

# TSE

## Energy & Climate Center

NEWSLETTER / November 2018



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# EDITOR'S NOTE



## In pursuit of a Nobel cause

**E**nergy and Climate Economics has its Nobel! This year, the Royal Swedish Academy of Sciences has awarded the prize in economic sciences in memory of Alfred Nobel to Paul Romer and William Nordhaus for 'Integrating technical innovation and climate change into long-run macroeconomics analysis'. It summarizes what energy transition is all about: innovation and technological adoption to mitigate climate change. Both laureates have improved our understanding of long-term growth whilst focusing on different issues. Romer is the father of endogenous growth theory. He has embedded technical progress as a choice made by society into Solow's model of macroeconomic growth. Nordhaus has introduced greenhouse gas emissions and temperature into the growth model to investigate the impact of economic activities on climate change.

In October, the Jean-Jacques Laffont prize was awarded to Daron Acemoglu during a prestigious ceremony in the Toulouse city hall. Daron is a very prolific scholar who has contributed to many fields in economics. His work on directed technological change and the environment builds a bridge between Romer and Nordhaus by including endogenous innovation and climate change within the same framework. At TSE, we have a long and successful tradition of research on economic growth and natural resources initiated by Michel Moreaux in 1970s.

We are happy to present you the latest research and analysis of our energy & climate experts as well as the center's latest news and events. We begin by congratulating Christian Gollier whose paper on "Discounting an Uncertain Future" has been awarded the Publication of Enduring Quality by the Association of Environmental and Resource Economists for 'works that are of seminal nature and with enduring value in environmental and resource economics'.

Hope you enjoy reading this issue!

**Stefan Ambec**  
Director, TSE Energy & Climate Center



Paul Romer, William Nordhaus  
Sveriges Riksbank Prize in Economic  
Sciences in Memory of Alfred Nobel 2018

# NEWS



Christian Gollier, TSE Director

## FRENCH-AMERICAN FOUNDATION

On October 19, TSE received the Young Leaders of the French-American Foundation for an afternoon of exchange with TSE economists. Created in 1981, the Young Leaders program brings together as of today more than 400 executives from the corporate world, the senior civil service, the military, the media and research.

**Christian Gollier**, Scientific Director of the Energy and Climate Center addressed this delegation of more than 50 young promising leaders with a talk on fighting climate change and carbon pricing, and the social value of reducing emissions.

During a round table, **Camille Lévy**, (General Electric Power), **Simon Tafoya** (Office of Policy and Research for Colorado Governor John Hickenlooper) and **Stéphanie de Bouard Rivoal** (Château Angelus), three young leaders from different fields of activity shared their views and cross-perspectives on climate change issues.

[www.frenchamerican.org](http://www.frenchamerican.org)

Young Leaders of the French-American Foundation at TSE



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## PORTRAIT



### INTERVIEW WITH BLAKE SHAFFER

#### How will we use electricity in future?

Blake Shaffer holds a PhD in Economics from University of Calgary and is currently visiting TSE. Blake is an energy and environmental economist interested in how people and firms respond to prices, policies and natural phenomena. He has extensive experience in the energy sector, with a specific focus on electricity markets. Prior to returning to academia, Blake enjoyed a 15-year career that took him from the trading arm of BC Hydro, to Lehman Brothers and Barclays Capital in NY as a senior energy trader, and finally as Director of Energy Trading at Transalta Corporation in Calgary, Alberta. Blake has also served as a policy advisor for the Government of Alberta on various energy-related matters. He served on the 2015 Royalty Review Secretariat, playing a pivotal role in the development of Alberta's modernized royalty framework.

#### What are you currently working on?

*My current research looks at the demand side of electricity markets. It is fair to say that the demand side of electricity has received far less attention than the supply side, however, two developments are shifting this order. The first is climate policy bringing more intermittent renewable generation to the grid. The second is technology, making more elastic demand response a realistic possibility. No longer do we see electricity grids as an issue of incentivizing and dispatching flexible supply to meet inelastic demand. Now the question is how can we balance intermittent supply with other flexibility, including a flexible demand side?*

*To that end, my recent working papers look at how electricity consumers respond to prices and climate change. In the first, I look at how consumers respond to the introduction of an increasing block tariff, a form of nonlinear pricing. I find empirical evidence that consumers do respond, albeit many seem to misperceiving the nonlinear tariff. This has important policy implications in terms of achieving conservation goals and general efficiency. In the second paper, I estimate how rising temperatures from climate change will alter both the level and shape of future electricity demand. I incorporate adaptation by estimating both the direct effect and indirect effect of higher temperatures (the latter being that higher temperatures lead more households to purchase air conditioners, and in turn use more electricity at higher temperatures). A novel finding from this work is the effect climate change has on increasing the peakedness of the intraday hourly shape of demand. This finding coming from the demand side exacerbates growing issues arising from the supply side as a result of more solar generation.*

*Overall, my research seeks to provide a better empirical understanding of electricity consumer behavior to assist policy makers grappling with a massive transition in electricity markets currently underway.*

***“The recent TSE forum was an excellent example of academia and industry collaborating in a two-way exchange. What impressed me most was the policy relevance of the research, and the willingness of industry officials to speak frankly and openly about challenges and issues they are facing today and what they are expecting in the near future”***

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## NEWS

#### What is your experience of life in Toulouse?

*In Toulouse I am working with Stefan Ambec studying the effect of growing shares of intermittent generation on electricity markets. In particular, we are considering the effect the growing share of intermittent renewable energy has on the exercise of market power. This research, grounded in theory and calibrated to real-world electricity markets, has timely policy relevance.*

*I can't say enough about how fortunate I feel to have come to TSE. The city is wonderful, as are the people. With so much activity in the department, I feel spoiled by my options of seminars to attend and people to meet. I have become an (unsanctioned) ambassador of the School, recommending it highly to colleagues in Canada!*

## AWARDS

➔ Congratulations to **Paul Lanoie** (HEC Montréal) and **Stefan Ambec** (TSE-INRA) who have received the Decade Award from the Academy of Management for their article “Does It Pay to Be Green? A Systematic Overview” published in 2008 and cited more than 1,220 times in scientific journals.

➔ Congratulations to **Christan Gollier** who has received the AERE Publication of Enduring Quality (PEQ) award for his paper “Discounting an Uncertain Future”.



## INTERNATIONAL SCIENTIFIC NETWORK

Charles Pebereau - PhD Student on GEMCLIME

◀ GEMCLIME enabled me to travel to New Zealand - thanks to its partnership with the University of Auckland - where I initiated a research project and met with academic researchers as well as with staff from the Electricity Authority, the regulator of the electricity market.

*The research project aims at better understanding how consumers make decisions regarding their electricity consumption. In particular, the project focuses on new services and tariffs that can be offered with smart meters. New Zealand offers great research opportunities in this area because smart meters have been largely deployed and used for several years already. Furthermore, research in the field of electricity is very active in New Zealand, both from economists and engineers, and I have had the chance to meet academic researchers from both disciplines.*

*Finally, as a PhD student, it was a rare and fascinating experience to spend time at the Electricity Authority and see and discuss some of the challenges and opportunities of this sector - be they technical, economic or political - at the place where they are dealt with every day.*



# RESEARCH HIGHLIGHTS



LATEST SCIENTIFIC STUDIES

## THE CLIMATE BETA

**Christian Gollier**  
on the social cost of carbon



What is the impact of climate change on the global risk borne by future generations? Does fighting climate change hedge this risk? Is it desirable to use a financial evaluation approach to value long-term investment in energy transition? Drawing on theory and integrated assessment modelling, TSE founder Christian Gollier and his LSE co-authors aim to determine the climate beta, which is a standard concept in finance to measure the contribution of this investment to the global risk. They find that the climate beta is positive and close to unity for maturities of up to about 100 years. This implies that mitigating climate change raises the consumption risk, which justifies a relatively high discount rate on the expected benefits of emissions reductions.

Fighting climate change not only reduces the expected climate damages in the future, it also affects the risk borne by future generations. When measuring the impact of the energy transition on intergenerational welfare, it is important to take account of these two dimensions together. In the tradition of finance and the practice of investment evaluation, this is done by adjusting the rate at which future expected benefits of the investment are discounted to its global risk impact. The choice of the rate at which these benefits should be discounted is thus a crucial determinant of our collective willingness to reduce emissions of greenhouse gases. The discount-rate controversy in economics over the past two decades shows there is still substantial disagreement about the choice of this parameter for cost-benefit analysis.

One source of controversy comes from the intrinsically uncertain nature of these benefits. It is a tradition in economic theory and finance to adapt the discount rate to the risk profile of the flow of net benefits generated by the policy under scrutiny. The underlying intuition is simple. If a policy tends to raise the collective risk borne by the community of risk-averse stakeholders, this policy should be penalized by increasing the discount rate by a risk premium specific to the policy. If a policy tends to hedge collective risk, this insurance benefit should be acknowledged by reducing the rate at which expected net benefits are discounted.

### The CCAPM beta

This simple idea can easily be implemented through the Consumption-based Capital Asset Pricing Model (CCAPM). An investment raises intertemporal social welfare if and only if its Net Present Value (NPV) is positive, where the NPV is obtained by discounting the expected cash flow of the investment at a risk-adjusted rate. This investment-specific discount rate is written as  $r = r_f + \beta\pi$ , where  $r_f$  is the risk-free rate,  $\pi$  is the systematic risk premium and  $\beta$  is the CCAPM beta of the specific investment under scrutiny. It is defined as the elasticity of the net benefit of the investment with respect to a change in aggregate consumption. This means that a marginal project, whose net benefit is risky but uncorrelated with aggregate consumption, should be discounted at  $r_f$ , because implementing such a project has no effect at the margin on the risk borne by the risk-averse representative agent. A project with a positive beta raises collective risk and should be penalized by discounting its flow of net benefits at a higher rate, and vice versa for a project with a negative beta.

Christian and his co-authors' objective is not to offer a new contribution to the debate about the choice of the risk-free rate, or of the systematic risk premium (he has other published works on this question). Rather, they aim to discuss the CCAPM beta that should be used to value climate-mitigation projects. This 'climate beta should play an important role in the determination of the social cost of carbon (i.e. the present social value of damages from incremental carbon emissions), just as an asset beta is known to be the main determinant of the asset price. In the United States over the past 150 years, financial markets have exhibited a real risk-free rate of around 1.6% and a systematic risk premium

of around 4.8 percentage points. Thus, assets whose CCAPM betas are respectively 0 and 2 should be discounted at very different rates of 1.6% and 11.2% respectively.

The researchers provide an overarching analysis of the sign and size of the climate beta, using both a simple analytical model and an empirically grounded Monte Carlo simulation of the DICE model. This enables them to take into account the effects on the climate beta of investment, as well as generalizing the form of the damage function.

## Results and discussion

The results strongly suggest that the climate beta is positive and close to unity for maturities of up to about 100 years. Beyond that, the climate beta depends more strongly on the emissions path. On “business as usual” it falls to about 0.5 for maturities of 200 years or more, while it remains close to unity on a path of deep emissions cuts that aims to limit warming to 2°C. One might think that reality will turn out to be somewhere between these two extreme cases, hence the climate beta for very long maturities is somewhere between 0.5 and 1.

The overwhelming driver of these results is uncertainty about exogenous, emissions-neutral technological progress in the shape of transitory but moderately persistent shocks to total factor productivity (TFP). Positive TFP shocks are simultaneously associated with higher marginal benefits of emissions reductions and higher consumption, implying a positive beta. Uncertainty about climate sensitivity and the damage intensity of warming provide a countervailing effect that tends to reduce beta, but it is outweighed by the effect of TFP shocks. Indeed, a larger than expected climate sensitivity is associated with a smaller aggregate consumption net of the damages, and larger marginal damage, thus a larger benefit of reducing emissions. The researchers allow for fat-tailed climate sensitivity and large convexity of the damage function, two of the principal sources of risk of catastrophic climate damages, which have been claimed to give rise to a negative beta.

Naturally, the validity of the numerical estimates is affected by the well-known weaknesses shared by all integrated assessment models. In addition, the researchers face the issue of whether and to what extent damages are proportional to output. The basic assumption embodied in a multiplicative damage structure is that damages are a constant fraction of output, for given warming and damage intensity. By contrast, in an additive structure the share of damages in output decreases as output increases, and vice versa. Therefore, it is related to the so-called ‘Schelling conjecture’ that developing countries “best defense against climate change may be their own continued development” (Schelling, 1992, p6).

The researchers’ simple analytical model of the climate beta makes clear that if climate damages are better represented by an additive structure, then the conditions required for a positive climate beta are stricter. However, the empirical evidence used to calibrate the income elasticity of damages in DICE does not support this. Rather, it suggests that the income elasticity of damages in most regions at most times is greater than zero and often greater than one, without strong support for a central value other than one. More empirical evidence is clearly required on this issue.

Understanding the implications of these findings for climate mitigation requires understanding the dual role played by beta in determining the NPV of mitigation. It is most straightforward to observe that positive beta implies the future benefits of emissions abatement should be discounted at a relatively higher rate. How much higher?

Two approaches can be followed to answer this question, both using the CCAPM rule  $r = r_f + \beta\pi$ . The first approach uses the systematic risk premium  $\pi$  that has been observed in markets, for instance in the United States over the past century, where it has been around 5% (see Gollier 2012). For a project with a unit beta, this means the efficient discount rate for that project should be five percentage points higher than the risk-free rate. The second approach is model-based, using the CCAPM formula  $\pi = \gamma\sigma^2$  to estimate the risk premium, where  $\sigma^2$  is the volatility of consumption growth estimated in DICE. According to the researchers’ simulations,  $\sigma^2 = 0.1\%$  with respect to average growth over the period 2015-2230, giving a risk premium of only 0.2 percentage points if one accepts a coefficient of relative risk aversion  $\gamma = 2$ , as much of the existing literature suggests. This leads to a much smaller impact of the positive climate beta on the risk-adjusted climate discount rate.

The large discrepancy between these two recommendations may be seen as a manifestation of the well-known “equity premium puzzle”. Three decades of research on this financial puzzle suggests that the model-based CCAPM approach fails to capture many dimensions of the real world, especially structural uncertainties and fat tails - a new concept of beta will need to be developed to accommodate these features.

**The climate beta should play an important role in the determination of the social cost of carbon**

The CCAPM beta also showed that the NPV of climate mitigation is increasing in beta if beta is larger than  $\beta - (\mu/\sigma^2)$ , which is at most of the order of -2.5. Since the researchers’ estimates are clearly larger than that, it can be concluded that the NPV of climate mitigation is indeed increasing in beta. This shows that the implications of this research do not just concern the discount rate. It would be wrong to discount the future benefits of emissions abatement at a risk-adjusted rate with unit beta, unless the undiscounted future benefits have been calculated in a way that properly factors in, implicitly or explicitly, how they scale with economic growth.

## SUMMING UP

The choice of the rate at which future climate damages should be discounted plays a critical role in the determination of the social cost of carbon. Most of the recent literature implicitly assumes that these damages are uncorrelated with aggregate consumption, so they should be discounted at the risk-free rate. However, Christian and his colleagues show that the climate beta is close to one for maturities of up to 100 years. This is mainly due to the role of exogenous, emissions-neutral technological progress in raising consumption, emissions, atmospheric carbon and marginal damages. This implies that mitigating climate change raises the risk borne by future generations, which justifies a climate discount rate that is larger than the risk-free rate. How much larger depends on the evaluation of the equity premium puzzle.

A large climate beta does not only imply a large climate discount rate. Indeed, the climate beta measures the sensitivity of monetized climate damages to a change in consumption of other goods and services in the economy. In a growing economy, a large climate beta also implies large expected damage in the long run, and thus a larger expected benefit of reducing emissions today. This research shows that an increase in the climate beta increases expected damages more than it reduces the discount factor, so that in fact the social cost of carbon is increasing in the climate beta.



# WHEN DO SENATORS VOTE GREEN?

**Hélia Costa**  
on lobbying and electoral incentives



2010 - Deepwater Horizon oil spill

How much power does the fossil-fuel industry wield over Capitol Hill? As the Trump administration threatens to roll back a whole raft of environmental protections, new empirical research by TSE's Hélia Costa offers timely insights about how US senators respond to pro-environmental voters and oil, gas and mining special interests. Her results have important implications for assessing the political feasibility of environmental regulation.

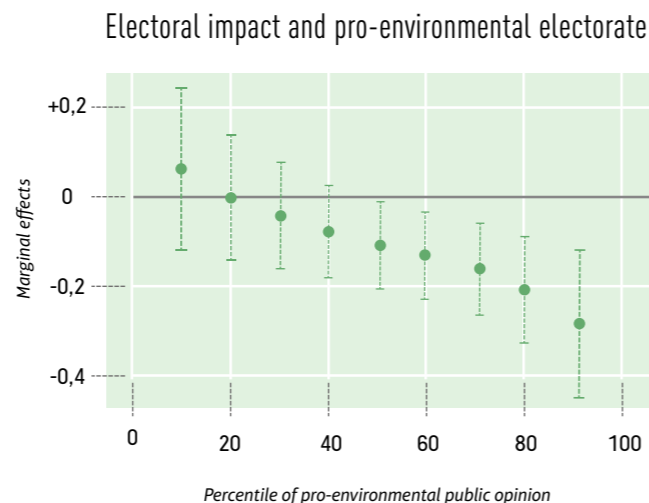
Many economists have focused on identifying the environmental policies that might serve the greater good, but there is concern that these policies cannot be easily implemented within political systems with agents that differ in preferences and political power. Previous research has shown that political forces have a powerful impact on the design of environmental policy. In many instances, however, it is difficult to determine the main forces at play – such as voters or special interest groups – and how they interact at different points of the political process.

Hélia's paper *'The political economy of environmental regulation: the role of lobbying and elections in the US Senate'* attempts to address this gap by studying the impact of electoral accountability and lobbying in the passing of environmental legislation. Using a comprehensive dataset on 499 environmentally related roll-call votes in the US Senate from 1971-2013, she analyzes how the voting behavior of senators varies according to the preferences of citizens (electoral accountability) and contributions from the oil, gas, and mining industry (lobbying impact). To determine which votes are environmentally related, she uses the classification of the League of Conservation Voters (LCV).

In the US Senate all senators fulfill six-year terms and one third of senators are up for re-election every two years. This means that at any given point there are senators in the first two years (first generation), third and fourth year (second generation) and last two years (third generation) of their term. Hélia uses this staggered structure of senatorial terms to identify the impact of an election, and to study behavioral differences between recently elected senators and those who are about to face new elections.

## Results

Her preliminary results show that the electoral incentive has an impact on voting behavior with regards to environmental protection. Specifically, Hélia finds that being of the third generation (and thus closer to re-election) decreases the probability of casting an anti-environmental vote by between 1.01 and 1.8 percentage points, depending on the empirical



This graph shows how the impact of election proximity on the probability of voting against the environment varies with the proportion of environmental citizens: the effect is larger the more environmental citizens a state has. We can clearly see that belonging to the third senatorial generation has a negative impact on voting against the environment. The graph also shows that the marginal impact is only statistically significant once public opinion reaches a certain threshold.



specification. This implies a decrease in the predicted probability of voting against environmental protection of between 2.1% and 3.5%. This effect is larger for larger shares of pro-environmental public opinion, in line with an electoral accountability motive. When looking at different types of votes, these results are notable for votes on drilling, lands/forests, water, dirty energy, and transport, which arguably present some of the most visible issues.

Hélia then investigates whether these effects differ depending on the ideology of senators. Since Democrat senators are more likely to have preferences aligned with pro-environmental voters than Republican senators, then if changes in voting behavior are due to the re-election incentive to please these voters, these changes should be observed only (or more) for Republican senators. Her results corroborate this hypothesis.

Finally, she studies the impact of contributions from the oil, gas, and mining industries on voting patterns. She compares their impact on senators belonging to different generations, and finds that probability of senators casting an anti-environmental vote close to elections is significantly smaller when they have received larger contributions in the past. She observes this effect for votes more directly related to the oil, gas, and mining industries, but not for others. There is no significant impact of contributions on the voting behavior of senators that have just been elected (of the first generation), which suggests pro-industry voting is used to attract more funding but not to reward past contributions.

## Breaking new ground

This paper extends the empirical literature on lobbying and electoral accountability in two ways. First, by providing an empirical analysis that uses the timing of elections, public opinion data, and campaign contributions to disentangle lobbying and election impacts in the choice of public policy. Second, it adds to the literature by studying this issue in the specific context of environmental policy for the data-rich setting of the US Senate.

Environmental policy has gained an important role in the American political landscape, and thus understanding the political economy aspect of it is of particular relevance. The insights generated however, have more general implications to the political economy of environmental regulation that go beyond the specific setting.

## Policy implications

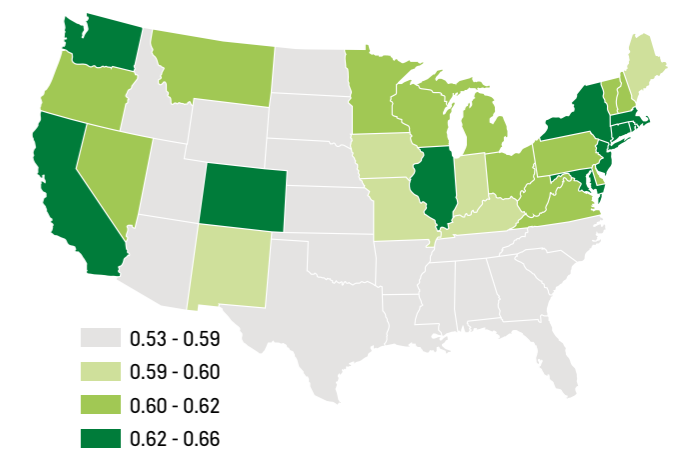
In terms of the timing of the introduction of environmental regulation for which there is public support but strong interest group opposition, these results imply that passing regulation might be more politically feasible when electoral incentives are higher, particularly if public support reaches a given threshold. Moreover, there might be scope for limiting campaign contributions to allow for electoral incentives responding to the democratic will to prevail.

The insights generated by this research also help to explain how some policies are passed in some legislatures but not in others, even if they have the same support from citizens. They also help us understand whether monetary campaign contributions (specifically from powerful industries) have a disproportional impact relative to voters' preferences in the passing of regulation, a question that has long been of interest to political scientists. This is particularly relevant for environmental policy – an effective transition towards environmental sustainability strongly hinges on our grasp of these questions.

## Future research

Hélia's findings are particularly relevant in the context of environmental policy, where the introduction of new and effective regulation is essential to ensure the sustainability of energy resources and promote environmental protection. Understanding the political and institutional forces at play is thus central to designing environmental policy that is both efficient and politically viable. For example, considering the different

Average environmental opinion by state, 1971-2013

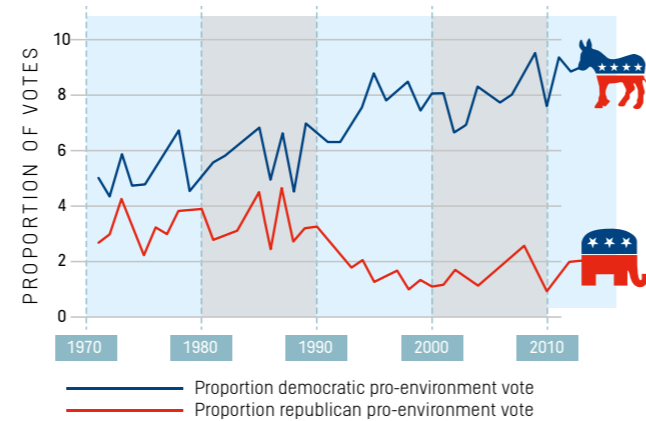


**Understanding the political and institutional forces at play is central to designing environmental policy that is both efficient and politically viable**

shares of environmentally concerned voters in different states and the location of powerful industry lobbies is important to understand the success probability of environmental protection regulation.

It is important to put together this information to understand at which point lobbying contributions can cancel out or even reverse the impact of electoral accountability in the formation of environmental regulation. In addition, understanding the circumstances in which campaign contributions alone play a deciding role in policy is central for designing a political process that promotes the democratic will. Finding these thresholds will be the subject of future research.

Proportion of pro-environment vote by party, 1971 - 2013



## SUMMING UP

Despite increased interest in the political economy behind environmental regulation, comprehensive analyses of voting behavior in the face of both electoral incentives and lobby contributions are still scarce. Héliá conducts an analysis of electoral incentives and lobby contribution impact in the voting of US senators on environmental issues. She finds that the re-election incentive reduces a senator's probability to vote against environmental regulation by over 2%, and this effect is higher when environmental support in their state is high. The results indicate this effect is driven by Republican senators trying to capture pro-environmental vote. Contrary to findings in previous studies, past contributions seem to have a significant impact on voting behavior only toward the end of senators' terms, suggesting pro-industry voting is used to attract more funding but not to reward past contributions.



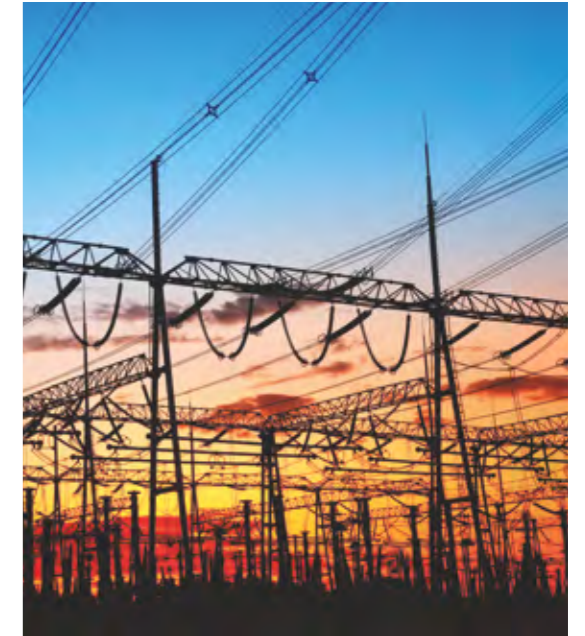
People protesting the Dakota Access Pipeline - Funcrunch Photo

LATEST SCIENTIFIC STUDIES

# REGULATING NETWORK EXPANSION

Bert Willems

on the incentives for electricity companies



Upgrading European electricity networks to replace ageing infrastructure and accommodate renewable energy sources will cost about €30 billion per year (EIB forecasts, 2017). However, network companies, who are responsible for making those upgrades, will be reluctant investors unless regulation allows for a high enough return.

In his paper 'Regulating network expansion', co-authored with Gijzbert Zwart (Groningen University) and recently published in the Rand Journal of Economics, Bert Willems (Tilburg University & TSE) recommends a sliding-scale revenue tax.

## Competitive and green electricity markets

European electricity markets were liberalized in 1996. To provide a level playing field for all electricity companies, policy makers decided that the transport of electricity should remain a regulated activity. Independent network companies operate electricity networks, and decide where and when to invest in network capacity. National regulatory authorities define the regulatory framework. This framework consists of rules that specify how transmission prices are set and who bears the risks of new investments. Most European regulators choose some form of incentive regulation, such as a price cap regime. Under this, transmission tariffs remain fixed for several years. This gives high incentives to network companies to become more cost efficient, as they can keep any cost savings as profits. This explains the popularity of this type of regulation.

To reach the ambitious EU climate goals, massive investments in electricity networks are needed. Overall demand grows as electricity replaces other energy sources (eg electric cars), renewable energy sources need to be integrated into the network (off-shore wind farms) and local networks have to become more responsive and smarter. Policy makers now question whether existing incentive regulation will provide the network operators with sufficient incentives to invest, and are moving away from a pure price-cap framework. For instance, in Europe, new transmission investments are sometimes partially exempted from regulation if they are risky and will not be taken otherwise. In the UK, the price-cap regime has been extended, and now provides room for experimentation and includes explicit quantity targets. However, a theoretical economic framework to analyze regulation and investments in such a dynamic setting was still lacking. Gijzbert and Bert propose such a theory.

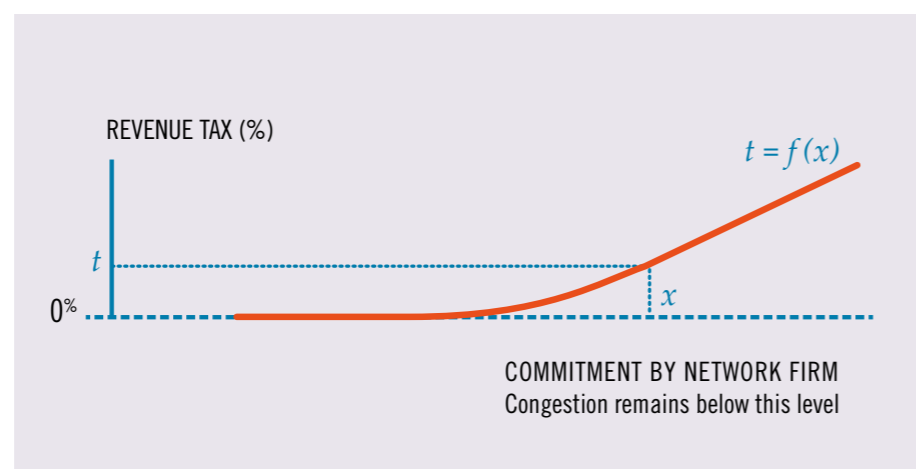
## The model

They identify four essential factors for a theoretical framework of network regulation. First, demand for network capacity is growing, but unpredictably so. So the model should have a dynamic component. Second, investments in network capacity are irreversible; once invested, the assets remain in place. Third, network companies have more information than the regulator about the cost of network expansion. So there is some "information asymmetry". And, fourth, the government is not allowed to subsidize network companies. Indeed, the EU state-aid guidelines restrict subsidies for energy infrastructure.

A theory model is built by combining existing theories on real options and regulation under asymmetric information and by adding the self-financing constraint. In this model at each moment in time the network company decides on capacity expansion given the level of demand observed at that time. By investing early and plenty, congestion levels in the market will be low, as is the price for transmission. Of course, the investment decisions of the network company will depend on the regulatory framework. So which rules should the regulator set?

The model considers a regulator that aims to maximize total expected surplus of network users and the network company. To achieve optimal regulation, the regulator needs two instruments: an investment obligation, which obliges firms to keep congestion below a threshold level; and a revenue tax, which limits the rents that the network firm obtains. However, in order to fully use the information advantage of the network company, the regulator should not just offer one contract, but a sliding scale (see Figure 1), which rewards a network company that accepts an early investment obligation with a lower tax rate. This lower tax rate is a reward for the firm for investing early.

*Figure 1: The regulator announces a sliding revenue tax rate  $f(x)$ . If the network firm commits to keep the level of congestion below level  $x$ , then the revenue tax rate will be  $t=f(x)$ . The revenue tax increases (higher  $t$ ) the weaker the commitment made by the network company (higher  $x$ ). Note that if the network company commits to invest very early, it will end paying no taxes (tax rate is zero), and can keep all payments of network users.*



In practical situations the level of congestion can be measured by re-dispatch costs, or by the congestion rents paid by network users. This information is readily available and could be aggregated on a year-by-year basis. Note that with the proposed revenue tax, at each moment in time, the discounted future revenue streams are higher than the discounted future expansion costs. Hence, the network company will have an incentive to remain active in the market.

## SUMMING UP

Lowering CO<sub>2</sub> emissions will require massive investments not only in renewable energy sources, but also in transmission infrastructure. This requires an appropriate regulatory regime. Gijsbert and Bert show that the optimal regulation should consist of sliding-scale revenue tax. A network firm that commits to invest early will face lower taxes.





# OUTREACH

**How have recent changes in environmental regulation impacted firms' choices and market outcomes?**



In May 2018, Stefan Lamp and Giulia Pavan organized a two-day workshop at TSE on “*Environmental Regulation and Industrial Performance*”. The workshop aimed to analyze how recent changes in environmental regulation might impact firms’ choices and market outcomes. During the workshop, 14 academic papers were presented covering theoretical and empirical contributions that dealt with the impact of climate policy on market structure, firm performance, and innovation. The full workshop program can be accessed online:

[www.tse-fr.eu/conferences/2018-environmental-regulation-and-industrial-performance](http://www.tse-fr.eu/conferences/2018-environmental-regulation-and-industrial-performance)

The event included a keynote lecture by Michael Greenstone, who is the Milton Friedman Professor in Economics and the Director of the Energy Policy Institute at the University of Chicago. His keynote lecture discussed the central role of incentives and information in determining the efficiency of environmental regulation. While we “know a great deal about how to optimally design environmental policy, costs and benefits critically depend on information and incentives too, and here we know much less.” According to Michael, three promising areas for better implementation of environmental regulation are aligning incentives to produce desirable outcomes, exploiting technology, and leveraging information dissemination.

Environmental regulation often focuses on the potential costs and benefits, yet information and incentive problems can drive large gaps between actual and expected impacts of regulation. For example, if there is a low rate of punishment or a low probability of inspection. In his paper “Truth telling by Third-party Auditors and the Response of Polluting Firms: Experimental Evidence from India”, together with co-authors Esther Duflo, Rohini Pande, and Nicholas Ryan, Michael designs an experiment to improve environmental regulation in Gujarat, the most industrialized state in India. In particular, they document the poor incentive structure in which polluters select and pay their auditors themselves and implement an intervention to break this conflict of interest. They show that when polluters pay into a central fund, which randomly assigns auditors to the plants, the auditors become more truthful than in the status quo. The reformed auditing caused plants to reduce their pollution emissions by 28 percent.

In a set of ongoing research projects with Rohini Pande, Nicholas Ryan, and Anant Sudarshan, Michael’s research focuses on the role of technology and the importance of transparency and public information disclosure. The main idea is to test whether better information, resulting from continuous emissions monitoring systems (CEMS), can improve environmental regulation, for example by lowering compliance and inspection cost. Finally, Michael and his co-authors are also interested in measuring the impact of pollution information disclosure programs, with the goal of improving transparency for the public and the industry by benchmarking firms. Insights from these case studies can help us to uncover general lessons on the critical role of information and incentives for improving efficiency.



Organizers: Stefan Lamp and Giulia Pavan



# OUTREACH



The Energy and Climate Forum brought together researchers and key industrial players for a morning of discussion on the major issues in the development of renewable energies and the impact of their integration into the energy market.

The researchers Stefan Ambec and Stefan Lamp presented their research projects followed by a round table including Adeline Duterque, Christian Gollier, Laurent Joudon, and Ladislav Paszkiewicz, led by Bloomberg journalist François de Beaupuy.

## Stefan Ambec (TSE)

### Living with intermittent energy

To open the forum, the director of the TSE Energy and Climate Center, **Stefan Ambec**, presented his research article, co-written with **Claude Crampes**, on the challenge of the intermittency of renewable energy sources such as solar or wind. Inspiration for this study comes from the variability of renewable energy load factors that do not necessarily adjust to the demand for electricity, hence the need to rethink the organization of electricity generation to ensure sustainability.



The economist presented a framework of analysis that explicitly considers the problem of the intermittency of renewables in the energy mix. The supply of electricity from wind turbines or solar panels depends on weather conditions. Thermal power plants are used to meet the demand in the absence of wind or sunshine.

Stefan Ambec explains that *“investments in thermal and wind production units can be substitutes or supplements depending on the social value of carbon”*: in a highly carbon-free energy mix, thermal power plants are used as ‘back-up’ in the absence of wind. Therefore, any new wind-generation capacity must be based on an equivalent thermal-generation capacity. He emphasized the importance of reducing fossil-fuel consumption and subsidizing energy storage when renewable energy itself is subsidized.

On the question of demand, the article quantifies the interest of pricing electricity on market rates rather than at a fixed price. The aim is to make consumers responsive to variations in supply. The authors show that benefits linked to the decline in the production of fossil fuels offset the costs for consumers to adjust their consumption, regardless of their aversion to the volatility of the amounts used.



## Stefan Lamp (TSE)

### Renewable energy and industry competitiveness



The TSE researcher discussed the different impacts of renewables on electricity prices and energy markets. **Stefan Lamp** explained that renewable energy has lowered electricity prices in Germany thanks to the Merit Order Effect, especially in years with high fossil-fuel prices. Other effects highlighted were the direct costs on system balancing, mainly related to the integration of intermittent energy into the electric grid, as well as the direct cost of subsidies. For this last point, the positive impact of feed-in tariffs on technology adoption has been impaired by its total cost, which needs to be financed through a levy on electricity prices.

To illustrate this point Stefan presented his research work, in collaboration with Andreas Gerster, on expanding the exemption from a tax for ‘electricity-intensive’ firms in the manufacturing sector in Germany. The authors estimate that the exempted plants consume 5-7.5% more electricity than the group of non-exempt plants: *“This type of reform favors very electricity intensive industries and makes the rest of the economy (especially households) pay a heavy price to cover the expansion of renewable energy without improving competitiveness.”* In the room, the interest of sparing companies which consume more was questioned by Christian Gollier: *“Sparing consumers from true prices - that energy transition is expensive - is an economic aberration.”*

This presentation generated many questions about the financing of these public policies - the dilemma of international competition transferred to the domestic consumer, and whether it would be possible to measure the potential to distort households’ choice of equipment.



## ROUND TABLE

# The challenges of renewable sources entering the energy mix

Led by:  
Francois de Beaupuy  
(Bloomberg)

### Participants:

**Adeline Duterque** (Engie), Foresight department director  
**Christian Gollier** (TSE), Managing director  
**Laurent Joudon** (EDF), Director of economic studies  
**Ladislav Paszkiewicz** (Total), Vice-president strategy and climate

Opinions on issues surrounding the future of energy were many and varied. **Christian Gollier**, director of TSE, began the discussions by laying out the major issues in energy transition. The economist spoke of the complexity of the risk problem and the uncertainty in these big investments: *"The uncertainty is so phenomenal that it is at the heart of the problem. There is not enough debate in France about sharing this risk."* The value of the option of waiting is paramount.

**Adeline Duterque** presented Engie's decision to back renewable energies, a vision boosted by the expectation that costs will decrease. The Foresight department director spoke of a more decentralized world and the need to develop flexibility to manage intermittency, through storage for short-term variations, and through the development of renewable and dispatchable capabilities (biogas power plants), to ensure adequate long-term supply and demand at a controlled cost.

**Laurent Joudon** of EDF emphasized the importance of looking at different timeframes: 2030, 2040 and beyond. The challenge for the director of economic studies is to reform an electricity market that is short-term focused, in order to provide a reliable framework for the necessary capital-intensive investments. Laurent said that uncertainty remains too high by 2050, emphasizing the need for research and development work in energy storage and for the development of a carbon value. Asked about the uncertainty related to investment in nuclear energy, Laurent explained that a long-term contractual framework was necessary. He said that by 2030-2035, the French electricity mix could accommodate, economically, 40% renewables and the existing nuclear capacity.



**Ladislav Paszkiewicz** of Total pointed out three major trends: the strong development of carbon-free electricity by 2030-2040 in all International Energy Agency (IEA) scenarios, but especially scenario 2°C\*, the importance and growth of gas in the energy mix in all IEA scenarios, and the reduction in the relative weight of oil in the energy mix of all IEA scenarios, even if the latter would still remain important. As an example of Total's commitment, the VP of Strategy and Climate discussed the development of an indicator that shows the change in carbon intensity of all energy products made available by Total to customers.

On the price of carbon, Ladislav recalled the benefits of a sustained price at a floor of €20 per ton, which would enable transition from coal power stations to gas power stations for the production of electricity. Adeline Duterque added that it is important to look at the price of carbon in other sectors, using the production of cement as an example.

Finally, the panelists emphasized energy efficiency and the importance of developing ways to reduce overall energy consumption. *"Electrification is a key to energy efficiency and decarbonisation"*, said Laurent Joudon.

\* Long-term scenario aiming to limit global warming to 2°C in 2100



# ANALYSIS

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## PUBLIC DEBATE

TSE Debate is a portal that gathers the opinions and analysis of TSE researchers on topics of public interest. Members of the Center regularly publish blog posts that can be consulted in TSE Debate's "Energy" section.

*Here we feature some of the recent posts.*

### Smart meters fulfil basic needs - June 4, 2018 - Stefan Ambec, Claude Crampes

In France, the new generation of smart meters for household electricity consumption are causing quarrels. In South Africa, such smart meters for water consumption have helped to reduce the risk of rioting by preventing Cape Town from running out of water. The meters' accuracy and interactivity make them a valuable management tool in periods of water shortage or high demand.

[www.tse-fr.eu/smart-meters-fulfil-basic-needs?lang=en](http://www.tse-fr.eu/smart-meters-fulfil-basic-needs?lang=en)

### The value of lost load - June 18, 2018 - Stefan Ambec, Claude Crampes

In situations where the electricity grid is under pressure, the operator of the system can either increase the input of energy by calling on an additional power station or reduce the demand by rationing supply. The best choice is the least expensive one. But how do you assess the cost of power cuts?

[www.tse-fr.eu/value-lost-load?lang=en](http://www.tse-fr.eu/value-lost-load?lang=en)

### Compensating welfare losses from economic disruptions - July 9, 2018 - Aleh Tsyvinski, Nicolas Werquin

Many economic disruptions create winners and losers. This column presents an analytical formula for tax reform to offset welfare losses by redistributing the winners' gains when tax instruments are distortionary and wages are endogenous. It shows how the model can be applied to empirical data, for example to offset the impact of robots in the US and Germany.

[www.tse-fr.eu/compensating-welfare-losses-economic-disruptions](http://www.tse-fr.eu/compensating-welfare-losses-economic-disruptions)

### Of lobbyists and men - September 4, 2018 - Stefan Ambec, Claude Crampes

On August 28, Nicolas Hulot, the French Minister for Ecological and Solidary Transition, stepped down. One alleged reason for his decision was the attendance of a hunt lobbyist at an official meeting held at the Elysée Palace. The presence of lobby groups within the President's inner circle is a democratic issue for the former minister. Are lobbies detrimental to public decision-making?

[www.tse-fr.eu/lobbyists-and-men](http://www.tse-fr.eu/lobbyists-and-men)

### Learning by doing in Solar Panel industry - September 19, 2018 - Claude Crampes, Yassine Lefouili

Every industry benefits from learning-by doing (LbD). Learning effects reduce production costs and increase the quality of products by acquiring experience, better organising tasks and sharing knowledge. In the photovoltaic solar panel sector, in just a decade LbD has led to a spectacular drop in cell costs. But it has also caused much of the manufacturing business to be transferred to Asian countries.

[www.tse-fr.eu/learning-doing-solar-panel-industry](http://www.tse-fr.eu/learning-doing-solar-panel-industry)

### Will LNG Canada increase greenhouse-gas emissions? - October 2, 2018 - Blake Shaffer

LNG Canada - a massive \$40-billion project that takes natural gas from western Canada, cools it to its liquid form, and ships it to energy-hungry destinations in Asia - just got the investment green-light.

[www.tse-fr.eu/will-lng-canada-increase-greenhouse-gas-emissions-its-complicated](http://www.tse-fr.eu/will-lng-canada-increase-greenhouse-gas-emissions-its-complicated)

### Intermittence and flexibility in electricity markets - October 18, 2018 - Stefan Ambec, Claude Crampes

In electricity delivery systems, whether integrated or open to competition, solar and wind power are dispatched before conventional energies due to their low generation cost. The result is a change to the wholesale price of electricity that tends to modify the composition of the overall electricity mix.

[www.tse-fr.eu/intermittence-and-flexibility-electricity-markets](http://www.tse-fr.eu/intermittence-and-flexibility-electricity-markets)

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# CALL FOR PAPERS

## 12<sup>TH</sup> CONFERENCE ON THE ECONOMICS OF ENERGY AND CLIMATE

TOULOUSE, JUNE 18-19, 2019

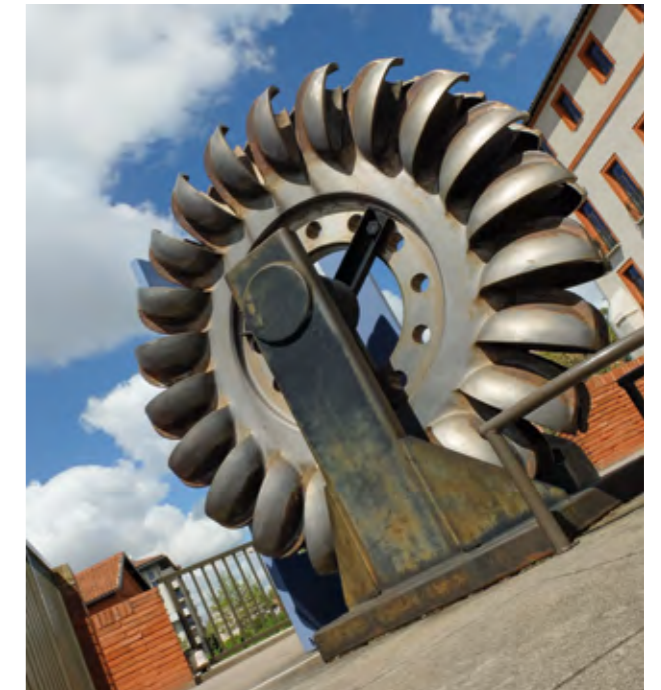
The objective of the conference, organized by the TSE Energy and Climate Center in Toulouse, is to discuss recent scientific contributions to the understanding of energy markets and the design of environmental and climate policies. Keeping the spirit of previous years, the conference will feature theoretical, empirical, experimental and policy-oriented contributions. All papers related to the economics of energy and/or climate change are welcome.

### KEYNOTE SPEAKERS:

- Peter Cramton (*University of Maryland*)
- Juan-Pablo Montero (*PUC-Chile*)

### SCIENTIFIC COMMITTEE:

- Severin Borenstein (*University of California, Berkeley*)
- Estelle Cantillon (*Université Libre de Bruxelles*)
- Natalia Fabra (*Universidad Carlos III de Madrid*)
- Christian Gollier (*Toulouse School of Economics*)
- Richard Green (*Imperial College London*)
- Bård Harstad (*University of Oslo*)
- Paul Joskow (*Massachusetts Institute of Technology*)
- Andreas Lange (*University of Hamburg*)
- Matti Liski (*Aalto University*)
- Thomas Sterner (*University of Gothenburg*)
- Jean Tirole (*Toulouse School of Economics*)
- Bert Willems (*Tilburg University*)
- Frank Wolak (*Stanford University*)
- Catherine Wolfram (*University of California, Berkeley*)



PROSPECTIVE PARTICIPANTS are invited to pre-register and/or submit papers by sending an email to [eleconf@tse-fr.eu](mailto:eleconf@tse-fr.eu)

The deadline for submission is **January 15, 2019** (abstracts will be considered, but papers are more likely to be accepted). The program and list of presenters will be confirmed and notification will be made to presenters by **February 28, 2019**. Complete drafts of accepted papers are due **May 15, 2019**.



**GEMCLIME**  
Global Exchange in Modelling  
of Climate and Energy



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