa uses either wood coal, leading to deforestation, or water power. They can increase solar power without problems when helped financially.

Table 5 shows the number of huge solar parks necessary for a few Asian countries. The numbers are staggering, but can be fulfilled, if turned into the number ONE priority. Some of the poor nations need external financing and technical assistance.

Table 5. Number of Ouarzazate plants necessary in 2030 for COP21's GOAL II. Asian scene (Note: Average of 250 - 300 days of sunshine was used for Kazakhstan, 300 - 350 days of sunshine per year for the others).

Nation	Co2 reduction pledge / % of 2005 emissions	Number of gigantic solar plants needed (Ouarzazate)	Gigantic plants needed for 40 % reduction
Saudi Arabia	none[II]	0	150
Iran	4 – 12[IV]	22	220
Kazakhstan	none[II]	0	100
Turkey	21	60	120
Thailand	20 - 25[IV]	50	110
Malaysia	none[II]	0	80
Pakistan	none[II]	0	60
Bangladesh	3,45	2	18

Finally, we come to the European scene (Table 5), where also great investments are needed, especially as nuclear power is reduced significantly and electrical cars will replace petrol ones, to a large extent.

Table 6. Number of Ouarzazate plants necessary in 2030 for COP21's GOAL II: European scene (Note: Average of 250 - 300 days of sunshine per year was used).

Nation	Co2 reduction pledge / % of 2005 emissions	Number of gigantic solar plants needed (Ouarzazate)	Gigantic plants needed for 40 % reduction
Germany	49[V]	550	450
France	37[V]	210	220
Italy	35[V]	230	270
Sweden	42[V]	30	30

Is there space to build all these solar parks, one may ask. But many, many small houses with solar roofs will also do well. Public buildings and company offices may be run on solar power from their roofs! Innovation is needed everywhere.

GIANT MANAGEMENT TASKS AHEAD

As the Keeling curve continues its relentless rise (Earth CO2), we must take Hawkins warning about irreversibility seriously. Moving now and up to 2030, according to the COP21's GOAL II for decarbonisation eliminates irreversibility. The main solution is solar power parks of Ouarzazate type size. Above is a calculation of what is needed in many countries around the world, taking into account the insights of the research into GDP-energy-emission links.

The COP21 project suggests decentralised implementation of goals, given the dominance of state sovereignty in Public International Law. But what tools can be conducive to such an enormous transformation, outlined in Tables 1-5? The COP21 Treaty speaks of a Super Fund with a budget of 100 billion US dollars to assist poor countries and emerging economies. The upcoming COP23 must clarify the technicalities of this Super Fund. Taxes or charges on fossil fuels is an effective means, but will it be accepted by unanimity is the coordination group of so many states?

The UNFCCC must develop a management structure, combining the international level with national ones. And the solar power revolution must be initiated in the COP21 member states. Each country will manage its version of the giant energy transformation in this century, mixing solar power with other renewables and maybe atomic power. But it is now time to start managing this COP21 process.

CONCLUSION

If CO2 emissions continue to rise on the Keeling curve (Earth CO2), then temperature could go towards a 3-5 Celsius increase. Everything would be affected negatively – all social systems, the economy, all living organisms. This goal of avoiding irreversibility is more important for mankind than North Korea's aggression, the South China Sea, the new Silk Road, Brexit and the civil war in the Muslim civilization. To stop global warming, huge investments in solar power parks and house roofs are necessary. It will be costly but eminently worthwhile.

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