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NEWSLETTER – November 2019

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## Economics of electricity storage P.9

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## Outreach

12<sup>th</sup> Toulouse Conference  
on the Economics of Energy and Climate

Christian Gollier:  
In defense of the carbon tax

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Economics for the Common Good

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# Editor's note



**F**ollowing Greta Thunberg, children stayed out of school on Fridays to protest against inaction on climate change. Likewise, academics sometimes leave their offices and classrooms to participate in the policy debate. Christian Gollier's book *Le climat avant la fin du mois* puts climate-change mitigation on the nightstand of French-speaking readers. The takeaway message is that climate is an urgent issue that won't be solved without the sacrifice of today's generations. We need well-designed economic instruments such as a carbon tax or emission permits right now. Christian is pushing this agenda into the policy arena through many interviews and the economists' statement on carbon pricing he launched as president of the European Association of Environmental and Resource Economists. In the same vein, I have been appointed by the French Prime Minister to chair a committee in charge of evaluating the EU-Mercosur trade agreement. The aim is to provide a scientific background to inform the debate during the ratification stage.

Our research is also inspired by the challenges that are facing the energy industry and our policymakers. Claude Crampes and Jean-Michel Trochet's microeconomic

modeling improves our understanding of the economics behind the technicalities of energy storage. Similarly, by revisiting the measurement of carbon footprint at a country level, Philippe Bontems and Marie-Françoise Calmette's study allows us to better quantify the impact of trade on greenhouse gas emissions.

Finally, some news about human resources in energy and climate economics at TSE. We welcome back Matthias Reynaert from his sabbatical leave in Leuven and at MIT. We wish good luck to Xavier Lambin who defended his PhD thesis in June and has joined Grenoble Ecole de Management. We are happy to host Knut Einar Rosendhal who is going to escape the Norwegian winter to be with us from January to May in 2020.

*Bonne lecture !*  
**Stefan Ambec**  
 Director, TSE Energy & Climate Center

# News

## Capitalism and the challenge of global warming

On August 28, TSE director Christian Gollier took part in a plenary session dedicated to global warming at the *Rencontre des entrepreneurs de France*, an annual gathering organized by France's largest employer federation, MEDEF.

The effects of global warming are devastating and only accentuate the inequalities between North and South. More and more voices are being raised, especially among the younger generations, to encourage states to tackle the problems, or to call for alternative modes of production and consumption.

The coming years will be decisive, but where do we start? Is capitalism responsible? Can we get by without binding measures? Is delay an option? What can companies do?



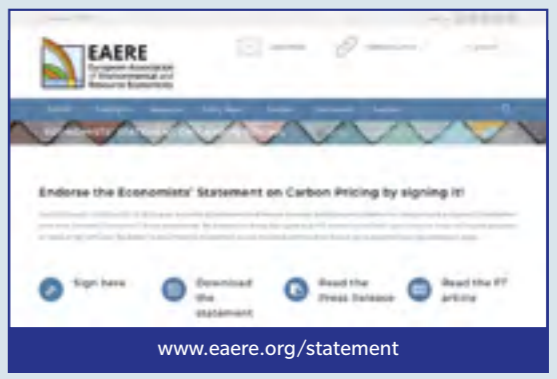
*The only way to stop producing greenhouse gases is to substitute fossil fuels with other, much more expensive energy sources - we have to ask for sacrifices for the good of humanity. Unlike other countries such as the United States, in France the problem is no longer a lack of awareness about climate change. The problem is how to organize our society so it can achieve carbon neutrality within 30 years.*

## European economists call for carbon pricing

The Policy Outreach Committee of the European Association of Environmental and Resource Economists (EAERE) has released a public plea to "address climate change more effectively and to adopt the best solution we have so far: carbon pricing".

**TSE director Christian Gollier**, who will take up the EAERE Chair in the fall of 2019, joins the signatories of the statement, alongside the full EAERE Council and a number of Nobel laureates.

The signatories underline that a price on polluting activities is a crucial and efficient way to reduce GHG emissions, drawing the attention of policy-makers to its importance as a key instrument, although not the only one, for meeting decarbonization targets.





## Stefan Ambec to lead French evaluation of EU-Mercosur trade agreement



The French Prime Minister has asked a commission of independent experts to carry out a full and transparent assessment of the draft trade agreement between the European Union and Mercosur.

This commission is comprised of 10 scientific experts in environmental, commercial, agricultural, health, legal, social and geopolitical matters. Their purpose is to provide objective insight into the issues at stake in the agreement in order to stimulate public debate and prepare France's position in the Council of the European Union.

The conclusions, which will be supplemented by a quantitative impact study and specific work on sensitive agricultural sectors, will be submitted to the Government in November 2019 and made available to the public thereafter.



*European trade policy must be an instrument of economic sovereignty, but also one that promotes European preferences and values, including sustainable development, the fight against climate change, the protection of biodiversity and food safety. As such, the so-called new generation international agreements must aim not only to deepen trade integration, but also to contribute to achieving these objectives by strengthening international trade rules.*

*Édouard Philippe, Prime Minister of France, in the letter addressed to Stefan Ambec*

### THE MEMBERS OF THE COMMISSION

**Stefan AMBEC:** Environmental economist at TSE and research director at INRA  
**Hélène OLLIVIER:** Environmental economist at the Paris School of Economics  
**Yann LAURANS:** Director of the IDDRI biodiversity program  
**Sébastien JEAN:** Director of CEPII  
**Hervé GUYOMARD:** Research Director at INRA  
**Philippe CHOTEAU:** Head of the Economics Department at the Institut de l'Élevage  
**Jean-Luc ANGOT:** Inspector General of Veterinary Public Health  
**Yves NOUVEL:** Professor of International Law at the University of Paris 2 Panthéon-Assas  
**Raymond TORRES:** Member of the FUNCAS Foundation, former Director of Research at the ILO  
**Olivier DABENE:** Professor of Political Science at Sciences Po, specialist in Latin America

## A new transatlantic alliance

Twenty years after the first negotiations began, the European Commission has reached an agreement in principle on free trade with the South American trade bloc Mercosur (the Southern Common Market), whose full members are Argentina, Brazil, Paraguay and Uruguay.

The June 28 agreement is said to include a political dialogue and cooperation component.

If ratified, the agreement will enable preferential access to Mercosur markets for EU exporters. France has €31bn directly invested in Mercosur countries, with which it achieved a trade surplus of €2bn in 2018.

As negotiated, the EU-Mercosur agreement covers 91% of trade between the two areas. It will open up many agricultural and industrial markets, including provisions on reciprocal access to public procurement, sanitary and phytosanitary measures. Close cooperation between the EU and Mercosur will be required for the implementation of such measures, the protection of intellectual property rights and geographical indications, and the promotion of sustainable development.

*France will only be able to support this agreement if it provides sufficient guarantees on three essential points:*

- ① Effective implementation of the Paris Climate Agreement;
- ② Compliance with European environmental and health standards;
- ③ Protection of sensitive agricultural sectors, in particular beef, sugar and poultry.





## Xavier Lambin on the future of electricity markets

Xavier defended his thesis on *“Essays in Industrial Organization with Applications to the Electricity and Digital Markets”* in front of a panel of senior economists.

Estelle CANTILLON, *Université libre de Bruxelles* | Paul BELLEFLAMME, *Université catholique de Louvain* | Bruno JULLIEN, *TSE* | Patrick REY, *TSE* | Thomas-Olivier LEAUTIER, *TSE* | Andreas EHRENMANN, *ENGIE*

“The strong decentralization of electricity supply and demand is moving us further and further away from the traditional production model. In particular, significant challenges related to the variability and unpredictability of new generation sources require changes to the rules governing electricity trading. This thesis mobilizes the tools of industrial organization to propose market architectures capable of meeting these challenges, he told them”.

An engineer by formation and former consultant, Xavier followed his 2013 master’s in economic theory and econometrics with a PhD in energy and digital economics, directed by Thomas-Olivier Léautier and Bruno Jullien. He gave tutorial classes at Ecole Nationale de l’Aviation civile, and was successively a visiting scholar at Berkeley, Bologna and Northeastern. Today, he is an assistant professor at Grenoble Ecole de Management, continuing his work on the architecture of electricity markets and their interactions with the digital economy.

## From Belgium to Boston Mathias Reynaert on the drive for greener cars

Mathias Reynaert is an assistant professor of economics at TSE. His fields of interest are empirical industrial organization and environmental economics. He completed his PhD in economics at the University of Leuven and the University of Antwerp in 2015.

### RESEARCH HIGHLIGHTS :

*“My research aims to evaluate environmental policy in the car market, with a specific focus on European regulations and the European car market. I try to evaluate the market outcomes when regulators impose taxes or require cars to have lower emissions.*

*Automobile manufacturers can respond to emission regulations with different abatement strategies. I find that manufacturers adopt green technologies and sell more fuel efficient vehicles in response to stringent EU policy. But in the wake of the Volkswagen emissions testing scandal, my research also uncovers that automobile manufacturers game EU carbon emission ratings. This gaming harms consumers by eroding information, but it benefits them when cost savings are passed through into prices. My research evaluates how market equilibrium, consumer choice and profits change when firms respond to environmental regulation with different abatement strategies.*

*Thanks to GEMCLIME funding, I was able to spend eight months at the MIT Center for Energy and Environmental Policy Research. I was hosted by Christopher Knittel, an expert in my field. The visit allowed me to learn about global policies in the energy and environmental domain at a place with researchers from around the world. Boston is a great place to be for researchers – you get to connect with many interesting people and it’s a perfect environment for finding inspiration. This experience gave me the opportunity to deliver seminars at different institutions, to sample other research and to shape my own research agenda.”*



## Portrait Knut Einar Rosendahl



*TSE and its Energy and Climate Center has a very good reputation, with a large number of highly skilled scholars working in the field of environmental economics. One of them is Stefan Ambec, who I know personally and highly appreciate.*

*By visiting TSE I expect to get new ideas and inspirations for my research, through interesting events and interactions with people at TSE. I also look forward to several months of living in southern France! ”*

Joining the TSE community of world-class experts on environmental and resource economics, Professor Knut Einar Rosendahl (Norwegian University of Life Sciences) will be a visitor at the Energy and Climate Center from January to May. Here, he discusses his research on climate policy and the Norwegian energy experience.

### How have the challenges of research in environmental economics evolved in recent years?

- One particular challenge for environmental economists, especially in the field of climate economics, is that our main message (“put a price on carbon”) is rarely accepted by policymakers as well as the public. Hence, we need to look into not only first-best policies, but also second- (and third-) best policies. Then our conclusion tends to be less clear-cut, as it typically depends on which policy constraints are out there.

### What have you been working on lately?

- My research mostly focuses on climate policy. For a long time, I have been doing research on policies to prevent carbon leakage. Carbon leakage means that climate policies in one part of the world (e.g. Europe) can lead to higher emissions elsewhere. Lately, I have been investigating whether taxes on consumption and use of emission-intensive products can be a good supplement to the current climate policy in Europe. The short answer is yes. I have also been working on the EU Emission Trading System (ETS), and how the new rules that came into force this year may affect the ETS. The new rules are probably the main reason why the ETS price has quadrupled over the past two years. This fall I am also studying the (proposed) coal phaseout in the UK and Germany; both what led to this policy and the impacts it may have.

### How might your research help policymakers in the fight against climate change?

- It can help policymakers to understand the effects of different types of climate policy, both with respect to emissions and costs of the policy. Then policymakers are in a better position to make knowledge-based decisions.

### What can we learn from the Norwegian experience to guide energy transition in Europe?

- Norway has combined quite high carbon prices (CO<sup>2</sup> tax since 1991) with quite generous support to green energy technologies. This combination of ‘carrot and stick’ is important for a rapid energy transition. Support of green energy technologies has mostly been directed to new technologies, supporting both R&D and deployment.

The most prominent example is probably the huge support of electric vehicles (EV), which has made Norway by far the biggest EV country in the world when it comes to the share of EVs. Both monetary and other types of benefits for EVs have led to this rapid market penetration of EVs. There is, however, much discussion in Norway about the extent and design of these support schemes, not least among economists.



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# Research highlights

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## Economics of electricity storage

Claude Crampes



How will the energy sector be affected by advances in electricity storage? TSE's Claude Crampes teamed up with EDF economist Jean-Michel Trochet to conduct a unified economic analysis of the various technologies and services now available. Their research highlights the complementary value of storage in electricity systems using a high share of sources that have low variable cost and low carbon generation, such as nuclear and renewables.

Over the past decade, electricity storage has generated many economic studies. Per se, the subject is nothing new: the history of lead-acid batteries and PHS (Pumped Hydroelectric Storage) is nearly as long as that of the electricity sector. The basic economic rationale has also remained unchanged. But Claude and Jean-Michel highlight two facts that have revived economists' attention in electricity storage for stationary use.

Since the early 2000s, the array of technologies has widened with the use of lithium-ion (Li-ion) batteries in mobile phones and other portable devices, then in electric cars, and more recently for stationary use. Other less mature technologies are considered at R&D level or in the mid- or long-term, such as sodium-sulfur batteries, flywheels, redox flow batteries, compressed-air storage, metal-air batteries, super-capacitors, pumped thermal electricity storage and liquid-air energy storage. Hydrogen produced by electrolysis, stored and then reused for electricity is also a potential solution.

Meanwhile, the recent deployment of intermittent wind power and solar photovoltaics (PV) has created new opportunities and requirements for storing electricity at a low cost, adding to those already provided by nuclear and hydro power.

As a result, the study of services provided by storage to the electricity system has naturally been growing. These include: energy transfers (also named arbitrage) across weeks, days, day-night, load-following; energy transfers for a few seconds or minutes (ancillary services) to provide frequency-control, quality improvement in electricity networks and uninterrupted power supply (UPS) at locations of industrial consumers connected to the grid.

### Unified cost-benefit analysis

A growing number of economists are interested in analyzing the electricity mix of storage and variable renewables (wind power and solar PV) to smooth intermittent power injections. However, these cost-benefit analyses give an incomplete view of the rationality for the choice and sizing of storage technologies in relation to the type and size of renewables and non-renewables capacity. This is not surprising, say Claude and Jean-Michel, as short-term scheduling and long-term investment analyses are both newer and more complex for storage than for fossil-fuel plants. For the latter, scheduling through the merit-order of variable costs and investing through the criterion of break-even points of the expected use duration are classical and well-understood concepts.

In a new paper, Claude and Jean-Michel aim to lay a foundation stone for a similar unified cost-benefit analysis for electricity storage. Their first goal is to fill the gap at the analytical level. The optimal running of a stored limited resource (oil, hydro in dams, CO<sup>2</sup> in the atmosphere) is well documented and the researchers' approach may be seen as a follow-up to this literature.

They determine the conditions for the optimal scheduling of a storage installation in a given power-generation system, summarized by the chronicle of hourly wholesale market prices. The result is a short-term gross profit for the installation. They then determine the conditions for optimally sizing the storage installation that maximizes long-term profit. But it is also essential to examine the feedback of this sizing to the sizing of the power-generation system, and in

“ A growing number of economists are interested in analyzing the electricity mix of storage and renewables to smooth intermittent power injections. However, short-term scheduling and long-term investment analyses are both newer and more complex for storage than for fossil-fuel plants.

particular the savings in peak-load and mid-load generation that storage might provide. This assumes a power system with investment needs in peak-load and half-baseload generation plants. In cases of overcapacity such as in continental Europe over the past few years, the benefits from storage, hence the relevance of installation development, are substantially reduced.

## Charge and discharge durations

The researchers' main point is to make explicit the difference in value across technologies characterized by different charge and discharge durations, defined in the following way:

- Charge duration is the duration needed to fill up the reservoir initially empty at maximal inflow capacity.
- Symmetrically, discharge duration is the duration needed to empty the reservoir initially full at maximal outflow capacity.

The two durations differ because of the technology design, the inflow and outflow capacities, and energy losses in the process. These technical specifications differ from duration uses that are much longer. For instance, an electric vehicle (EV) with a full battery can be used for a few hours, although its discharge duration is shorter than one hour.

Storage technologies have different charge and discharge durations. Durations of super-capacitors and flywheels are a matter of a few seconds or minutes. Li-ion battery durations are usually less than one hour, while some recent designs reach four hours. Sodium-sulfur batteries made by NGK have a 7-hour discharge duration. Compressed-air storage durations can exceed 10 hours. PHS durations are from a few hours to a few dozen hours. Hydroelectric reservoirs also are usually classified by their durations: pondage reservoirs for a few hours, dams for a few dozens or hundreds of hours. In the future, hydrogen-based technologies could include storage discharge durations of a few hundred hours. In fact, the storage segment of the full hydrogen chain value might have similarities with natural gas storage, for which discharge is seasonal.

Based on these duration differences, technologies can deliver different services. PHS systems are primarily designed for energy transfers across days and weeks, although they can also deliver frequency control. Acid-lead batteries are commonly used in delivering UPS. They are now joined by Li-ion batteries and flywheels. More recently, changes in US federal regulations on wholesale power markets have been instrumental in favoring frequency control by batteries and flywheels. They have entered intra-day energy transfer markets even more recently, mainly on mini-grids in remote areas. Flywheels have delivered UPS and more recently frequency control, but remain uneconomic for energy transfers.

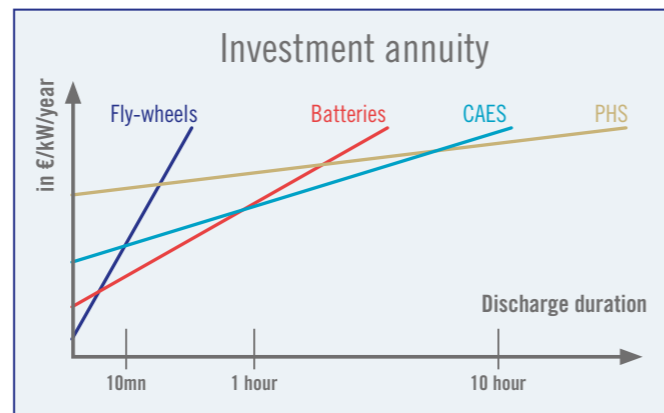
## Storage and the energy mix

Claude and Jean-Michel show how an electric system with efficient mix and size might integrate several types of storage installations to provide fossil-fuel savings - and possibly capacity savings - in peak-load and mid-load plants, without reaching full substitutability. This is the consequence of both the current cost of state-of-the-art storage technologies and the current relatively low cost of fossil fuels and carbon emissions. These conditions might change during the next decades if significant technological progress impacts storage technologies and environmental policy becomes more stringent. Determining the thresholds for these economic parameters to trigger full substitutability between carbonized fossil fuels and renewables (or nuclear) with storage is an open topic.

The researchers' paper is uniquely supply-oriented. This means that they do not address specific storage problems faced by industrial and household customers at their consumption location. Some types of equipment such as Tesla's Powerwall are specifically built for domestic usage, particularly for prosumers who can store a fraction of the output from their PV panels for nightly usage.

Claude and Jean-Michel's unified economic approach with charge and discharge durations proceeds as follows. First, they analyze how to optimally schedule the charging and discharging of installed storage equipment. They determine both the primal variables - quantity of input during charging periods and output during discharging periods - and dual variables, in particular the reserve storage value. They show that the shorter the discharge and charge durations, the more frequently the reserve storage value will change.

Second, the researchers determine the optimal sizing of storage installations by using the discharge duration as the decision variable. They first determine the optimal duration for an isolated storage plant by comparing the discounted value of profits and the investment



Manufacturers propose heterogenous energy storage types with different investment costs according to duration parameters. CAES - Compressed Air Energy Storage. PHS - Pumped Hydroelectric Storage

**“All storage technologies are still so expensive that further development of nuclear and renewables coupled with storage to eliminate totally mid-load and peak-load technologies (gas plants) is unprofitable today. That may change with a very high carbon tax, technological breakthrough or shifts in consumer behavior.**

annuity. They then address the problem of combining several plants characterized by different charge and discharge characteristics. They also complete a long-term analysis of the whole power system production function, including investment in storage installations. They further examine the feedback between well-sized storage installations and the sizing of the power-generation system, e.g. the investment savings in peak-load and mid-load generation plants that storage might provide.

## Key points

Claude and Jean-Michel's paper presents a unified cost-benefit analysis for storage technologies providing heterogeneous services to the electricity system. In particular, they identify the role of discharge and charge durations as a key metric for segmenting storage technologies and services. The analysis allows them to highlight the following points:

- With basic capital budgeting technics one can determine I) the optimal operation of a given storage equipment characterized by its charge and discharge durations and, going backwards, II) the optimal size of equipment to install.
- The charge and discharge durations can be used as instrumental variables to determine both the optimal combination of several storage technologies and the optimal mix of production and storage equipment.
- Present state-of-the-art storage technologies provide potential economic savings in fuel costs for peak-load and mid-load plants, consequently in CO2 emissions, since most peak-load and mid-load plants are fossil-fuel plants.
- All storage technologies are still so expensive that substitutability for peak-load and mid-load generation development is partial. This means that further development of baseload technologies (nuclear and renewables) coupled with storage to eliminate totally mid-load and peak-load technologies (gas plants) is unprofitable today.

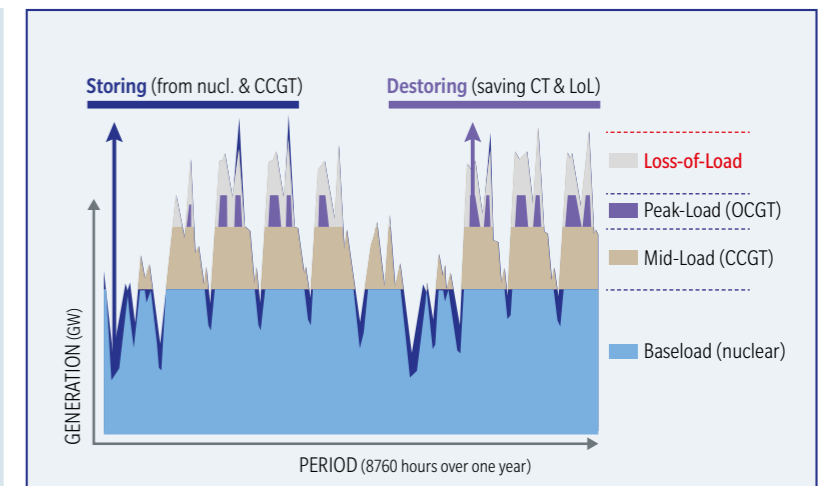
Studies on the possible new electricity mix in 2050 illustrate the last point to a certain extent, Claude and Jean-Michel observe. Nearly 100% decarbonized electricity mixes with nuclear and renewable technologies show a growing role for storage development. Fossil-fuel plants that used to make the major baseload part of electricity worldwide are kept in this new mix but relegated to a role of security of supply, used in mid-load and peak-load.

## SUMMING UP

The researchers' deterministic analytical framework, although simplistic, still provides for key intuitions. Complementary analysis with demand and renewables uncertainty would show the essential quality of storage equipment as an insurance device on top of a mere buffering function.

Access to storage equipment gives a premium (the convenience yield) since it allows unexpected demand to be met without changing the production process.

As flexibility requirements on demand side are growing, their analytical analysis might be relevant to common final electricity uses that display storage characteristics, such as water heating from direct electricity or heat pumps, air-conditioning, air heating or cooling processes with "inertia", washing clothes, and electric-car charging and discharging.



Demand and production with storage equipment

**FIND OUT MORE:** Read 'Economics of stationary electricity storage with various charge and discharge durations' and other research by Claude Crampes at: [tse-fr.eu/people/claude-crampes](http://tse-fr.eu/people/claude-crampes)



# Sharing the bill for trade-induced pollution

Philippe Bontems and Marie-Francoise Calmette



The ‘polluter pays’ principle is a widely accepted idea that those responsible for pollution should bear the costs of managing it. But who exactly is the polluter? Existing approaches that ask either producers or consumers to foot the bill have important limitations. In search of a fair and feasible solution, Toulouse researchers Philippe Bontems and Marie-Françoise Calmette have devised a formula that allocates responsibility based on the CO<sup>2</sup> emissions created by each country’s net trade balance.

To establish policies for the reduction of greenhouse-gas (GHG) emissions, it is essential to evaluate a given country or region’s environmental responsibility. For instance, national emission targets have been set up by the United Nations Framework Convention on Climate Change (UNFCCC) based on emissions produced domestically under the Kyoto Protocol. Countries are required to submit national emission inventories to benchmark reductions in GHG emissions. Evaluating and comparing responsibilities in emission flows is important to establish where GHGs are emitted, why they are emitted and which sectors are involved, and to assess climate mitigation progress.

Two ways of accounting for emissions, along with other approaches, have been discussed in the literature: producer responsibility and consumer responsibility. The first of these principles holds that a country is responsible for the pollution emitted when producing goods and services domestically, whether consumption takes place in the country or abroad. This fairness of this producer-responsibility approach has been questioned, partly because it fails to consider GHG emissions from international transport; and because it may encourage carbon leakage, which occurs when producers transfer their operations to countries with laxer emission constraints.

## Outsourcing pollution

According to figures from the Intergovernmental Panel on Climate Change (IPCC), overall emissions rose twice as fast in the first decade of the 21st century than during the previous three decades, and a significant part of this growth is due to international trade. A 2011 study found that CO<sup>2</sup> emissions from the production of traded goods and services have increased from 4.3Gt in 1990 to 7.8Gt in 2008. More recently, opening borders for international trade has been estimated to raise global CO<sup>2</sup> emissions by about 5%.

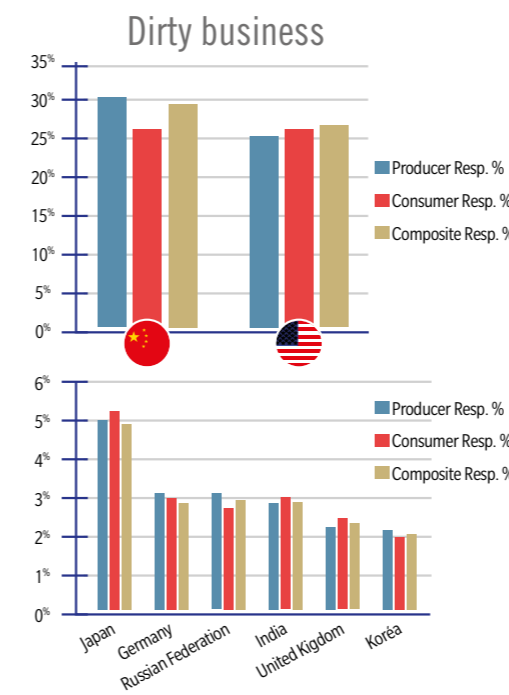
The main explanation, say Philippe and Marie-Françoise, is that the world’s richest countries are increasingly outsourcing their emissions to emerging economies. According to the IPCC, “a growing share of emissions in developing countries is released in the production of goods and services exported, notably from upper-middle-income countries to high-income countries”. OECD countries, for example, have a carbon footprint greater than the emissions produced on their territory, while large emerging countries are in the opposite situation: they use polluting techniques to produce goods which are shipped to and consumed in developed countries.

It is therefore not surprising that less developed countries argue that a growing share of their emissions is due to the production of goods exported to rich countries, whose consumers should ultimately bear the responsibility. In parallel, big emitters like the USA and other developed countries fear their economies’ competitiveness will be impaired if other countries do not commit to curbing their emissions, because of the possibility of relocation of industries towards pollution havens and potential expansion of carbon leakage.

“The fairness of the producer-responsibility approach has been questioned, partly because it fails to consider emissions from international transport; and because it may encourage carbon leakage, which occurs when producers transfer their operations to countries with laxer emission constraints.”

## Shared responsibility

A consumer-responsibility approach, similar to the concept of an ecological footprint, recognizes that no matter where the polluting good or service is produced, the impact is global. Its proponents argue that problems like polluting industries relocations and carbon leakage consequences can only be avoided if the final consumer is held responsible. One counter-argument against switching to consumer responsibility is that it is simply a shift from one extreme (allocating sole responsibility to producers), to another extreme (allocating sole responsibility to consumers). This drawback could be easily alleviated by introducing the notion of shared responsibility, but it is not easy to define the distribution between producers and consumers and to avoid double counting.



The top 10 polluting countries (ranked according to producer responsibility) compared using Philippe and Marie-Françoise’s three measures of responsibility. The worst offenders are China and the US, together responsible for more than 55% of global emissions

Nevertheless, shared responsibility between producers and consumers could represent a compromise solution in international negotiations and facilitate the adoption of a consensus. In a new paper, Philippe and Marie-Françoise aim to find a consensual criterion of allocation of responsibilities for country emissions that would help, for example, to establish a rule for sharing the financial burden of the energy transition. Their goal is not to establish the optimal taxation of CO<sup>2</sup> emissions or to devise a trade policy to correct distortions in competitiveness between countries with different climate policies. Instead, they aim to find a sharing rule of national responsibility at the global level, based on each country’s participation in international trade.

Analyzing GHG emissions from trade requires computing a trade emission balance as the difference between emissions from exports and those from imports. At the global level, the trade emission balance approach coincides with the country-responsibility approach in which one would compute the difference between emissions produced inside the country and the emissions required by its domestic final consumption.

## Designing a new rule

The researchers’ paper first presents the concept of producer, consumer and shared responsibilities in a highly simplified framework, ignoring trade in intermediate goods, and shows the net carbon trade balance that explains the difference between producer and consumer responsibilities. The consumer-based rule does not consider that imports from a cleaner country help in reducing world emissions. Similarly, the production-based rule includes exports, even if exporting helps to decrease world emissions when they go to less clean countries.

To address these problems, Philippe and Marie-Françoise propose a modified definition of the net carbon trade balance that attempts to establish the best emission-intensity ratio in bilateral trade relationships. This consensus criterion for sharing environmental responsibilities must take into account some national characteristics. In particular, they want to take into account the wealth of countries,

the efforts they have already made to decrease their emissions, and producer versus consumer responsibility.

The researchers illustrate their concept using World Bank and OECD data on tradeflows and emission ratios for 98 countries. They consider to what extent tradeflows for a specific country increase or decrease global emissions compared to the virtual situation where imports would have been produced domestically. They argue that it would be fair for countries to retain responsibility for the additional emissions, if any, that they create through trade. The concept is then straightforwardly extended to the case of trade in intermediate products.

## Incentives for cleaning up

To be accepted by as many countries as possible, a burden-sharing rule must be simple and based on observable criteria or indicators. Philippe and Marie-Françoise observe that the main fault of consumer-based emissions inventories is that they require more complex calculations, so results may be subject to more errors, bias and uncertainty. Moreover, even if the regulation of emissions is not the first objective of the rule, it ought not encourage countries to pollute more. The burden-sharing rule must also be such that the sum of countries’ responsibility coincides with world emissions.

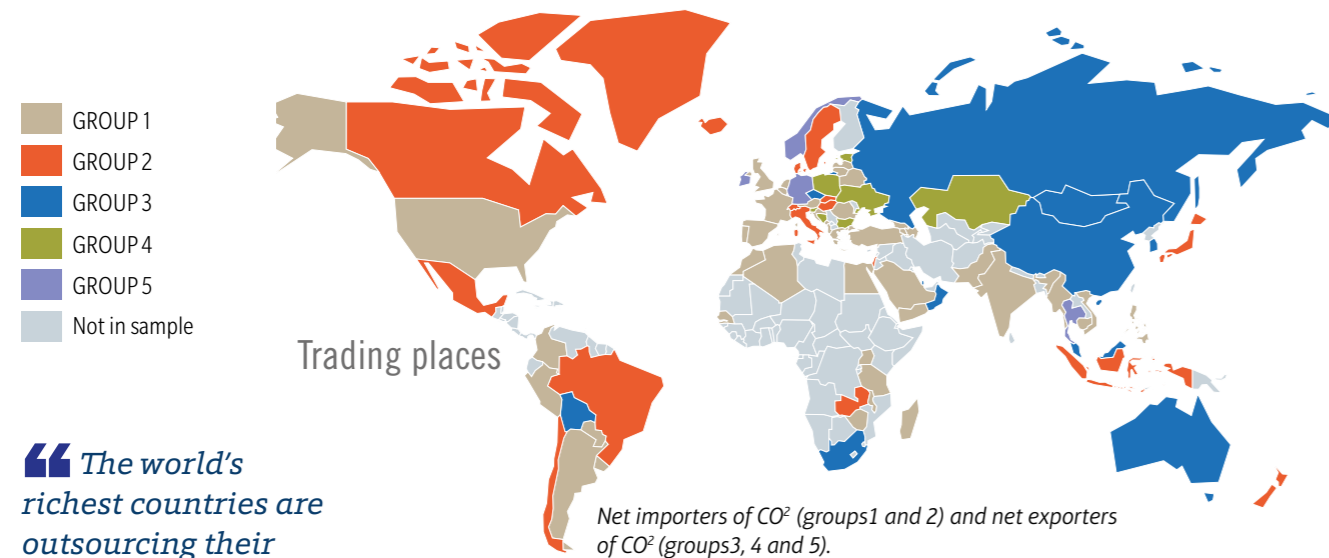
In general, the researchers’ modified rule provides countries with more incentives to adopt new technologies aimed at reducing emissions, and would reinforce the importance of technological transfers between countries during negotiations. Compared to a pure producer-based rule, this rule increases the incentives to reduce emissions if, and only if, the country under scrutiny is a global net importer from less clean

countries. However, this modified rule diminishes the incentives to reduce emissions when the country is a global net exporter towards less clean countries. Compared to a pure consumer-based rule, this rule always increases the incentives to reduce emissions.

### Will countries agree to share?

Compared to the consumer-based rule, the researchers show that the modified rule will increase (reduce) a country's responsibility when it is creating more (less) emissions by exporting towards cleaner countries than by importing from less clean countries. Philippe and Marie-Françoise's responsibility criterion allows them to distinguish between countries for which trade helps to decrease emissions (so that a country's responsibility is attenuated compared to its consumer responsibility), and those for which trade helps to increase emissions (so that a country's responsibility is augmented compared to its consumer responsibility).

The results place emblematic countries together in each category. It is particularly interesting to find, in the same groups, countries classified differently in terms of national wealth by the World Bank: this is a good signal of the acceptability of the modified rule. Note also that 59% of the researchers' sample of 98 countries will retain a responsibility that is intermediate between consumer and producer responsibility. Philippe and Marie-Françoise's criterion assigns a lower responsibility than the two other approaches for 20 countries. Overall, this criterion would more harshly penalize historical emitters – developed countries, except for Germany – when compared to the current UNFCCC approach.



“The world's richest countries are outsourcing their emissions to emerging economies. OECD countries have a carbon footprint greater than the emissions produced on their territory, while large emerging countries use polluting techniques to produce goods which are shipped to and consumed in developed countries.”

### SUMMING UP

The researchers propose a new way to evaluate a country's environmental responsibility by considering its carbon trade balance. As production-based and consumer-based approaches have important limitations, they propose a consensus criterion that would help to establish a rule for sharing the financial burden of the energy transition. Countries with trade deficits and high emissions would have their responsibility reduced using the consumer-based rule, whereas the modified rule points out their role in increasing world emissions. In general, the researchers' criterion provides countries with more incentives to invest in new technologies that reduce emissions.

FIND OUT MORE: Read 'On Sharing Responsibilities for Pollution Embodied in Trade' and other research by Philippe Bontems and Marie-Françoise Calmette at: [www.tse-fr.eu](http://www.tse-fr.eu)

# Outreach





# Recent events

## 12<sup>th</sup> Toulouse Conference on The Economics of Energy and Climate

Every two years, in Toulouse, the TSE Energy and Climate Center organizes a scientific conference dedicated to the economics of energy and climate change. During two days, this event brings together over 120 participants from international universities, companies as well as government bodies. This year's event was organized around 16 sessions.

- | Competition
- | Carbon Emissions
- | Permit Markets
- | Electricity Transmission and Distribution
- | Retail electricity pricing and energy efficiency
- | Environmental Taxes and Energy Prices
- | Energy Storage
- | Electricity Demand
- | Population Growth, Land Use and Climate Change
- | Capacity
- | Renewables
- | Coal & Climate
- | Transport Policies
- | Consumers' awareness, Equity and Efficiency Energy Efficiency
- | Choice of Instruments



### Peter Cramton

*Electricity generation is the single largest emitter of carbon to the atmosphere. Efforts to address climate change will shift generation from fossil fuels to wind, solar, nuclear, and other non-emitting resources. Electricity market design must be able to handle this transformation. The task is non-trivial as the main renewable resources, wind and solar, are intermittent sources of supply with zero marginal cost of production and no inertia.*



### Juan-Pablo Montero

*Authorities rarely turn to pricing schemes, such as congestion charges and pollution-based registration fees, to persuade drivers to give up their cars in favor of public transport or to switch to cleaner ones. Instead, they increasingly rely on schemes that face less public resistance, such as driving restrictions or license-plate bans, despite studies that show they typically result in more congestion and pollution.*



# The war for the climate cannot be won without everyone on board

The French branch of the International Association for Energy Economics (IAEE) invited TSE director Christian Gollier to the Paris headquarters of oil and gas giant Total. Here, he presented his latest book and ideas on the costs of tackling climate change.

The highly ignitable illusion of a wonderful ecological transition that would create jobs and wealth for all, while restoring nature to its former glory, has long been sold to the public. This Ali Baba cave does not exist. No matter what we do, the fight for the climate is an attack on purchasing power. It forces us to turn away in the medium term from this fossil energy that has made us rich for two centuries, and to ask developing countries to do the same.

This war for the climate cannot be won without the active participation of everyone. This requires applying the polluter-pays principle, imposing a universal price on carbon that reflects the value of the damage it generates, even if it means offsetting it for the poorest. But are the French willing to sacrifice a little of their well-being today to greatly improve the well-being of others, even if that other person is not French, and not even born yet?

For most people, here and elsewhere, the end of the month is a more pressing concern than the end of the world. This disturbing observation raises the question of our responsibilities towards humanity.



*The idea of a carbon tax is unanimously accepted in the western world. It is the polluter-pays principle that translates as “you pollute, you pay the damage corresponding to your pollution”. It is not a punitive rule, but an incentive rule. It seeks to ensure that everyone takes into account the social impact of their decisions: whether to go to work in a car or to buy goods that increase fossil-fuel consumption... It encourages awareness of the damage our decisions can cause others today, in 20 years and in 20 centuries.”*



# Analysis

TSE Debate is a portal that gathers the opinions and analysis of TSE researchers on topics of public interest such as electric cars, the European carbon market, and renewable energy. Members of the center regularly publish blog posts and newspaper op-eds that can be consulted in TSE Debate’s “Energy” section.

Here we feature some of the recent posts.



## The cost of Elexcit

*Stefan Ambec and Claude Crampes - September 10, 2019*

In its decision of 11 July 2019, the French Energy Regulation Commission (CRE) expressed reservations about any increase in electricity interconnection capacity between France and Great Britain beyond the projects already under construction. It invoked an unprofitable evolution of market fundamentals, but also the lack of visibility on public policies in the electricity sector and on the modalities of implementing Brexit. Our researchers are working on how the Brexit is likely to affect the profitability of an electricity interconnection.

## Is green liberalism possible?

*Christian Gollier - September 5, 2019*

The best way to change fossil-fuel energy consumption patterns, and the best way to do this is to change the price structure. As we saw during the various oil shocks and counter-shocks in Europe at the end of the last century, changes in oil prices have very significant effects on long-term oil consumption.

This application of the polluter-pays principle also makes it possible to force all economic agents to include in their decisions the ecological damage they impose on the rest of humanity by emitting CO<sub>2</sub>.



## Yes, politics can save the environment

*Paul Seabright - June 19, 2019*

As the European elections have just reminded us, environmental protection priorities are often chosen at times of political change, for reasons more related to changing feelings than to new scientific findings. The importance in the public debate of global warming and the prevailing scepticismskepticism about the ability of the political system to provide solutions may have made us forget the history of other forms of air pollution, as well as the political solutions that have successfully fought tackled it.



## Can trees and pylons live side by side?

*Claude Crampes and Stefan Ambec - April 15, 2019*

Pacific Gas and Electric Company (PG&E) filed for bankruptcy on January 29, 2019. The Californian energy supplier, which was valued at more than \$25 billion at the beginning of November 2018, was, mere months later, only worth \$4 billion following suspicions of its responsibility in for the fires that ravaged northern California, killing 86 people and destroying 15,000 homes.





Infra4Dev Conference:  
Infrastructure in the  
Digital Era – How Should  
Regulation Adapt?

Toulouse, december 11, 2019



*TSE will be hosting the annual Infra4Dev Conference sponsored by the World Bank's Infrastructure Vice Presidency, this december. The conference focuses on a wide range of cross-sectoral and trending topics. This year's event covers digital infrastructure, digital platform, energy and transport. Infrastructure networks are becoming increasingly digitalized, transforming and creating new interconnections between networks for communications, energy and transportation. The conference will explore this process and the resulting new challenges for the regulation of infrastructure services.* ”

Stéphane Straub - TSE researcher

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