A World Market of Tradable Permits and the Specific Place of Tunisia[1]

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Abstract

Though adopted by all parties to the COP 21 more than two years ago the Paris Agreement faces serious hurdles, the least important being not the hostile position taken by the new American administration.

From the start it has been acknowledged that the total of commitments by countries for 2030 is far from setting the world economy on the trajectory consistent with the long-term target of limiting global warming to 2°C. Even before the adoption of the Paris Agreement, the vast majority of economists warned that the implementation a market mechanism is required in order to go beyond the bottom-up approach of the INDCs which obviously favors a free-riding behavior by Parties to the Convention.

The paper first presents a comprehensive assessment of the pledges by the countries (INDCs) and where they fail. It then develops and justifies a market mechanism based on the trade of quotas, with a rule of allocation weighting feasibility on the short run and equity on the long run, and gives the results of a simulation for the year 2030 showing which countries are respectively the potential sellers and the potential buyers, and what would be the financial size of the market.

A specific application is devoted to Tunisia which, though a small country and a very small GHG emitter, showed a great ambition in its conditional contribution.

على الرغم من اعتمادها من قبل جميع الأطراف21 في مؤتمر باريس قبل أكثر من عامين ، فإن اتفاقية باريس تواجه عقبات جسيمة ، و ليس الأقل أهمية الموقف السلبي الذي اتخذته الإدارة الأمريكية الجديدة.

لقد تم الاعتراف منذ البدء، على أن إجمالي التزامات الاقتصاد العالمي لعام 2030 بعيدة على المسار الذي يتطلبه الهدف المنشود، طويل الأمد وهو الحد من ارتفاع درجة حرارة الأرض إلى درجتين مئويتين.

لقد حذر أغلب الاقتصاديين حتى قبل اعتماد اتفاق باريس، من أن تنفيذ آلية السوق أمر ضروري من أجل تجاوز النهج التصاعدي في الإنبعاثات المحددة على المستوى الوطني.

هذا البحث يعرض أولاً تقييماً شاملاً لتعهدات الدول (INDCs) ومكامن فشلها. ثانيا، يقوم البحث بعد ذلك بتفسير آلية السوق القائمة على تجارة الحصص، مع قاعدة تخصيص الجدوى على المدى القصير والمساواة على المدى الطويل. ثالثا، تعطي نتائج المحاكاة لعام 2030 الدول التي ستكون من البائعين المحتملين أو المشترين المحتملين ، كما ستوضح الحجم المالي للسوق.

وفي الأخير، يخصص البحث تطبيقة على تونس و التي، على الرغم من كونها دولة صغيرة وكمية الغازات الضارة للبيئة المنبعثة منها محدودة جدا ، إلا أنها أظهرت طموحا كبيرا في مساهمتها المشروطة.

Keywords

Climate change; Paris Agreement; INDC, Marginal Cost of Public Funds; Marginal Abatement Cost; Market of Tradable Permits

[1] Presented in a seminar held at the Institut Supérieur de Gestion of the University of Gabès, April 14. I benefited from help and comments from Mosbah Lafi, assistant Professor at ISG.

Introduction

Two years after COP21, where are we in the Paris Agreement? It was hailed all over the world as a great diplomatic success, reversing the failure of the Kyoto Protocol.

Since its adoption on December 13, 2015, on the one hand the US Government announced its withdrawal, on the other hand, GHG emissions continued to growth steadily, even at a higher rate than before. According to International Energy Agency, global energy demand grew by 2.1% in 2017, and carbon emissions increased of 1.4%, rising for the first time since 2014.

Long term perspectives of GHG emissions

In its Energy Outlook 2040 issued in February 2018, British Petroleum forecasts that carbon emissions will continue to grow in an "Evolving transition" scenario and this "*highlights the need for a more decisive break from the past*". In the 2017 issue of International Energy Outlook, the American Department of Energy exhibits a steady increase of (energy-related CO2) world emissions, reaching 39 billion of tons from 30 in 2010 (Reference case). And in the 2018 issue of the American Energy Outlook, the DOE exhibits a figure of 5.279 Billion tons of (energy-related CO2) US emissions, 2% higher than in 2016.

According to OECD/IEA in its last World Energy Outlook published June 2017, "*it remains three years to safeguard our climate*".

Finally, Exxon plans for carbon-constrained future and "*believes it will be able to exploit all of its reserves*", contrarily to the tenet that most fossil energy resources must be stranded if climate is to be safeguarded[2]

Two more COP were held after Paris in great pump, but no significant progress has been recorded and we are all of us waiting for the COP24 and then the Year2020, the starting date of implementation of the Paris Agreement.

It appears the first signs of the end of an illusion that has been carefully nurtured by the United Nations and its main bodies, according to which the civil society, local governments and industrial firms could massively contribute to the implementation of the agreement and allow to reach the long-term targets.

UNFCCC, who engaged in this path, now seems to acknowledge that national governments are unavoidable partners and the key to success, highlighting the seriousness of the US withdrawal. Patricia Espinosa, Executive Secretary of UN Climate Change, declared few days ago (March 26, 2018):

"With countries clearly in the driving seat of the climate change process, we look forward to supporting nations towards the 2018 milestones throughout the year and at the 24th Conference of the Parties (COP24), to be held in Katowizce, Poland in December 2018,"

What does not work in the Paris Agreement?

Clearly it is the lack of economic incentives and, immediately after its adoption and even before, nearly all economists warned that it could not work. For instance, Jean Tirole, on November 25, 2015, answering to the question "What do you expect from the Paris Summit" in Les Echos, declared:

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[2] According to Ed Crooks, New York Times editorialist, « *ExxonMobil, Royal Dutch Shell and Chevron are jumping into US shale production with gusto"*

« Soyons réalistes : l'accord de Paris est déjà bouclé dans ses grandes lignes. Il ne contiendra pas ce qui est à mon avis essentiel : créer un prix mondial du carbone. Les économistes savent qu'un système de prix est le meilleur outil économique pour réduire les émissions de gaz à effet de serre, via une taxe carbone ou un système de droits d'émission négociables sur le marché. Il est généralement plus efficace d'agir par des prix que par des interdictions ou des réglementations. »

And in December 12, 2015, in L'Opinion:
« Dans les faits, nous ne sommes guère plus avancés qu'il y a six ans »

A group of well-known economists[i] published a freely downloadable report with the collective conclusion that:

"The real problem is not the climate, or the lack of climate-science knowledge, and it's not the lack of a common aspiration or goal. It's not even the lack of blueprints for global action. The trouble is that negotiations end in acrimony or hollow victory statements. So the problem is to find and fix the cause of these negotiation failures.

Paris will fail by hollow victory, but there is an alternative.

It requires some understanding of the science of cooperation, and how to use it to design an agreement and its negotiation process."

According to the New York Times, October 19, 2015, Heads of State, City, Regional and Business Leaders declared to unite to "*Call for Price on Carbon*" and the Carbon Pricing' Panel stressed that *"It's time to put a #PriceOnCarbon"* And Jim Yong Kim, World Bank Group President, stated:

" There has never been a global movement to put a price on carbon at this level and with this degree of unison. It marks a turning point from the debate on the economic systems needed for low carbon growth to the implementation of policies and pricing mechanisms to deliver jobs, clean growth and prosperity. The science is clear, the economics compelling and we now see political leadership emerging to take green investment to scale at a speed commensurate with the climate challenge."

What is the real challenge and what can be done

The Kyoto Protocol had such economic incentives, and a top-down approach, but failed because it focused mainly on developed countries which were at the time the main GHG emitters.

But the main emitters are now the developing and emerging economies, foremost China, and any wholesale mechanism must include them in parity with developed countries.

UNFCCC and a majority of countries, which don't want "too" binding commitments, thought that the solution was in reversing the approach, from a top-down to a bottom-up, ignoring what is well-known by economists since decades and maybe more as the "free-rider" problem.

Plan of the paper

The paper has three sections devoted to the following issues:

1. An assessment of the Paris Agreement in its economic aspects;

2. A world market of tradable permits: how it can work, and what would be the results in the medium run
3. The specific case of Tunisia

and concludes on the feasibility and the merits, in terms of efficiency and equity, of a market of tradable permits, and what Tunisia can expect from it.

1. Assessing INDCs

Assessing INDCs is to be performed in reference both to a "Business as Usual Scenario" (what would result if no decision is taken in the concerned area) or a "Current Policy Scenario" (what would result from existing or expected –i.e. announced- policy[3]), and to a desirable long-term evolution of the economy, consistent with a specific aim. Concerning climate change, the obvious benchmark for the latter scenario is represented by the long-term target of limiting average global warming to 2°C above pre-industrial levels[4].or, consistently, to peaking the concentration of GHG in the atmosphere to 450 ppm. The related scenario is labelled "Benchmark Pathway to Long Term Decarbonization" (BPLTD or Benchmark scenario for short.

1.1. Definition and underlying assumptions of the two reference scenarios

Both scenarios have been assessed with the model GEMINI-E3 and the details, the underlying assumptions in particular, have been presented in a communication to the last annual conference of the Association Française de Science Economique (AFSE) held in June 2017[5]. They are consistent with two reports written in 2013 and 2015 for the United Nations Environment Program[6]. It must be specified that the implemented version of GEMINI-E3 does not model all GHG but only "energy related CO2 emissions", which is the standard approach of the International Energy Agency and the Energy Information Agency of the American Department of Energy in their forecasting or modelling work.

To be significant, the simulations must be operated with enough detail in terms of goods or commodities (in particular energy products) and in regional aggregation of countries. As for the nomenclature of goods, eleven were selected, of which five for energy. Concerning the regional nomenclature, main emitting countries such as USA, China, India are individualized, and European Union member countries are taken as a whole. Represented separately are the main energy and oil exporters, OPEC and Russia, and the remaining countries are aggregated according to their level of development (Other Developed Countries and Other Developing Countries, the limit between them being a Gross National Income per capita of 12375 US$ in 2014).

The Benchmark scenario is based on the assumption of a uniform carbon price (tax) implemented in all countries and regions. It is calibrated on the average IPCC-AR5 scenario, and in particular on the same level of emissions decrease from the average period 1990-2000

[3] The distinction between BAU and Current Policy Scenario is not always obvious. In fact, it depends on the reference year.
[4] A 1.5°C warming above pre-industrial levels, retained as the target by the Paris agreement, has not yet been really assessed in the community of modelers and has not been considered up to now by IPCC, which announced that it will be the yardstick for the next Assessment Report.
[5] "From Nationally Determined Contributions to a World Carbon Market - The Road to Success for the Paris Agreement," by Alain L. Bernard, ASSESSECO
[6] Bernard A. & M. Vielle, "Modelling Impacts of a Global Carbon Price", (2013) and "Re-thinking a Minimum Global Carbon Price" (2015), Ecole Polytechnique Fédérale de Lausanne

(related to the Kyoto Protocol) up to the year 2050, i.e. 63.2%. This brings out a carbon price of 355 US$ of 2007.

From 2040 to 2050 is applied the rule of increase according to the (average international) interest rate of 5.7%. Applying the same rule from 2020 to 2040 would produce a too high carbon price in 2020 (which is only 2 years from now) and a too steep increase from 2020 to 2030, knowing that important technologies such as Carbon Capture and Storage won't be commercially available at this horizon. Lower figures have been selected and their justification will appear below.

The resulting path of carbon price in the Benchmark scenario is given in the Table below in domestic money (the values for U.S. representing the "international price").

Table 1: Evolution of the carbon price in domestic money in the Benchmark scenario

	2020	2030	2040	2050
USA	6	76	203	355
EUR	6	73	189	325
Other Developed Countries	6	72	190	329
RUS	6	86	251	480
CHI	8	110	300	531
IND	8	102	273	470
OPE	7	88	256	480
Other Developing Countries	7	88	245	447

Though all are measured in dollars of the base year (2013), differences in the carbon prices across countries reflect the change over time of the real exchange rates which, as is the case for the real interest rates, are endogenous in the model.

1.2. Results of the BAU and Benchmark scenarios

Detailed results –in particular concerning exchange rates and interest rates- are to be found in the above-mentioned paper. Here the focus is put on emissions and welfare costs. The resulting evolution of emissions is given in the two following Tables:

Table 2: CO_2 emissions in the BAU scenario (millions tons of CO_2)

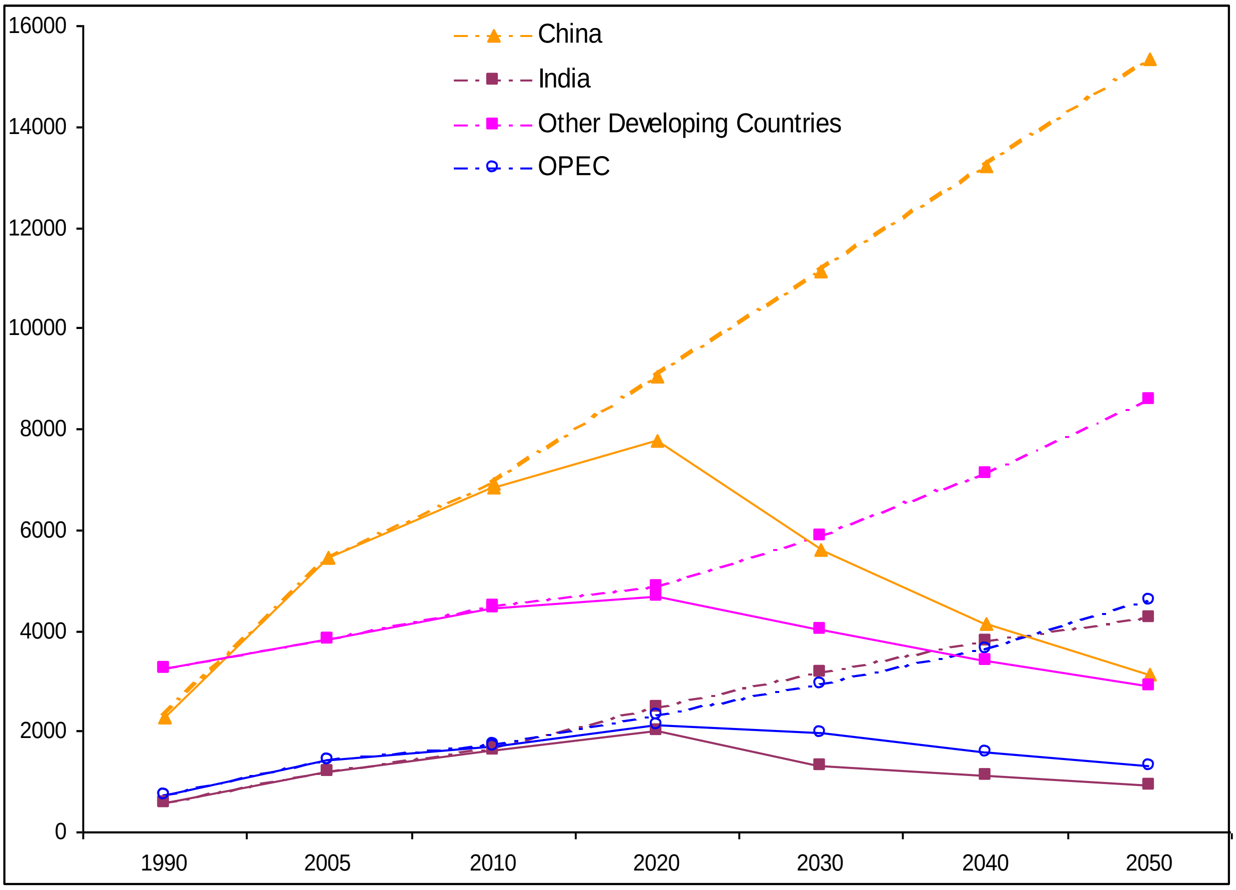
	1990	2005	2010	2020	2030	2040	2050
USA	4869	5774	5538	4935	5612	5643	5881
EU28	4068	3988	3926	3459	3664	3875	4139
Other Developed Countries	2396	3333	3531	3282	3453	3633	3876
Russia	2179	1512	1593	1668	1902	2214	2613
China	2278	5444	6927	9027	11126	13226	15325
India	580	1191	1648	2487	3186	3779	4261
OPEC	732	1421	1729	2317	2951	3647	4580
Other Developing Countries	3251	3834	4475	4884	5877	7093	8596
WORLD	**20353**	**26498**	**29367**	**32059**	**37770**	**43110**	**49271**

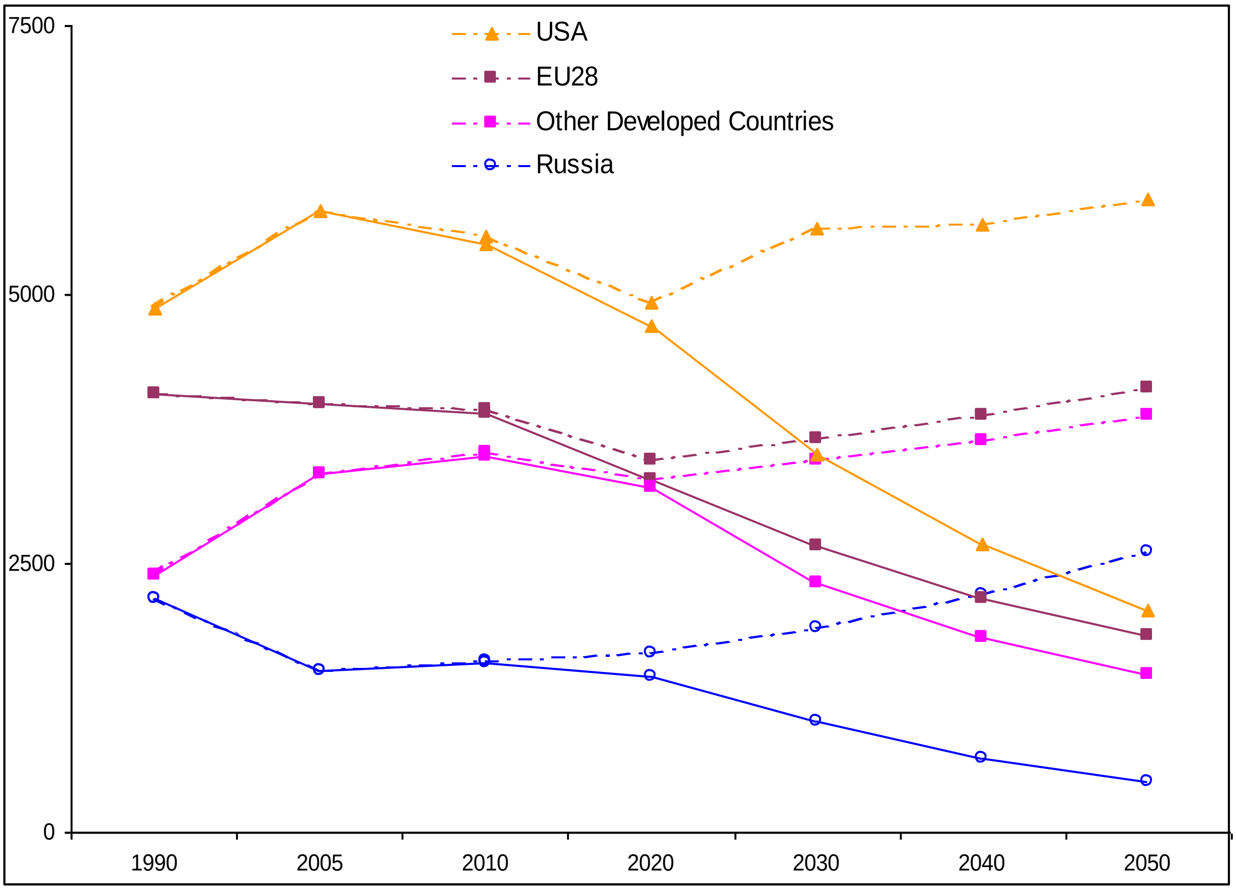
Table 3: CO_2 emissions in the Benchmark scenario (millions tons of CO_2)

	1990	2005	2010	2020	2030	2040	2050
USA	4869	5774	5479	4713	3514	2677	2068
EU28	4068	3988	3889	3271	2663	2181	1829
Other Developed Countries	2396	3333	3503	3214	2318	1803	1460
Russia	2179	1512	1575	1449	1038	693	468
China	2278	5444	6856	7782	5590	4133	3123
India	580	1191	1636	1993	1324	1110	942
OPEC	732	1421	1706	2108	1956	1569	1306
Other Developing Countries	3251	3834	4432	4693	4021	3397	2891
WORLD	**20353**	**26498**	**29075**	**29223**	**22423**	**17563**	**14086**

They are represented in the following graphs:

Figure 1: Benchmark Pathway to Long Term Decarbonization (BPLTD)
(solid lines, BAU; dotted lines, Benchmark scenario)





1.3. Assessment of INDCs by comparison to BAU and Benchmark scenarios

The BAU and Benchmark scenarios set the stage for assessing the Intended Nationally Determined Contributions, and in particular their effective ambition. The exercise has been performed, mostly partially, by world or regional bodies such as IEA, by research centers and academic institutions, and by think tanks and NGOs.

Estimates for some countries or group of countries have been performed by UNEP and IEA[7] and issued through graphical representations that don't facilitate their utilization. In the same unwillingness to initiate a genuine debate, the related publications abstain to emit any judgment or to give clues for measuring ambitions.

From a thorough study of the literature, it is possible to find more detailed assessments, which usually converge towards the same results and judgments.

A comprehensive and detailed assessment has been performed on the 189 countries which have submitted INDCs by a team in Ecole Polytechnique Fédérale de Lausanne (EPFL), led by Marc Vielle[8],

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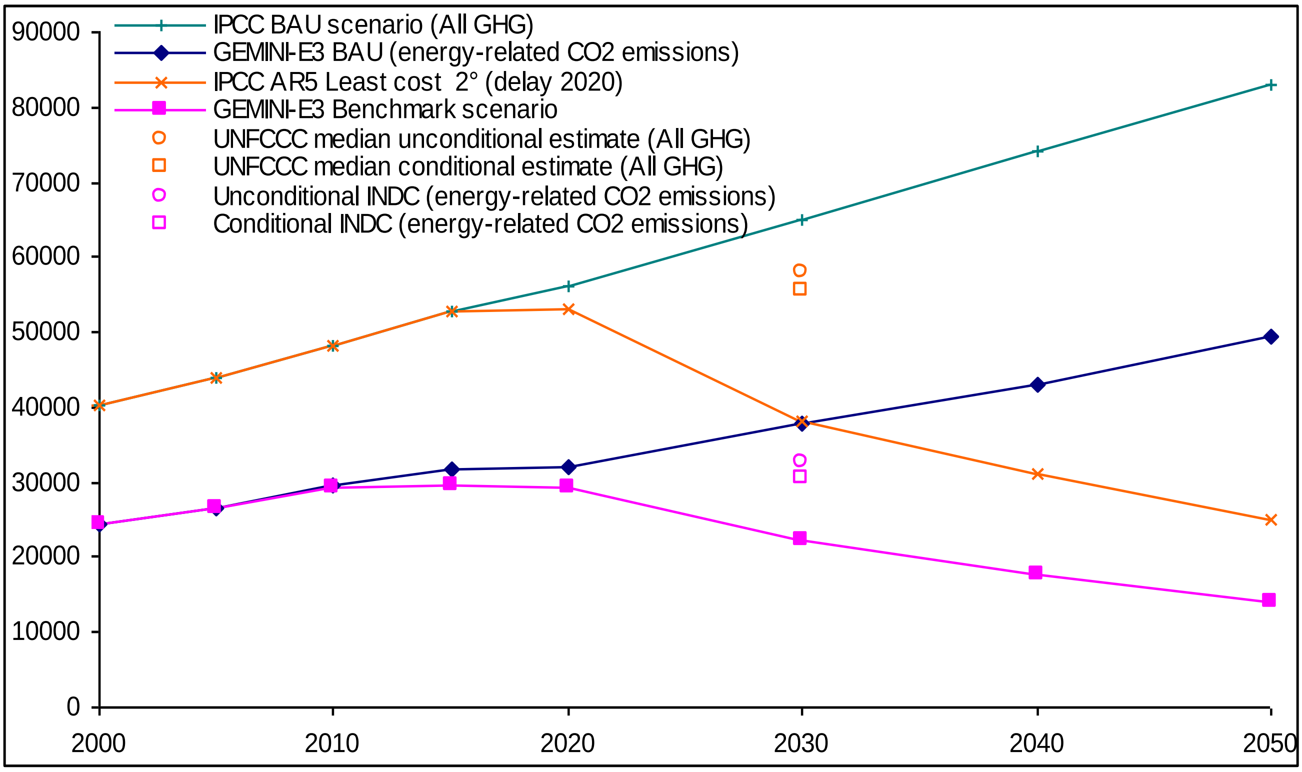
[7] See UNFCCC, 2015. "Synthesis report on the aggregate effect of the intended nationally determined contributions," 30 Octobre 2015, UNEP (2015); "The Gap Emissions Report 2015," United Nations Environment Program, Nairobi; IEA, "World Energy Outlook 2015," Special Report on Energy and Climate Change

[8] Marc Vielle has been my co-author in the near totality of my work on climate change, through in particular the GEMINI-E3 model we built and continue to manage together. The paper on INDCs has not yet been published but Marc Vielle has been kind enough to communicate it to me.

1.3.1. Global assessment from various estimates

As shows the graph below, INDCs aggregated at the world level, unconditional and conditional, are well below the BAU scenarios but significantly above the Benchmark scenario. On the whole, it appears that *implementation of INDCs in 2030 would perform at best half of the way to joining the long term 2°C trajectory*. This is consistent with nearly all other assessments that have been performed and issued.

Figure 2: Unconditional and conditional INDCs compared to BAU and 2°C scenarios from IPCC AR5 and GEMINI-E3



1.3.2. Detailed assessments from EPFL figures

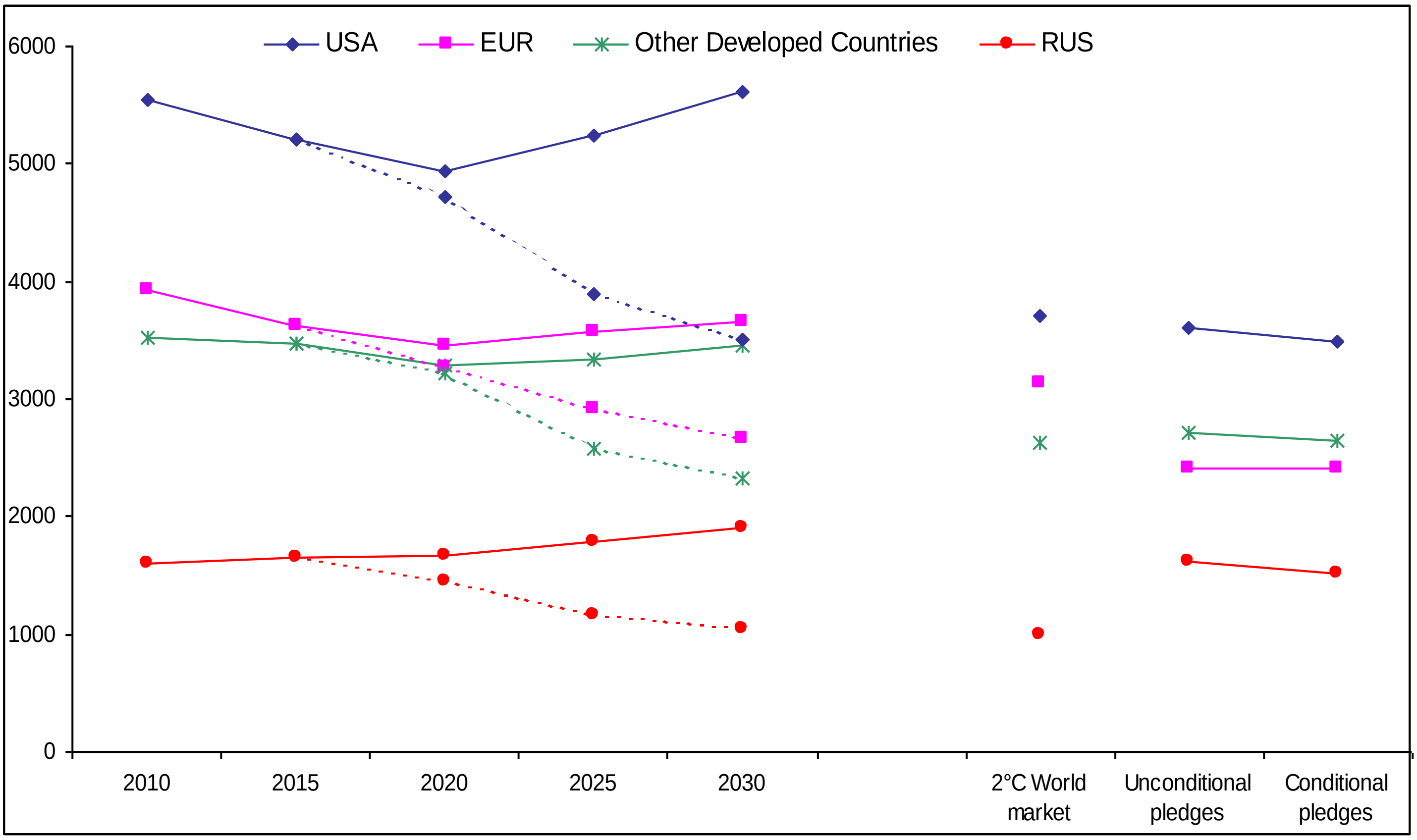
Figures from EPFL have been aggregated according to the country/region nomenclature of the model GEMINI-E3. They are presented in the Table below, for all GHG and for energy-related CO_2 emissions, the latter being compared to the BAU and Benchmark scenarios.

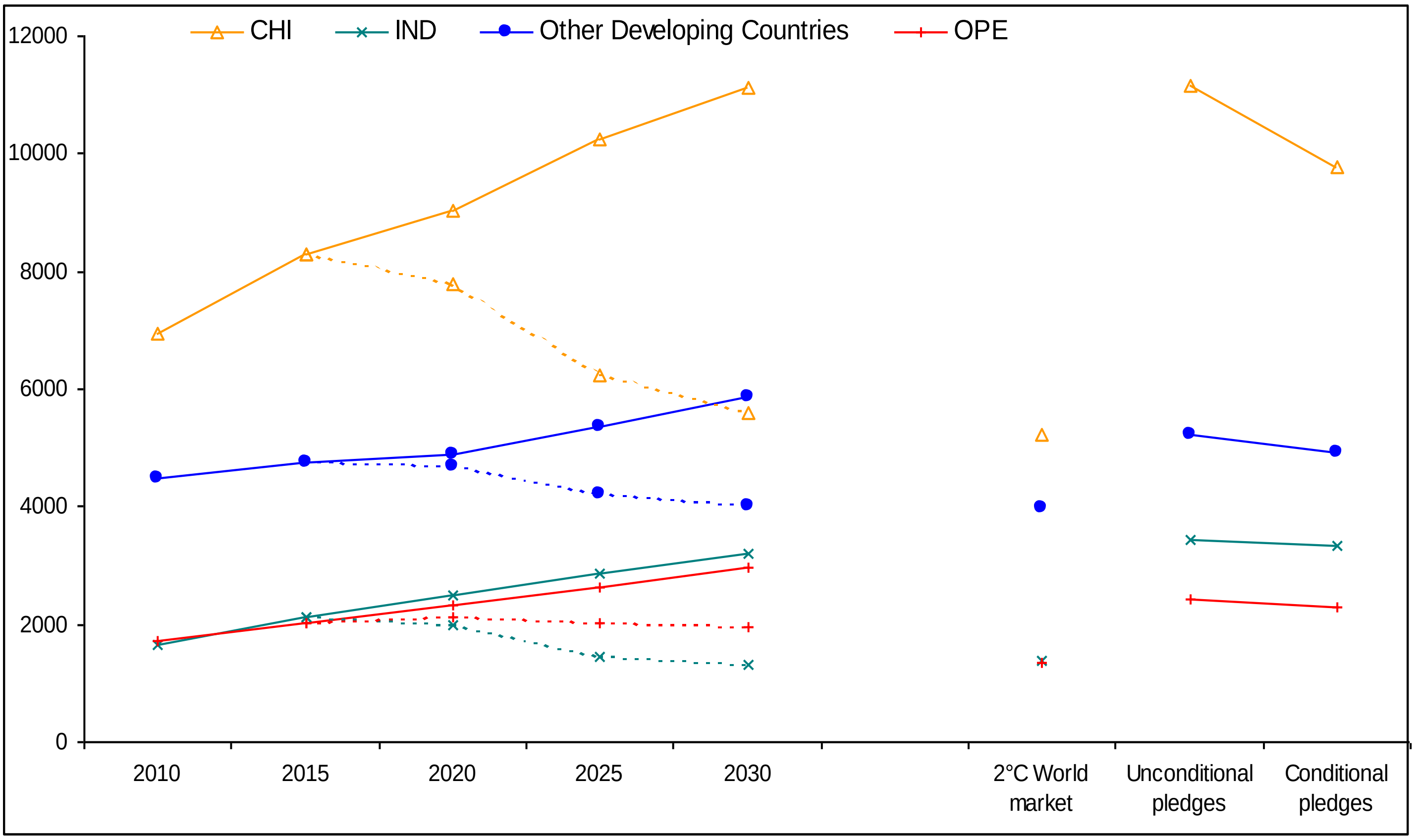
Table 4: Unconditional and conditional INDCs estimated by EPFL and comparison to BAU and Benchmark scenarios

	Unconditional GHG	Conditional GHG	Unconditional energy-related CO2	Conditional energy-related CO3	BAU scenario	Benchmark scenario
	(Millions tons of CO2eq)		(Millions tons of CO2)		(Millions tons of CO2)	
USA	3,918	3,794	3,604	3,490	5,612	3,514
EU28	3,230	3,230	2,414	2,414	3,664	2,663
Other Developed Countries	3,806	3,658	2,711	2,653	3,453	2,318
China	16,172	14,452	11,172	9,776	11,126	5,590
India	6,702	6,502	3,439	3,336	3,186	1,324
Russia	2,649	2,473	1,622	1,514	1,902	1,038
OPEC	3,830	3,453	2,420	2,300	2,951	1,956
Other Developing Countries	16,845	15,768	5,237	4,922	5,877	4,021
WORLD	57,154	53,330	32,621	30,404	37,770	22,423

Estimates concerning energy-related CO2 emissions are represented in the following graph and compared to past evolutions and BAU and Benchmark scenarios.

Figure 3: INDCs compared to BAU and Benchmark scenarios
(BAU: solid line; Benchmark scenario: dotted line)





It appears clearly that for developed countries INDCs are much below BAU and close to the Benchmark scenario. This is particularly the case of USA and EU28, not exactly for other developed countries for which there is a gap of around 15%.

Russia and OPEC are under BAU but above Benchmark scenario, and it is the same for Other Developing Countries.

The assessment is totally different for China and India, whose INDCs are close or even above BAU scenario and significantly above Benchmark scenario. The combined deviation of these two countries explains most of the world gap.

2. Designing and implementing a world market of tradable permits

Carbon pricing is much and hotly debated and if there is a nearly unanimous agreement among economists on the need to resort to economic mechanisms and/or signals, different frameworks are backed by them. A market of tradable permits based on quotas, designed in order to insure feasibility –in the short run- and equity –in the long run- is advocated below, then assessed up to the year 2030 as a candidate for implementing the Paris Agreement and setting the world economy on the trajectory consistent with the long-term target set by COP21[9].

9 The main ideas have been presented and applied to the Kyoto Protocol in two communications to the International Energy Workshop held in Paris in 1999, "The Pure Economics of Tradable Pollution Permits: Theory and Application to Micro- and Macro-Economic Assessment of Environmental Policies" and "Efficient Allocation of a Global Environment Cost between Countries: Tradable Permits VERSUS Taxes or Tradable Permits AND Taxes? An Appraisal with a World General Equilibrium Model".

2.1. The conceptual issue of carbon-pricing

In the presence of an externality such as a pollution, the obvious answer –nearly unanimously advocated by economists- is to tax or equivalently to subsidize the refraining to pollute. Markets of pollution rights are also a mean to internalize the pollution.

From the start of the endeavor by world countries and international organizations, United Nations and at the forefront UNFCCC, pricing the GHG emissions was contemplated and in particular the Kyoto Protocol, if it did not formally retain a universal carbon tax or a world market of emissions rights, set what were called "flexibility mechanisms" that were an ersatz of carbon pricing. It must be remembered that in the Kyoto Protocol, only developed countries were assigned commitments and emission ceilings for the Year 2020.

In a perfect world the simplest solution is to set a uniform carbon tax that would be implemented by all countries in all sectors and activities. But this supposes that there are no distortions, either fiscal or economic, in the various countries and in the world trade. The mere fact that in the initial situation the various concerned countries tax fossil energy at different rates –some even subsidizing its consumption by firms and/or households- contradicts the assumption.

The difference may be significant, even between developed countries and is obviously much bigger between developed countries and others, in particular fossil energy exporters such as members of OPEC. In a 1999 paper, William Nordhaus compared energy taxation in the US and in European countries and found a gap equivalent to 100 US$ by ton of carbon (around 25$ by ton of CO2). And he concluded: that the US should start implementing a carbon tax of this level before the European countries start taxing GHG emissions.

Independently of the above-mentioned distortions, a uniform carbon tax has two main drawbacks. The first is that its implementation can be bypassed by countries with the use of fiscal tools or other devices that would reduce or even cancel the effect of the carbon tax, subsidizing for instance equipments that produce or use fossil energy. This behavior is known in the economic literature under the name of "greasing".

In other terms, there is no incentive for countries to really implement the carbon price and there is no obvious mean for other countries and international organizations to check the reality of the carbon pricing. Then such a device may not operate in a decentralized way because checking and verification (by which supra-national authority?) would be essential but very difficult if not impossible to perform.

The second drawback is that a uniform carbon tax has equity effects, in each country but this may be corrected by the domestic fiscal tools, but also and mainly among countries and their sign and importance for each of them are not clear-cut. Of course, their estimation can be operated by models, in particular world General Equilibrium Models, but this would open the way to questionings and disputes. Comparisons of models simulating the same scenario, as operated for instance under the auspices of the Energy Modeling Forum, exhibit very large differences in the results, one would say from zero to infinity and even from minus infinity to plus infinity!

On the contrary a market of tradable permits does not exhibit these drawbacks. The only initial collective decision is, beside setting the long-term trajectory of world GHG emissions, to allocate the rights between countries. This can be considered politically very sensitive and them difficult to agree upon, but as will be shown below sensible and equitable solutions can be put forward.

Once the rights are allocated to countries, the market can work in a totally decentralized way. It is up to each country to determine its domestic abatement policy (and the corresponding domestic tools which can be a domestic carbon tax or a domestic carbon market) and its position in the international carbon market, i.e. its supply or demand of permits according to the equilibrium price. As is the case in an efficient market, **the autonomous optimizing behavior of each party is favorable to the whole collectivity**.

Operators in the world market may only be the countries because they detain the rights which represent their commitments if they don't trade. They are accountable towards the world community of these commitments and the use of their rights[10].

It is however possible for countries to delegate the trade of permits to domestic firms under a condition. It must be understood that in such a system, the world and the domestic equilibrium carbon prices have no reason to coincide. Briefly one can say that the difference represents the existing distortions in the given country, mainly the level of existing energy taxes. A country with no (distorting) energy taxation would obtain a domestic tax somehow equal to the world price, while a country with distorting initial taxation would exhibit a lower domestic taxation (and a country subsidizing fossil energy a higher domestic price –in order to cancel the effect of subsidies).

Then a country could give delegation to domestic firms in order to operate in the world market under the condition of compensating the difference (if the world price is higher the firm is positively compensated of the difference).

This mechanism of a world carbon market under distortions, i.e. in a second-best setting à la Boiteux, has been theorized in a 1999 paper presented at the Paris IEW conference of this year, and numerically applied in another paper presented at the same conference. An important issue is the efficiency of the market, according to the PARETO criterion.

In second-best problems, in particular in the present one where the issue is to determine the equilibrium (in the markets of goods and in the market of permits) between countries implementing each a second-best policy, PARETO efficiency is not in general strictly obtained except when specific properties such as in the Diamond & Mirrlees paradigm (with profits being totally taxed) are checked. In the present case, PARETO efficiency can be shown to turn up under separability conditions which are not exactly verified in the real world. But we can consider that the equilibrium is not far from PARETO-efficiency, and numerical simulations can check the eventual gap to efficiency.

The remaining issue is the allocation of permits and how it can be envisioned. The first consideration is that in the initial years, the allocation of permits may not be far from existing emissions –which is known as the rule of grand-fathering-: which prevents from a too high volume of trade –and of financial transfers- that would be considered unacceptable by some countries and anyway nearly impossible to manage. In the short run, the constraint is feasibility and simplicity.

In the long run, the only rule that can be considered as equitable is the allocation proportional to the size of populations, i.e. the same rights for every human, wherever he lives[11]. This concerns the mitigation issue and does not preclude others transfers under the adaptation issue, with tools such as the Green Climate Fund.

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[10] As mentioned in the introduction, UNFCCC by the voice of his Executive Secretary Patricia Espinosa now admits that "countries are clearly in the driving seat".

[11] Such an equity rule can be debated. Some people recommend allocating to all humans **since the end of pre-industrial era** an equal right on the **stock** of emissions. This would be much more disruptive in the monetary transfers, in fact not possibly implemented

What appears sensible is to stick to a progressive and linear shift between the two rules of allocation: 95% grand-fathering in 2020 (then 5% proportional to population); 100% proportionality to population around 2050 or 2060. Simulations in the present paper are made with this mixed allocation rule. Results of the simulations show that the two targets of short term acceptability and long-term equity can reasonably be accepted.

2.2. Application to the Paris Agreement

We simulate, up to the year 2030, a global world market of tradable permits with total world emissions consistent with the 2°C emissions trajectory. In order to determine the allocation of allowances we use for 2030 the weighted criterion consisting of 70% grand-fathering and 30% proportionality to population, consistent with the rule presented above.

Tables 5 presents the results of this scenario. The carbon price reaches 80 US$ in 2030. The worldwide welfare cost is estimated to 1.1% of households' final consumption[12] in 2030.

Table 5: effective emissions and allowances in a world market of tradable permits (in millions of tons of CO_2, year 2030)

	BAU 2030	Emissions	Abatement	Quotas (Basis 2010)	Purchases of permits	Financial transfers
USA	5612	3716	1896	3264	451	-36.3
EUR	3664	3143	521	2593	550	-44.2
Other Developed countries	3453	2633	820	2211	422	-33.9
CHI	11126	5209	5918	5024	185	-14.9
IND	3186	1386	1799	2081	-695	55.9
RUS	1902	994	908	992	3	-0.2
OPE	2951	1348	1603	1347	1	-0.1
Other Developing countries	5877	3994	1883	4911	-917	73.8
WORLD	37770	22423	15347	22423	**0**	**0**

The allocation rule of quotas limits the cost for industrialized countries (always lower than 0.9%) and generates incentives for developing and emerging countries. China and mostly India receive high revenues coming from their sales of permits, while the receipts from the emissions' sales are not sufficient for other developing countries to compensate the abatement costs. The main losers are energy exporting countries (RUS and OPE) with very high welfare losses, over 13% of households' consumption, but this is **mainly due to the losses in the Terms of Trade**.

3. The specific situation of Tunisia

Tunisia is a fairly small country according to its area, population and economic size. In terms of GHG emissions, Tunisia weights around 0.07% of the world total (compared to around1 % for France)

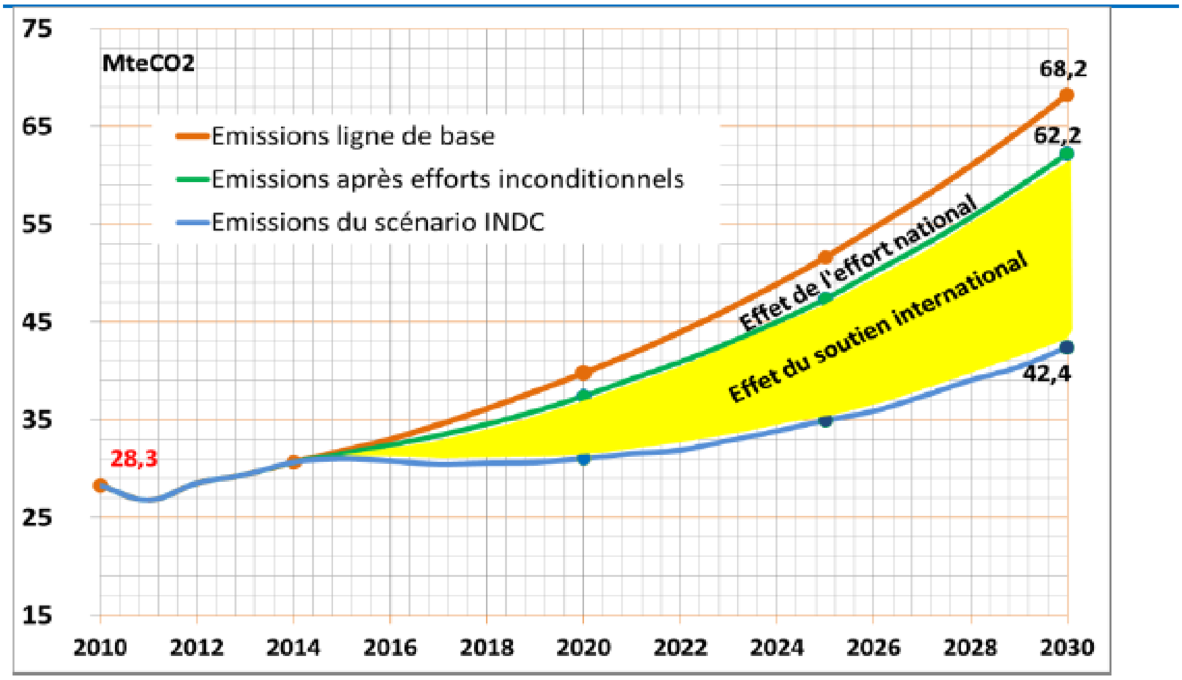
Tunisia issued and presented for COP 21 an INDC which is remarkable in terms of comprehensiveness and ambition. It is 20 pages long, longer than most other INDCs even of developed countries.

[12] labeled HFC. It can be considered as a measure of the standard of living of the whole population.

Its unconditional commitment is based on the target of reducing carbon intensity from 2010 to 2030 of 13% and its conditional commitment of 41%. The unconditional commitment can be supported by the country's own forces and resources but the conditional one needs "international financing". Total cost of investment and associated programs is estimated at 18 billion US$ for mitigation over the period 2015-2030, only 10% being possibly covered by Tunisian own resources.

As for attenuation, the Tunisian Government estimates the financial needs, mainly for immaterial investments and education programs, to 1.9 billion of US$ over the period of 2015 to 2030.

In terms of GHG abatement, and according to the economic growth forecast up to 2030, the rates with respect to the baseline (Business as Usual scenario) are slightly smaller, respectively 9% and 38%.



Trajectoires des émissions de GES selon les scénarios de la ligne de base, de l'effort inconditionnel et de l'INDC

These figures appear impressive, positioning Tunisia among the very best "pupils" among the world countries. However, they must be assessed and compared to other countries under the benchmark of the baseline scenario.

The table below shows this comparison with "Other Developing Countries" (i.e. excluding China and India who weight very heavily by themselves) and total world.

Table 6: GHG emissions of Tunisia compared to other countries

	Tunisia			Other Developing Countries			World		
GHG emissions	2010	2030	average groxth rate	2010	2030	average groxth rate	2010	2030	average groxth rate
Baseline	28.3	68.2	4.5%	15581	21607	1.6%	46963	64049	1.6%
Uncond. INDC		62.2	4.0%		18142	0.8%		59294	1.2%
Cond. INDC		42.4	2.0%		16927	0.4%		54823	0.8%
Population	10.64	12.5		2572	3370		6866	8289	
TeCO2/hab									
Baseline	2.7	5.5		6.1	6.4		6.8	7.7	
Uncond. INDC		5.0			5.4			7.2	
Cond. INDC		3.4			5.0			6.6	
Percent World									
Baseline	0.06%	0.11%		33.2%	33.7%				
Uncond. INDC		0.10%			30.6%				
Cond. INDC		0.08%			30.9%				

3.1. Comments on the base-line

The Tunisian INDC exhibits for the baseline an increase in emissions which is fairly high, not possibly explained only by the underlying economic growth. The annual rates are respectively of 4.5% and 2.8%.

The growth of emissions in the base-line is is significantly faster than for the world average and for the group of "Other Developing Countries", which appear to be the same (1.6%). China and India, not included in Other Developing Countries, exhibit a rapid growth but still smaller than Tunisia (respectively 2.7% and 2.3%).

As for the INDCs, and the more significant that is the conditional one, Tunisia is still much above the world average and the Other Developing Countries, but comparable to China and India. Though the forecasted rate of growth is smaller, Tunisia would then exhibit the same dynamics than the two Asian giants, in the consumption of fossil energy in particular. Such a rapid growth, in a country which is endowed with high potential resources of renewable energy, photovoltaic in particular, must be more carefully assessed and explained.

3.2. What would be the allocation of permits to Tunisia in a world market

With the present figures, it is interesting to reckon what would be the allocation of permits to Tunisia in 2030 according to the rule applied in section 2.

Taking into account emissions of 2010, grand-fathering would bring 12.9 million tons of CO_2eq, well below the conditional INDC. The rule of proportionality to the population would bring much more, 34.2 million tons of CO_2eq, but still below the conditional INDC.

The mixed rule, 70% grand-fathering and 30% proportionality to the population would bring 19.3 million tons of CO_2eq, less than half the conditional INDC. In a market of tradable permits as described and assessed in the previous section, Tunisia would be a net buyer, of 23.1 million tons of CO_2eq, for a cost of around 1.8 billion of US$ while globally Other Developing countries would be net sellers, with total receipts of 74 billion US$.

3.3. For a more precise assessment

A more precise assessment of the forecasts conditioning the Tunisian INDC is desirable. The Tunisian administration and academic institutions have the competence and the tools allowing to perform the task. In particular there exists a Tunisian version of the GEMINI-E3 model which has been built several years ago and could be updated for this purpose.

Summary and future work

The present paper started by assessing the INDCs and, from the finding –largely shared by analysts and academics- that they globally diverge from the path consistent with the long term target of GHG emissions' abatement, endeavored to find where are the main gaps. Two big Asian countries appear to have presented INDCs with very limited if not none ambition, and this finding is also shared by most other analysts and economists.

The paper then advocated and assessed a system of market of tradable permits allowing to give to all the Parties of the UN convention the incentive to act, in a decentralized and efficient way, and taking into account equity among nations.

The last part of the paper was devoted to Tunisia. Though a small country and a small GHG emitter, Tunisia exhibited in his INDC an ambitious goal for mitigation. Tunisia can then be a model for others, in particular developing countries.

Tunisia has large potential resources of renewable energy and in particular is contemplating a huge solar park to provide Saharan power to Europe in the Kébili Governorate, not far from where we are. But Tunisia needs to better assess the conditions of its development, and the associated investment programs.

Implementing its mitigation programs requires for Tunisia financial means not totally available in the country, least to say. It is the same for adaptation, but the Paris Agreement confirmed the commitments of developed countries. As Patricia Espinosa, Executive Secretary of UN Climate Change, declared few days ago (mar 26, 2018):

"… it is very important that developing countries receive assistance to act. To this end, developed countries committed to provide USD 100 billion per year by 2020 to leverage further significant funding."

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[i] MacKay was UK Chief Scientist for Energy and Climate. Stiglitz and Tirole have Nobel prizes. Dion was chair of COP 11 and was Canada's Minister of the Environment. Nordhaus has published on climate policy for 40 years. Weitzman and Cooper are Harvard professors and experts in international relations and environmental econ respectively. Ockenfels is a top behavioral economist and winner of the Leibniz prize.