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Decarbonisation with Solar Power Plants

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ABSTRACT: Halting climate change is an urgent global coordination task for international governance where the major powers play a very major role. The 2015 enactment of the COP21 Treaty is considered as the chief response to the set of challenges that global warming presents to mankind in this century. What more exactly is involved the implementation of the goal of limiting temperature rise at 1, 5 – 2 degrees Celsius?.

Key Words: **Decarbonisation and the UNFCCC, the COP21 GOALS, renewables, global warming dangers, Schneider, Stern, Kaya as well as Sachs.**

INTRODUCTION

While the global political community debates about the US defection from the COP21 Treaty, things are moving on in real life. The optimists about climate change argue that the objectives of COP21 are still within reach, the pessimists point out that the CO2 in the atmosphere keeps augmenting. We are now at 410 ppm on the Keeling curve.

The optimists underline the many micro changes the recent years in energy production, efficiency and transformation. However, the pessimists emphasize that the macro picture remains much the same, globally speaking: more of air and sea transportation, coal replaced by oil and gas, the shale gas revolution, constantly more cars and bigger engines, wood coal and deforestation, reduction of Amazons and Borneo forests, etc. Why have the recognition of climate change and its enormous dangers to mankind been so late and so contested by some groups?

THEORY OF GLOBAL WARMING

The first anticipation of the global warming mechanism was done by Frenchman J. Fourier in the early 19^{th} century, but the theory was developed by Swedish chemist Arrhenius around 1895. 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.

Yet, it was not until Stephen Schneider published Global Warming in 1989 that the theory started to receive wide attention, 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 jumped in besides the natural scientists, 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).

All theories need corroboration. When the polar ice mountains began to collapse, it seemed decisive evidence for the global warming theory. Other important test implications like glacier retreats everywhere, ocean warming and acidification as well as desertification in Africa also gave support for global warming theory. Denials of climate change appear more and more unfounded, although it is true that more of CO2 may benefit some fauna or environment niches.

DANGERS FROM ANTHROPOGENIC CLIMATE CHANGE

Considering the probable damages from global warming, it is astonishing that global warming theory has not been better recognized or even conceptually developed or empirically corroborated. If global warming continues unrestrained, much of Asia will be negatively affected, just as Australia is on the verge of losing its coral reefs. There will be sooner or later:

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 tremendous damages.

This list is far from complete or exhaustive. One could even mention worse outcomes, like the transformations of warm and cold currents in the oceans – Gulf Stream, North Atlantic Current for example. What one may underline is that so far no known negative feedback has been found that could stem global warming naturally. We seem to have mainly only positive feedbacks, meaning outcomes reinforce each other in the same direction. The situation in the Amazons and Borneo is basically “lost”, and Siberian forests threatened.

ENERGY-ENVIRONMENT CONUNDRUM

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 huge numbers involved – see Diagram 1.

Diagram 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

Basically, roughly 90 per cent of all energy consumption comes from non-renewables. The

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COP21 call for decarbonisation involves a sharp reduction of fossil fuels up until 2030 in order to stabilize climate change with a 30-40 decrease in CO_2 emissions.

SUSTANABILITY MYTH

The Kaya model correctly emphasizes the links between CO2:s, energy consumption of fossil fuels and the energy intensity of GDP (Appendix I). Applying this model onto most available data gives us two key Figures. First, we see that CO_2 emissions are closely connected with energy consumption, globally speaking. And the projections for energy augmentation in the 21st century are enormous (EIA, BP, IEA).

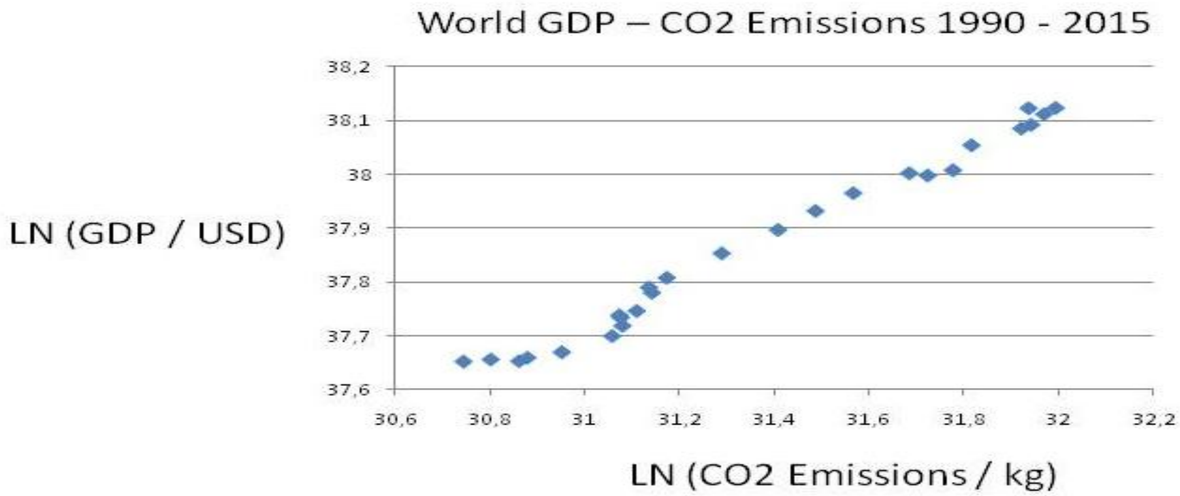

Figure 1. Global GDP-CO2 link: y = 0,4092x + 25,03, R^2 = 0,987 (N =26)

The findings show that total GHG:s or CO2:s go with larger total GDP, i.e. GDP per person * population. Decarbonisation is the policy promise to undo these inks by making GDP and energy consumption rely upon carbon neutral energy resources, like modern renewables and atomic energy. Thus, the upward sloping curves must be reversed but still slope outward. As, total energy consumed rises, so CO2:s increase. Secondly, energy means power and consequently affluence and wealth. It is hotly desired by men and women in today's world, as Figure 2 entails.

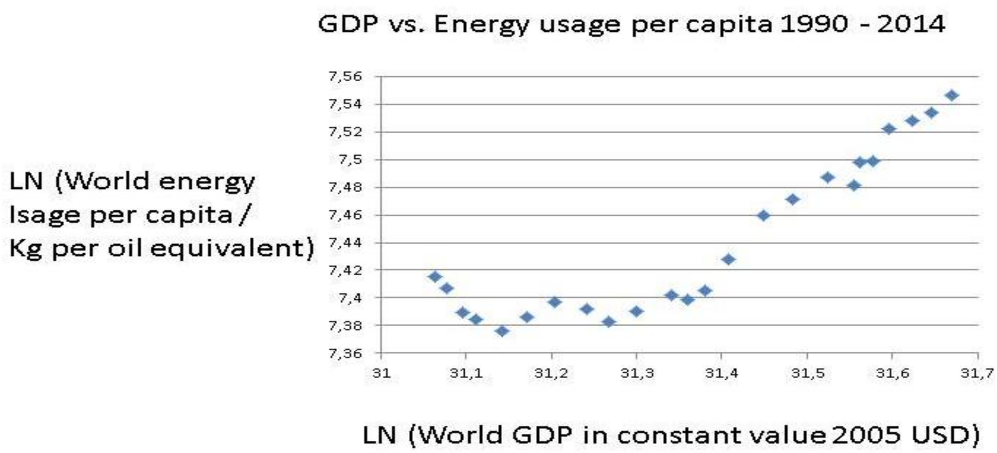

Figure 2. Energy consumption per capita globally

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With such a demand for energy, resulting in sharply rising CO2:s per capita, how is mankind to avoid the horrendous consequences of climate change? One solution is the vast economic depression with strong cut backs in energy consumption, but no governments will deliberately chose this alternative, as it entails mass poverty and starvation deaths. What international governance in the UNFCCC project aims at together with global state coordination is to engage in decarbonisation while securing economic development. 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, depending on how counts, by 2030 – an immense challenge; GOAL III: Complete decarbonisation by 2070-75 – an impossible goal to realize;

J. Sachs (2015) has suggested one way forward, namely the sustainable economy. It is a utopian proposal, mixing climate change with poverty reduction and energy durability. It employs the new catch phrase "sustainability", bit is just talk and morals. One cannot use the global warming crisis to solve other problems, like global redistribution and lack of planning as well as economic predictability. The more of a variety of issues one enters into the global warming equation, the more one receives of confusion and transaction costs, which are already substantial with the UNFCCC mechanism.No government in the advanced capitalist world will, realistically speaking, accept much of global redistribution, whatever the reasons. And a plan for the global economy lies beyond human intelligence, for computational reasons. The tangible issue is not what policy tools will reduce the burning of fossil fuels, the sooner the better!

COP21: PROMISE OF DECARBONISATION

Consider now Table 1, 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 1. 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

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

If countries rely to some extent upon wind or geo-thermal power or atomic power, the number in Table 1 will be reduced. The key question is: Can so much solar power be constructed in some 10 years? If not, Hawkins may be right. 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 2.

Table 2. 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 3 has the data for the African scene with a few key countries, poor or medium income..

Table 3. 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 4 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 4. 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

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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, 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 4. 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

CARRYING THROUGH THE COP21: State or Market

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 Table? 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? Law or international legislation by means of treaties is another tool, but it is hard to enforce such tools. Marker incentives must be called upon for this huge transformation (Barry, Hayek).

CONCLUSION

Even if some of the solar power will be generated from solar roof panels on small houses, the task of generating sufficient electricity for maintaining present standards of living is herculean, for the nations above and other countries as well most probably. When taking into account that global planning speak of a 20-30 per cent increase in energy for the coming decades, and then one understands the warning of Schneider: This century may most likely be the greenhouse period of mankind, especially when one looks at the future energy projections (Figure 3).

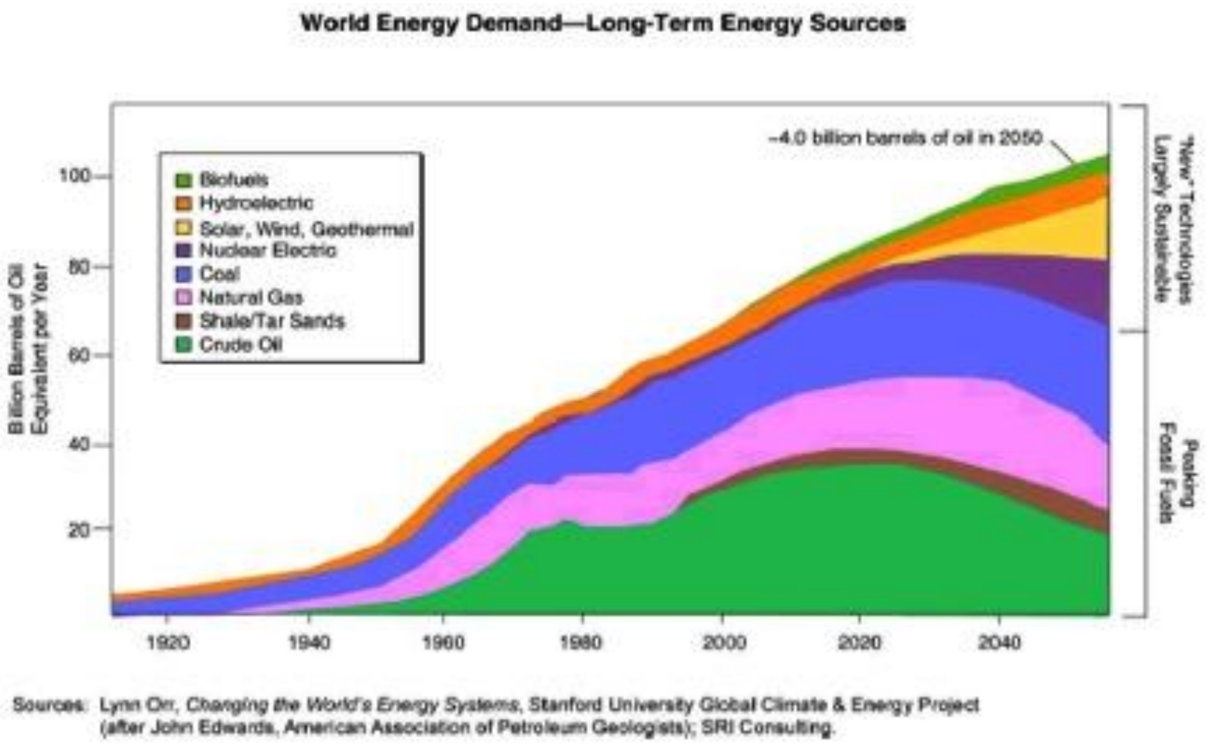

Figure 3. Standard energy consumption projections

The COP Framework amounts to a global common pool regime (CPR), but it is far weaker than Ostrom (1990) predicted, as gaming by the governments of the world could destroy it (Conca 2015; Vogler,2016; Dutta, 1999).

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Appendix I.

The so-called Kaya model runs as follows:
(E 1) Kaya's identity projects future carbon emissions on changes in Population (in *billions*), economic activity as GDP per capita (in *thousands of $US(1990) / person year*), energy intensity in *Watt years / dollar*, and carbon intensity of energy as *Gton C as* CO_2 *per TeraWatt year*."
(http://climatemodels.uchicago.edu/kaya/kaya.doc .html)
Concerning the equation (E 1), it may seem premature to speak of a law or identity that explains carbon emissions completely, as if the Kaya identity were a deterministic natural law. It will not explain all the variation, as there is bound to be other factors that impact, at least to some extent. Thus, it is more proper to formulate it as a stochastic *law-like* proposition, where coefficients will be estimate using various data sets, without any assumption about stable universal parameters. Thus, we have this equation format for the Kaya probabilistic law-like proposition, as follows:
(E2) Multiple Regression: $Y = a + b_1X_1{}^{+} b_2X_2 + b_3X_3 + ... + b_tX_t + u$
Note: Y = the variable that you are trying to predict (dependent variable); X = the variable that you are using to predict Y (independent variable); a = the intercept; b = the slope; u = the regression residual.
Note: http://www.investopedia.com/terms/r/regression.asp#ixzz4Mg4Eyugw

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Thus, using the Kaya model for empirical research on global warming, the following anthropogenic conditions would affect positively carbon emissions:

(E3) CO2:s = F(GDP/capita, Population, Energy intensity, Carbon intensity).

I make an empirical estimation of this probabilistic Kaya model with a *longitudinal* test for 1990-2014, i.e. World data 1990 - 2015:

(E4) Ln CO2 = 0,62*LN Population + 1,28*LN(GDP/Capita) + 0,96*LN(Energy/GDP); R2 = .90.

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