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CLIMATE CHANGE: GHGS, CO2S, METHANE AND ENERGY

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ABSTRACT

The US has now formally defected from the common pool regime (CPR) that the Paris Treaty created 2015 through the UNFCCC: COP21. It remains to be seen whether other signatories will chose reneging, now or in the future, when the COP21 GOALS I, II, III are to me implemented through a gigantic energy transformation management, internationally, nationally and locally. The collective action difficulty in international governance project is to avoid free riding, which now the US enjoys. Only selective incentives can hold together this global CPR. The COP23 must now start clarifying the Super Fund and how the GOALS are to be promoted by real activities of decarbonisation.

Key Words: Decarbonisation, Asian Development Bank, climate change, methane, solar power, CO2 – temperature rise.

Introduction

As international governance moves from decision making on goals, it must start deliberating on strategies of decarbonisation. By 2020, no country can any longer increase their CO2s, and by 2030 they must have achieved a significant amount of decarbonisation, in order to arrive at complete decarbonisation by 2075 roughly. As the greenhouse gases (GHG) stemming from anthropogenic sources are the focus of decarbonisation efforts, the attention is much directed towards energy consumption in a wide sense. And energy is planned to increase during this century in order to allow people affluence and wealth. This sets up the great dilemma of the 21^{st} century: How to transform energy production and consumption so that GHG emissions are reduced but there is still plenty of energy for decent socio-economic development of economic growth? Stern (2007) called climate change a giant externality, and external effects to the global market economy must be corrected (Stern, 2015), later or hopefully sooner.

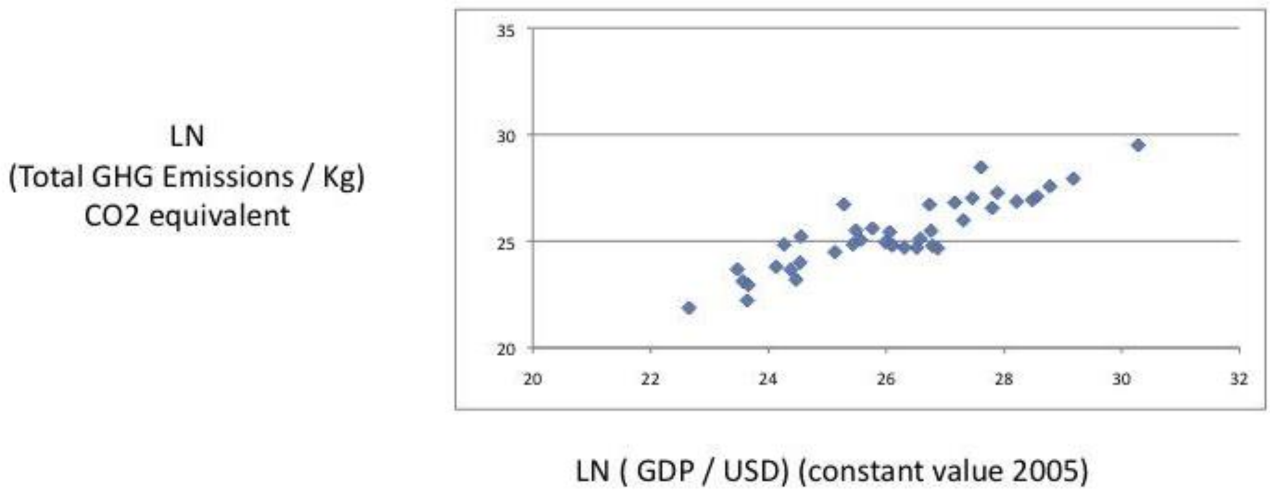
Here, I will argue that the solution is the combination of massive solar power electricity and electrical vehicles. Carbon sequestration is not a good solution. Atomic power helps, but creates other grave difficulties. Wind and geo-thermal energy offers each possibilities**.** Two problems must be addressed:

a) The growing methane threat;
b) The defection risk in the CPR.

I. GHC, CO2, METHANE AND ENERGY

The global situation with regard to the greenhouse gases appears from Figure 1, where the economic expansion, measured by the GDP, is accompanied by an inexorable growth in GHGs. This trend must be halted and reversed, as otherwise the 21st century will be the greenhouse century of mankind, as Stephen Schneider warned already 1989.

FIGURE 1. Global Link: GDP-GHC Globally: y=0.85x, R2=0.80



Source: World Bank Data Indicators

There are several greenhouse gases, but the two biggest are the CO2s and methane. The UNFCCC has concentrated upon halting and reducing carbon dioxide, but now we are about to face a methane threat. Table 1 shows that methane is growing faster than CO2.

TABLE 1. GHC minus CO2s

Year	GHG other than CO2 / Tton
1990	15,56
1995	15,20
2000	14,74

2005	17,20
2010	17,05
2011	18,47
2012	18,97

Source: EDGARv4.2FT2012, European Commission, Joint Research Centre (JRC)/PBL Netherlands Environmental Assessment Agency. Emission Database for Global Atmospheric Research (EDGAR), release version 4.2

Figure 2 displays the explosive increase in methane emissions, the consequenecs of which are far from fully known.

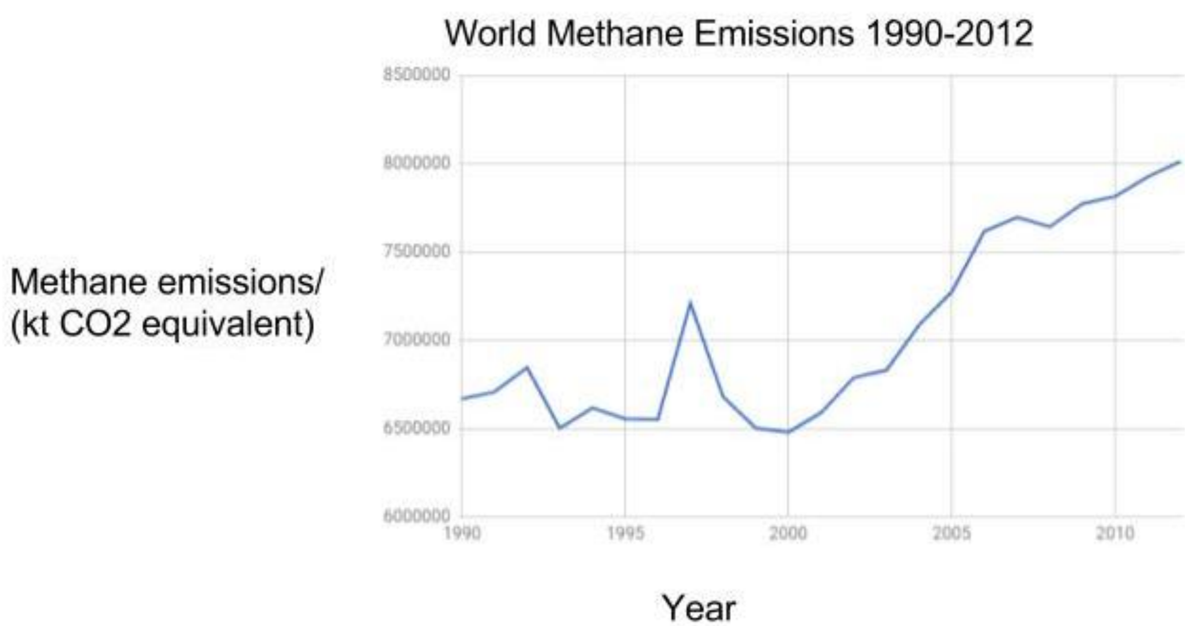
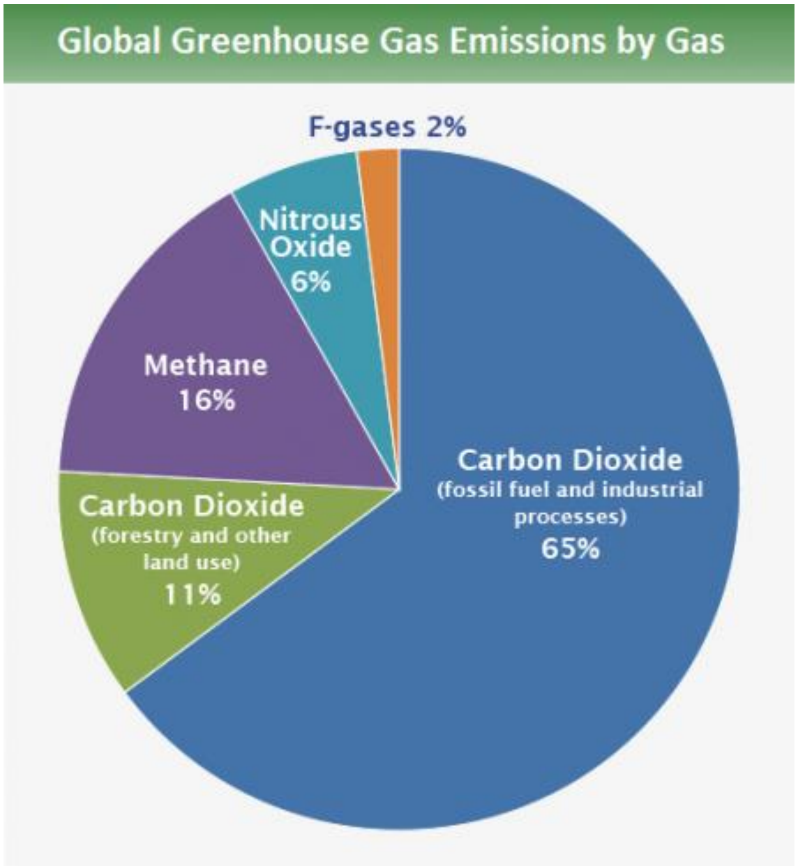


FIGURE 2. Methane emissions

Source: World Bank Data Indicators

The threat from global warming due to methane must be taken most seriously, as methane may be released by the now accelerating melting of the permafrost. The UNFCCC must start paying more attention to other GHGs than only the CO2s. It seems that the global picture in Diagram 1 must now be revised to take accelerating methane emissions into account. It may come as a global warming shock.

DIAGRAM 1. Greenhouse gases 2010



Source: IPCC (2014) based on global emissions from 2010.

The COP21 Treaty target carbon dioxide, requiring global action towards decarbonisation. It has set the goals, but it has not laid done the means. The ADB recommends carbon capture, but it is very costly and environmentally dangerous.

III. ASIAN DEVELOPMENT BANK (ADB) CLIMATE REPORT

The Asian Development Bank has in 2015 published a major investigation into the consequences of climate change for South East Asia. It is most read worthy, making hard and dismal projections for these economic miracles. But its suggested remedy – carbon sequesteration –is not acceptable. The South East Asian economies should move to solar power and electrical vehicles. South East Asia must comply with the COP21 Treaty and start its implementation now. No time for politicking in the UN any longer (Conca, 2015; Vogler, 2016)!

The ADB – Asian Development Bank –has produced a most interesting report on the consequences of climate change for South-East Asia. It is unusual in its earnest and encompassing coverage of how badly global warming would hurt these countries. Several of the conclusions may be extended to East Asia and Oceania. The ADB projections are supported by various kinds of research.

Two finding in this report stand out – let me quote:

(Q1- Diagnosis)

Southeast Asia is also becoming a larger contributor to global GHG emissions, with the fastest growth in carbon dioxide emissions in the world between _._ and ____. Deforestation and land degradation have been driving most of the emissions to date. At the same time, low improvements in energy intensity and increasing reliance on fossil fuels are causing energy emissions to escalate. Given the region's vulnerability to climate change, curtailing global emissions growth should be a priority consideration, to which the region can make an important contribution. (ADB, 2015: Foreword)

Several of the threats to South East Asia that rising temperature poses are mentioned at length by the ADB – very useful listing of damages and catastrophes. There is nothing controversial about these predictions by the ADB. What is stunning is the remedy that it suggests against global warming, namely:

(Q2 – Remedy)

The Asian Development Bank (ADB) is supporting efforts to make such transformations happen through its portfolio in the region. It has projects and technical assistance to address drivers of deforestation, expand clean power production, and fund energy efficient electricity and transport infrastructure. ADB also supports development and piloting of advanced low-carbon technologies, such as carbon capture and storage. (ADB, 2015: Foreword)

This method – carbon sequestration – has never been tested on a large scale. It involves most complicated procedure for sinkingCO2s into the Earth's crust with formidable costs and risks. ADB continues to recommend low carbon energy and does not endorse the only solution, namely complete reliance upon renewable in the long run with immediate elimination of coal. The use of oil and gas should be transitory, in accordance with the COP21 Treaty and its recommendation of decarbonisation with renewable.

IV. CO2 EMISSIONS AND TEMPERATURE RISE

Increases in greenhouse gases, where 70 % are CO_2s, impact upon temperature augmentations. For CO_2s, this mathematical formula is employed:

(1) $T = Tc + Tn$, where T is temperature, Tc is the cumulative net contribution to temperature from CO_2 and Tn the normal temperature;

When it comes to another GHG, methane, it is not known whether the tundra will melt and release enormous amounts. But methane does not stay in the atmosphere long, like CO_2s. For the other greenhouse gases, there is no similar calculation as for the CO_2s: 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:

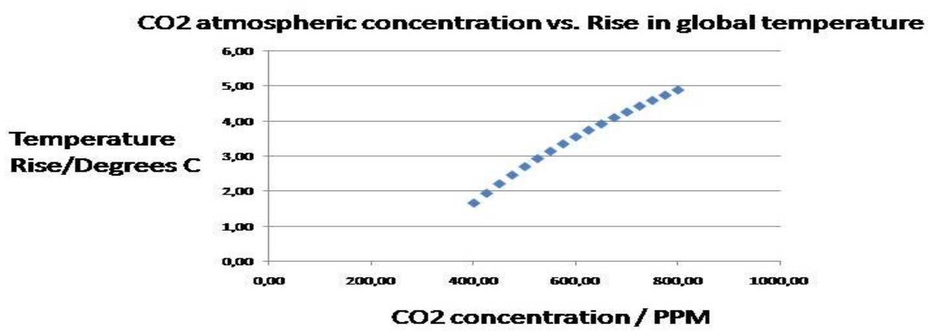
(2) $dT = \lambda * dF$, where 'dT' is the change in the Earth's average surface temperature, 'λ' is the climate sensitivity, usually with degrees Celsius per Watts per square meter (°C/[W/m2]), and 'dF' is the radiative forcing.

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 et al, 1998):

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

Diagram 2 shows how CO_2 emissions may raise temperature to 4-5 degrees, which would be Stephen Hawking's worst case scenario: climate change becoming irreversible.

DIAGRAM 2. CO_2s and temperature rise in Celcius



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 Hawking. 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.

AFFLUENCE AND EMISSIONS.

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 2.

TABLE2. Energy consumption 2015 (Million Tons of oil equivalent)

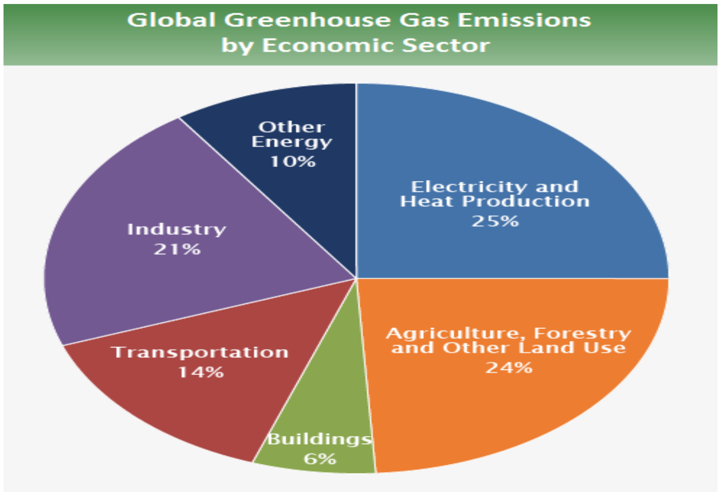
Total %

	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

Table 2 holds the answer to why CO2 emissions have become the global headache number 1. Energy for humans and their social systems come to an average of 90% from burning fossil fuels: stone and wood coal, oil and gas. And people do that all over the world, though to very different degrees from 100% to less than 50% of all energy consumption, because it is necessary for affluence and survival. The enormous expansion in the energy consumption of fossil fuels has allowed the world to take on many new inhabitants, as well as reducing poverty in the Third World and much enhancing affluence and wealth in the First world. Diagram 3 shows the sector origins of CO2s in the global economy.

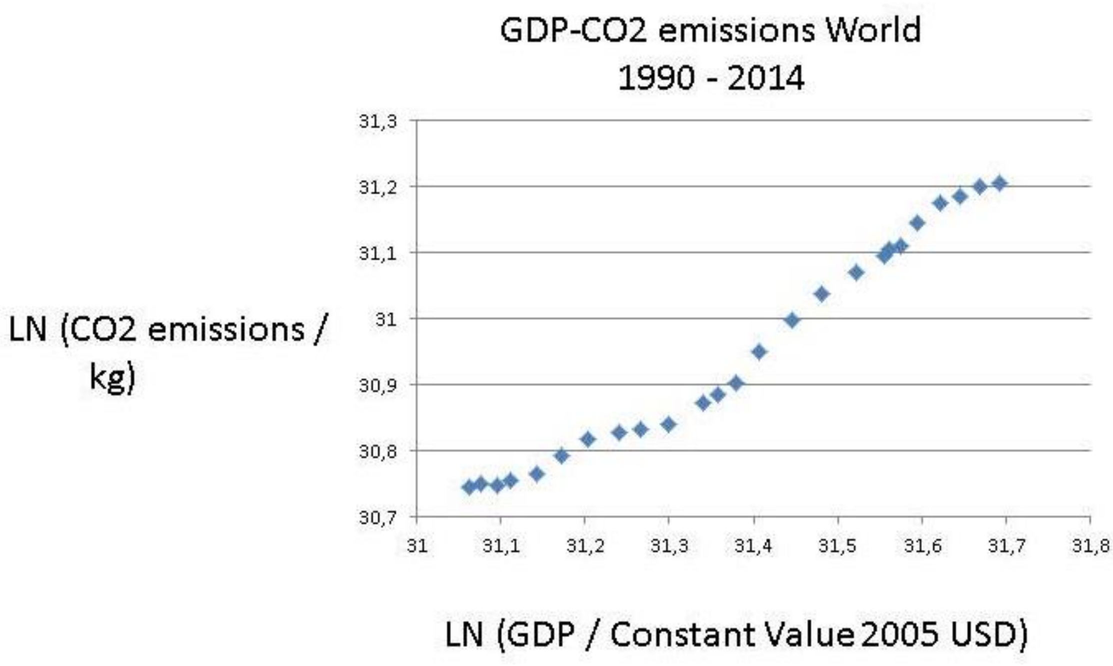
DIAGRAM 3. Sector distribution of CO2s



Source: IPCC (2014);based on global emissions from 2010.

Understanding the global climate change crisis, one must go back to the GDP and examine its links with energy consumption and the connections between energy and emissions. Thus, global warming is basically about economics, human needs and the survival of mankind. We start by looking at the longitudinal trend in Figure 3.

Figure 3. GDP – CO_2 emissions 1990-2014 (N = 59)

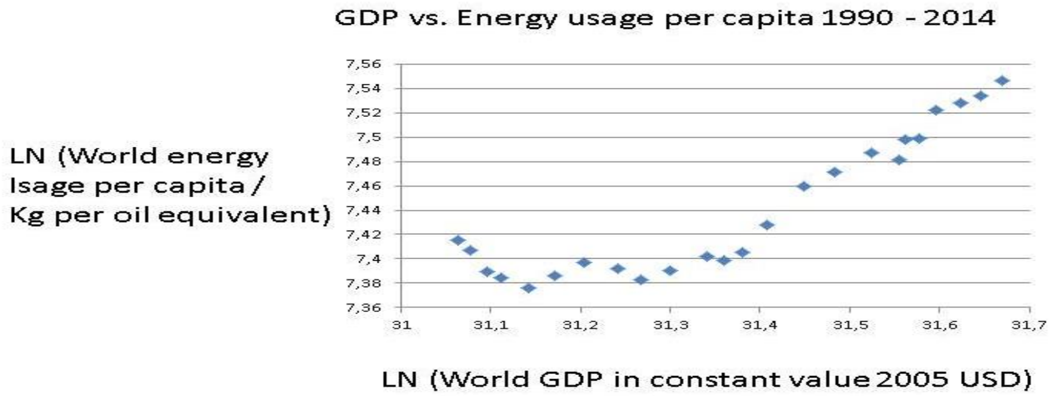


Source: World Bank Data Indicators, EU EDGAR database

To make the dilemma of energy versus emissions even worse, we show in Figure 2 that GDP increase with the augmentation of energy per capita. 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).

Decarbonisation is the promise to undo these dismal links by making GDP and energy consumption rely upon carbon neutral energy resources, like modern renewables and atomic energy. Figure 4 displays the energy link with the GDP.

FIGURE 4. GDP against energy per person (N = 59), 1990-2014



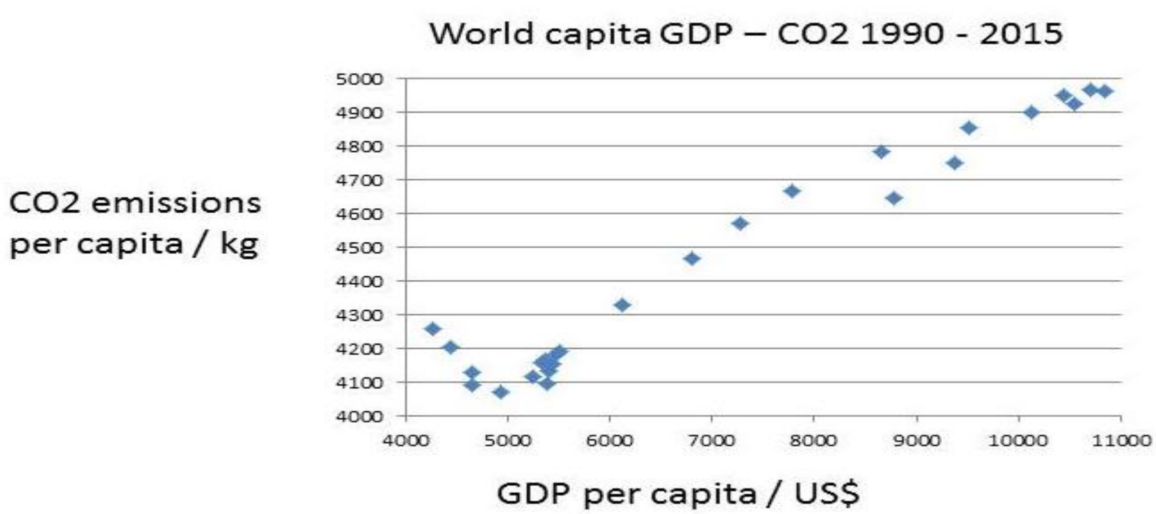
Source: World Bank Data Indicators

Thus, we arrive at the energy-emissions conundrum: GDP growth being unstoppable requires massive amounts of energy that results in GHC:s or CO2:s. The only way out of this dilemma is that renewables become so large and effective in a short period of time decarbonisation becomes feasible or likely, not merely desirable.

If energy consumption is key to understanding CO2 emissions, then what drives the enormous demand for energy globally? Reply, the human drive for affluence, need satisfaction and wealth.

Figure 4 shows the two trends going together: GDP per capita growth (affluence per person) and CO2 emissions per capita from 1990 to 2015 – longitudinal analysis.

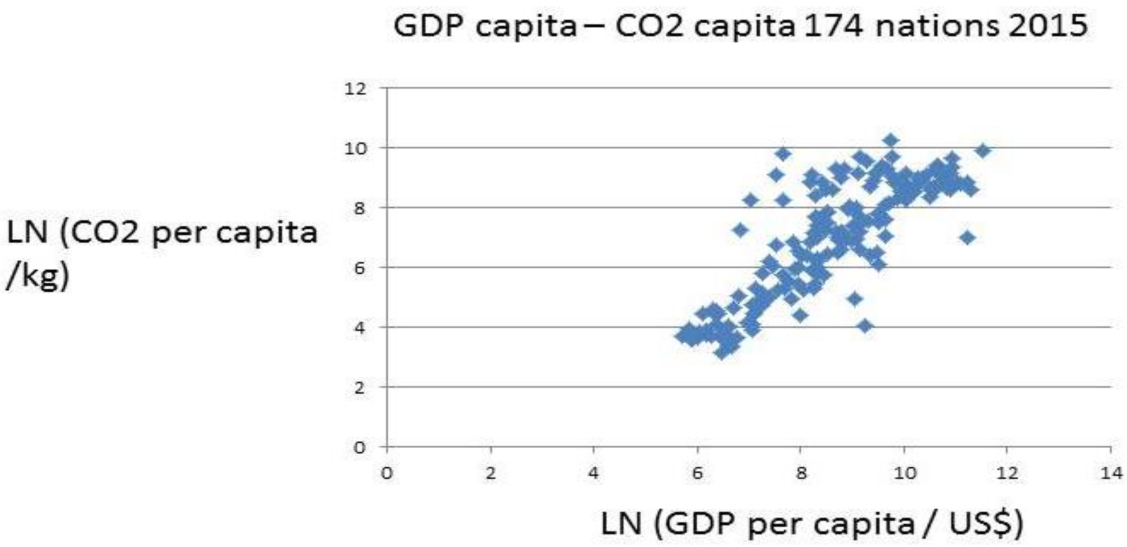
FIGURE 4. 1990-2015: Per capita affluence and CO2s: y = 0,15x , R^2 = 0,95



Sources: World Bank Data Indicators, data.worldbank.org; EU CO2 Data Base EDGAR, edgar.jrc.ec.europa.eu

The same relation between economic affluence and CO2s hold for the world difference in GDP per capita in 2015- cross-sectional analysis in Figure 5.

FIGURE 5. 2015: Affluence and CO2s per capita:y = 1,11x , R^2 = 0,69



Sources: World Bank Data Indicators, data.worldbank.org; EU CO2 Data Base EDGAR, edgar.jrc.ec.europa.eu

V. IMPLEMENTING THE COP21 TREATY

The COP21 project will put all governments that are members of this CPR in front of two serious challenges:

Implementation hiatus: 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? *Remedy:* The COP23 in Bonn this fall must move to operational stage of the COP21 Treaty and clarify the Super Fund, the oversight, resort to renewables, etc.

Defection in Ocean PD gaming: The COP2 Treaty as a *common pool regime* (CPR) is weak, and subject constantly to the threat of defection (Conca, 2015; Vogler, 2016). 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 in this ocean PD game, or lack of management resources and skills in this giant implementation process. *Remedy*: Selective incentives to keep the CPR together and make it a success,

VI. CORRECT DECARBONISATION: Solar Power Example

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

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
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 much if 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
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

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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

VIII. CONCLUSION

The question of climate change, i.e. minimizing CO2s under the restriction of keeping energy flowing to the global economy and human social systems, has only one solution. The solution to global warming under this restriction of maintaining affluence and a decent level of economic development is not a giant global redistribution (Sachs, 2015), but a massive investment in solar power parks in combination with a move to the use of electrical cars. In can be done in accordance with the COP21 Treaty and its three GOALS I, II and III. But the problems of *implementation gap* and defection gaming must be addressed, when the Super Fund of the COP21 offers the opportunities of using *selective incentives*, through which collective action difficulties in this Ocean game that is climate change can be overcome.

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APPENDIX 1.

A basic theoretical effort to model the greenhouse gases, especially CO2:s, in terms of a so-called identity is the deterministic Kaya equation. In theories of climate change, the focus is upon so-called anthropogenic causes of global warming through the release of greenhouse gases (GHG). To halt the growth of the GHG:s, of which CO2:s make up about 70 per cent, one must theorize the increase in CO2:s over time (longitudinally) and its variation among countries (cross-sectionally). As a matter of fact, CO2:s have very strong mundane conditions in human needs and social system prerequisites. Besides the breading of living species, like Homo sapiens for instance, energy consumption plays a major role. As energy is the capacity to do work, it is absolutely vital for the economy in a wide sense, covering both the official and the unofficial sides of the economic system of a country. The best model of carbon emissions to this day is the so-called Kaya model. It reads as follows in its standard equation version – *Kaya's identity*. (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 is 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

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),

in a stochastic form with a residual variance, all to be estimated on data from some 59 countries. I make an empirical estimation of this probabilistic Kaya model - the cross-sectional test for 2014:

(E4) k1= 0,68, k2=0,85, k3=0,95, k4=0,25;R2= 0,895.

Note: LN CO2 = k1*LN (GDP/Capita) +k2*(dummy for Energy Intensity) + k3*(LNPopulation) + k4*(dummy for Fossil Fuels/all)Dummy for fossils 1 if more than 80 % fossil fuels; k4 not significantly proven to be non-zero, all others are. (N = 59)

The Kaya model findings show that total CO2:s go with larger total GDP. Figure 1 shows how things have developed since 1990.