GERAD

LA JOURNÉE DES ÉTUDIANT(E)S SUR LA TRANSITION ÉNERGÉTIQUE

STUDENT DAY ON ENERGY TRANSITION

QUAND | WHEN: 4 FÉVRIER, DE 14H À 19H | FEBRUARY 4th 2025, 2PM TO 7PM

LIEU | WHERE: ZOOM & GERAD

Session 1

Salle | Room: 4488
Présidée par | Chaired by: Olivier Bahn, GERAD/HEC

14h00 Mot de Bienvenue | Welcome address

Bahn, Olivier, HEC Montréal

14h10 Hybrid Genetic Algorithms and Heuristics for Nonlinear Short-Term Hydropower Optimization: A Comparative Analysis

Séguin, Sara, Université du Québec à Chicoutimi
Fofana, Issouf, Université du Québec à Chicoutimi
Jafari Aminabadi, Mohammad, *pres.*, Université du Québec à Chicoutimi

This study introduces a Mixed Integer Nonlinear Programming (MINLP) model for short-term hydropower optimization, incorporating operational constraints such as demand and startup costs. Due to the complexity of solving MINLP problems, three hybrid methods are proposed: a binary genetic algorithm, an iterative heuristic approach, and a combined framework integrating the heuristic method into the genetic algorithm. Case study findings demonstrate that the combined approach reduces computational effort and proves to be highly effective compared to other methods.

14h20 Net-Zero Emission Pathway for Canada: Insights from AD-MERGE in the Multi-Model Comparisons Forum

Bahn, Olivier, HEC Montréal
Amirmoeini, Kamyar, *pres.*, HEC Montréal

This study explores Canada's net-zero emission pathway using the AD-MERGE integrated assessment model, highlighting scenarios that align with global climate goals. Four key scenarios—Reference, Balanced 2050, Pessimistic, and Rest of the World—are analyzed to assess the impacts of carbon pricing, technology adoption, and international collaboration on emission reduction and economic outcomes. Results emphasize the critical role of Direct Air Capture (DAC) and renewable energy adoption in achieving stringent emission targets, with sensitivity analyses revealing significant variations in shadow prices and energy use. Insights from this multi-model comparison provide valuable guidance for policy frameworks to balance economic growth with climate objectives.

14h30 AD-MERGE 3.0: Further Developments for Better Sector Representation in IAMs

Lamoureux, Maïka, *pres.*, HEC Montréal
Bahn, Olivier, HEC Montréal
Levasseur, Annie, ÉTS

Les modèles d'évaluation intégrés (MEIs), ou Integrated Assessment Models, combinent économie, climat et énergie pour évaluer les impacts des politiques climatiques à long terme. Ces modèles adoptent souvent une représentation agrégée des secteurs économiques, comme c'est le cas de MERGE. Cette présentation explorera les approches envisagées pour la désagrégation du module macroéconomique de MERGE en sous-secteurs tels que l'agriculture, l'industrie, le transport et les services, ainsi que les défis associés. Cette désagrégation permettra de distinguer MERGE des autres modèles similaires. Integrated Assessment Models (IAMs) combine economics, climate and energy to assess the long-term impacts of climate policies. These models often adopt an aggregated representation of economic sectors, as is the case with MERGE. This presentation will explore the approaches envisaged for disaggregating MERGE's macroeconomic module into sub-sectors such as agriculture, industry, transport and services, as well as the associated challenges. This disaggregation will distinguish MERGE from other similar models.

14h40 **A Physics-Informed Bayesian Calibration for Travel Demand Calibration of Urban Traffic Simulators**

Baik, Seung Min, *pres.*, HEC Montréal
Osorio, Carolina, HEC Montréal, GERAD, CIRRELT

The calibration of travel demand in urban traffic simulators often faces underdetermination, where multiple parameter configurations yield indistinguishable outcomes. To address this challenge, we propose a Bayesian calibration framework that quantifies uncertainties in travel demand while ensuring consistency with observed traffic count data. Unlike conventional approaches that rely on uninformative priors, our framework incorporates traffic theory to inform the priors of Gaussian Process surrogates, including the design of mean functions and covariance kernels, enabling a more robust and interpretable calibration process.

14h50 **Détection d'anomalies dans les précipitations mesurées**

Calves, Delhio, *pres.*, Polytechnique Montréal

La transition énergétique peut être vue par le prisme de la décarbonation, dont l'objectif est de réduire nos émissions de gaz à effet de serre. C'est la vision partagée par Hydro-Québec : 99 % de son énergie produite est d'origine hydraulique. En effet, l'hydroélectricité est, avec l'énergie éolienne, la filière énergétique qui émet le moins de GES par kilowattheure. Néanmoins, cette méthode de production d'énergie nécessite de disposer de données météorologiques fiables, notamment pour l'optimisation et la planification de la production, en plus de la prévision de la demande en énergie. À cet effet, Hydro-Québec dispose d'un vaste réseau de stations météorologiques possédant des capteurs qui collectent de façon automatique des données sur différentes variables climatiques (température, précipitation, etc.). Ces capteurs peuvent parfois produire des enregistrements erronés dont l'origine peut être instrumentale, ou encore dûs aux conditions météorologiques particulières. Ainsi, il est nécessaire de contrôler la qualité des données provenant des stations météorologiques, en détectant les anomalies, afin de pouvoir éventuellement les corriger et obtenir un ensemble de données fiables. Nous proposons donc une méthode reposant sur l'utilisation des précipitations enregistrées aux stations, de données surfaciques issues de prévisions numériques et de données d'altitude pour créer un ensemble d'images. Ces images sont ensuite analysées au moyen d'un réseau de neurones convolutif, qui les classe en deux catégories : image anormale indiquant une anomalie dans les mesures ou image normale. Le modèle parvient à détecter avec précision les anomalies générées artificiellement, avec un taux de bonnes classifications de 97%. Cette méthode est prometteuse, mais elle doit encore être testée avec des anomalies réelles afin de confirmer sa performance.

15h00 **A Distributionally Robust Optimization Strategy for Virtual Bidding in Two-Settlement Electricity Markets**

Audet, Xavier, *pres.*, Polytechnique Montréal
Qako, Kliti, Hydro-Québec
Lesage-Landry, Antoine, Polytechnique Montréal

This work presents a new strategy to virtual bidding based on distributionally robust optimization (DRO) using a Wasserstein distance. Virtual bidding, a mechanism used in two-settlement electricity markets, allows participants to arbitrage price differences between day-ahead and real-time markets. Traditional optimization methods for virtual bidding often rely on precise probabilistic models of market behaviour, which are unavailable in practice due to the inherent complexity and volatility of electricity markets. To tackle these challenges, this work formulates the virtual bidding problem as a DRO problem, incorporating Conditional Value at Risk (CVaR) into the objective to manage downside risk under volatile conditions. Tractable reformulations which can be efficiently solved to optimality are provided. The proposed strategy is developed and tuned using a 12-month training set to identify optimal parameters. The strategy is evaluated on historical pricing data from the New York Independent System Operator (NYISO) on an 8-month testing set. The results show improved performance over benchmarks, achieving higher Sharpe and Calmar ratios, as well as increased profit per bid. Through this DRO framework, a more reliable virtual bidding strategy that enhances profitability while effectively managing risk in uncertain market environments is presented.

15h10 **Investigating the Role of Canadian Non-Producing Oil and Gas Wells in Subsurface-Atmosphere Methane Fluxes Through Geochemical Signatures and Methane Origins**

Micucci, Gianni, *pres.*, McGill University
Kang, Mary, McGill University

The presence of approximately 400,000 non-producing oil and gas wells (OGWs) in Canada and millions more globally poses significant environmental and safety issues. These wells leak methane (CH_4) and other pollutants, which exacerbate climate change, pose explosion hazards, contaminate drinking water, and damage plants and animals. Plugging all existing non-producing OGWs would cost several hundred billion dollars [1], making this approach virtually impossible. However, since only 10% of these wells are responsible for >90% of the emissions [2], a better strategy may be to identify and target high-emitting wells for more effective and economical mitigation efforts. It is therefore important to fully understand the processes governing methane leakage and their subsequent emissions through non-producing OGWs. Another important aspect of these efforts is the identification of well integrity failures, which may not necessarily cause high emissions to the atmosphere but can cause subsurface fluid migration, even for low-emitting wells. A modern OGW typically consists of a system of casings and cement, providing multiple barriers designed to prevent contamination. The surface casing vent (SCV), installed at the wellhead, is designed to vent gas from the annular space between the surface casing and the next casing string. Generally, methane emissions at the SCV are viewed as a sign of well integrity failure but could be unrelated if the casing intersects natural fluid migration pathways. In this study, we compiled the geochemical data of 365 OGWs from Canada, with measurements made at the component level (wellhead, SCV and surrounding soil) wherever possible. By analyzing δ13C and δ2H isotopic signatures and gas compositions, we attributed an origin (primary microbial, secondary microbial, thermogenic, or abiotic) to our samples. These origins were only attributed to a third of the studied wells for at least one of the three components (wellhead, SCV and surrounding soil), due to the sensitivity of this approach. We found that the presence of thermogenic methane at the SCV is a good indicator of high-emitting wells, with magnitude of emissions 100 times higher than microbial emissions. Furthermore, our analysis revealed that a considerable number of emitting wells (~23%) produce methane of microbial origin, which is higher than previously thought (8% in the only existing meta-analysis), and with emissions exceeding previous estimates by a factor of 1,000. These results suggest that non-producing OGWs could act as bridge for subsurface microbial methane emissions to diffuse into the atmosphere. Finally, we generally found similar geochemical signatures of methane in corresponding wellhead and SCVs, suggesting that the structural integrity of these wells has been compromised and they can act as one single entity. [1] Raimi, D., Krupnick, A. J., Shah, J.-S. & Thompson, A. Decommissioning Orphaned and Abandoned Oil and Gas Wells: New Estimates and Cost Drivers. Environ. Sci. Technol. 55, 10224–10230 (2021). [2] Williams, J. P., Regehr, A. & Kang, M. Methane Emissions from Abandoned Oil and Gas Wells in Canada and the United States. Environ. Sci. Technol. 55, 563–570 (2021).

15h20 **Volt-var Optimization and Optimal Settings for Smart Inverters Using Blackbox Optimization**

Li, Feng, *pres.*, Polytechnique Montréal
Kocar, Ilhan, Polytechnique Montréal
Lesage-Landry, Antoine, Polytechnique Montréal

To regulate voltage levels on the power distribution networks, we propose an optimal reactive power dispatch (ORPD) stochastic program for volt-var optimization (VVO). The formulation considers not only control settings for voltage regulators, capacitor banks, and on-load tap changers which are conventional devices for VVO, but also optimal settings for volt-var droop curves of inverter-based distributed energy resources (DERs) for reactive power dispatch. Instead of directly solving the ORPD problem, we solve it using blackbox optimization (BBO) by reformulating it into a scenario-based BBO problem. The optimal settings sustain various demand and DER generation scenarios such that the settings do not need to be constantly changed. Through numerical simulations on IEEE test feeders, we demonstrate the performance of the solutions of our proposed approach on both in-sample and out-of-sample scenarios. We show that our approach outperforms a benchmark reinforcement learning method, and is also scalable to large-scale distribution networks.

15h30 **Efficient Design of Resilient Power Systems Through Global Sensitivity Analysis**

Gerkis, Aidan, *pres.*, McGill University
Wang, Xiaozhe, McGill University

Climate change has resulted in increasing frequency and intensity of extreme weather events, such as forest fires, floods, and ice storms. These extreme events pose a risk to the safe and secure operation of critical infrastructure, including power systems, that provide crucial services to our society. Designing adaptation measures to reduce this risk is critical to designing resilient power systems. Traditional power system planning methods rely on optimization-based approaches to guide decision-making in this process. However, these deterministic methods cannot be applied to enhance resilience due to the random nature of power system failures and the increasing penetration of renewable energy resources. This randomness mandates the application of probabilistic decision-making methods. However, commonly used probabilistic methods rely on Monte Carlo simulation or scenario-based approaches, which are computationally inefficient or incapable of quantifying the system's response over the complete random space. To address these issues, we apply global sensitivity analysis (GSA) using polynomial chaos expansions (PCEs). GSA enables the identification of sensitive power system components considering the entire random space while applying PCE to perform GSA significantly expediates the computation process. The GSA results are used to direct infrastructure investments towards adaptation measures which will have the largest impact on the system's resilience. Using this method, we gain valuable insights into the system's response, enabling the efficient design of adaptation measures and supporting the development of resilient power systems.

15h40 Posters & Pause

Salle | Room: 6214

Mohamad Charara, Polytechnique Montréal (*Hanane Dagdougui et Antoine Lesage-Landry*)

Optimisation des manœuvres de contrôle sur les lignes de transport électrique

Avec la demande croissante en énergie et l'intégration des sources d'énergie renouvelable, les réseaux électriques font face à d'importants défis opérationnels. Ces défis incluent les surcharges, les pertes de puissance et les instabilités du système, notamment lorsque les réseaux fonctionnent à proximité de leurs limites de capacité. Les dispositifs du réseau de transport jouent un rôle essentiel pour assurer l'exploitation sécurisée du réseau tout en facilitant l'intégration efficace des sources renouvelables afin de répondre à la demande croissante en électricité. Ce travail propose un modèle d'optimisation formulé sous forme de programme mixte en nombres entiers et à contraintes coniques du second ordre (MISOCP) pour la planification des actions de contrôle des dispositifs clés dans les systèmes de transport électrique, permettant ainsi d'améliorer l'efficacité opérationnelle du réseau et d'assurer une résolution efficace à l'aide de solveurs d'optimisation standards. Le modèle intègre (i) les changeurs de prise en charge (OLTC) pour gérer les niveaux de tension par des ajustements discrets des prises ; (ii) les compensateurs statiques synchrones (STATCOM) et les réactances shunt pour assurer la compensation de puissance réactive et la régulation de la tension ; et (iii) les condensateurs série à thyristors (TCSC) afin de contrôler l'impédance série et de réguler les flux de puissance. L'objectif du modèle est de minimiser les pertes de puissance active dans les lignes de transport en utilisant un nombre limité d'actions de contrôle, comme recommandé par l'opérateur, sur un horizon temporel donné, tout en garantissant le respect des contraintes opérationnelles et physiques à tout moment.

Pour modéliser efficacement les contraintes imposées par les caractéristiques opérationnelles des dispositifs, des techniques de linéarisation et de relaxation sont appliquées. Plus précisément, une relaxation conique du second ordre (SOCR) est employée pour modéliser les flux de puissance au sein du problème d'optimisation tout en garantissant une résolution computationnelle. Les contraintes associées aux OLTC sont discrétisées à l'aide d'une expansion binaire avant d'être linéarisées. Les STATCOM sont modélisés à l'aide de contraintes linéaires basées sur leurs valeurs maximales et minimales de puissance réactive afin de représenter leur comportement d'injection et d'absorption. Une technique d'expansion binaire est également utilisée pour modéliser les réactances shunt, permettant l'agrégation de plusieurs valeurs discrètes de puissance réactive. De plus, une technique de reformulation-linéarisation (RLT) est appliquée afin de modéliser la contribution des TCSC de manière convexe. Afin d'assurer une représentation précise du problème, un modèle d'optimisation multi-période est employé. Cette approche prend en compte la nature séquentielle des actions de contrôle, où les décisions prises à un instant donné influencent celles adoptées aux étapes suivantes.

Le modèle est testé sur les réseaux IEEE 9-bus et RTS 96 et comparé avec des modèles existants issus de la littérature. Les profils de tension et les pertes de puissance active sont évalués afin d'en mesurer la performance. Ces tests valident l'efficacité du modèle pour maintenir les tensions dans des limites acceptables tout en minimisant les pertes de puissance, soulignant ainsi son potentiel pour une application à des réseaux électriques de plus grande échelle.

Jonathan Eid, Université McGill *(James R. Forbes)*

A robust control approach to the design of power hardware-in-the-loop interfaces

The research project, conducted in collaboration with Hydro-Québec, aims to create a control interface that links real-time electrical grid simulations to renewable energy generation devices for testing purposes. This system will facilitate safe, efficient, and cost-effective testing of these technologies, enabling their integration into the grid and supporting the shift to cleaner energy sources. The design of the interface will leverage the tools of robust control theory to ensure stability and performance despite uncertainties in both the simulated grid and physical devices. After development, it will be validated using Hydro-Québec's infrastructure. This presentation aims to explain how, to date, an interface was designed for nominal operating conditions of the grid and device, and how such a design is insufficient for real-world application.

Liam Findlay, Université McGill
(*Roussos Dimitrakopoulos*)

Metaheuristics and Hyperheuristics with Parallel Computing for Large-Scale Optimization of Mining Complexes

An industrial mining complex is an integrated value chain includes the excavation, transportation, processing, and distribution of mineral products as well as the storage of waste products. Critical sources of uncertainty include the characterization of the mineral deposits, commodity prices, equipment performance, and processing facility performance. To maximize long-term value of the mining complex, an optimization model is formulated, accounting for decisions in block extraction, material destination policy, downstream material flow, capital investments, and major operating modes. The size of the model, number of binary and integer variables, and the presence of non-linear transformations in the formulation make optimization with exact methods highly impractical. Metaheuristics have been used to provide good solutions in reasonable execution times. Hyperheuristics have extended these capabilities, using online learning to accelerate optimization. Algorithms amenable for parallel computing present opportunities to scale hardware and further improve optimization results while reducing execution times. The present work reviews these developments and explores how they can be combined for the application of optimizing mining complexes.

Victor Guimaraes, Université McGill
(*Roussos Dimitrakopoulos*)

Simultaneous Stochastic Optimization of Mining Complexes: Integrating Waste Management and Progressive Reclamation with Encapsulation

Effective waste rock management is a crucial aspect of long-term planning of industrial mining complexes. When waste management is not considered during the optimization of the production schedule, it leads to an inaccurate assessment of the financial outcomes of the mining complex. This oversight can be especially costly when dealing with potentially acid-generating (PAG) waste rock, as it introduces the risk of significant treatment costs with rehabilitation, primarily due to acid rock drainage (ARD). Traditional practices don’t optimize production schedules while addressing this risk and fail to integrate geological uncertainty so as to create a production schedule resilient to waste misclassification and uncertain supply of material extracted from the related mines. To prevent or mitigate ARD, proactive measures such as encapsulating PAG material with non-acid-generating (NAG) material are essential. Furthermore, stricter legislation reinforces the necessity to restore mining sites to an acceptable post-mining condition using ongoing reclamation to ensure environmental stability and reduce long-term liabilities. This work integrates waste management and progressive rehabilitation into the simultaneous stochastic optimization framework, employing gradual encapsulation of PAG material to promote progressive reclamation, thereby reducing long-term environmental and financial liabilities. Uncertainties in acid generation are addressed using geostatistical simulations of the rock’s geochemical properties. A case study at a copper-gold mining complex demonstrates that incorporating waste management using progressive encapsulation has a minimal financial impact.

Frédérik Lavictoire, Université de Montréal
(*Olivier Bahn*)

Impact of the car fleet evolution on electricity demand in Québec

Under pressure to reduce greenhouse gas emissions, the global passenger car market is currently experiencing a shift from vehicles powered by internal combustion engines towards hybrid and fully electric models. Through an analysis of registered light-duty vehicles in Quebec, Canada, from 2011 to 2021, this study forecasts the evolving fleet's electricity demand under various electrification scenarios. The data indicates a yearly average fleet growth of 67,276 vehicles and an annual mass increase of 11 kg per vehicle from 2011 to 2021. Based on these trends, our projections estimate an electricity demand of 7.68 TWh in 2030, 17.84 TWh in 2035, and 29.03 TWh if the fleet continues evolving similarly. However, stabilizing the electric vehicle mass at the 2021 level reduces electricity demand by 17.6% in 2040 at a cost of a fleet that's 25.9% lighter.

Hanna Merrigan, Polytechnique Montréal (*Antoine Lesage-Landry*)

Coherent and fine-scale climate downscaling using probabilistic and physics-informed machine learning

This study explores wireless power transfer (WPT) systems for public electric vehicle charging, focusing on optimising the transmitter design to enhance interoperability across various receiver coil geometries and alignment conditions. Due to the complex non-linear relationships inherent to WPT systems, traditional optimisation methods are computationally expensive. Therefore, this study proposes an approach using artificial neural networks (ANNs) trained on finite element method (FEM) data to develop a surrogate model of the WPT system. This model is integrated into a blackbox optimisation solver, enabling faster identification of improved transmitter designs. The proposed method achieves computational speeds 6,000 times faster than traditional FEM simulations, with post-validation on the final solutions verifying prediction errors below 0.6%. The results demonstrate a significant acceleration in the optimisation process, establishing this method as an effective framework for developing practical WPT systems for public charging applications.

Lidiia Shchichko, Université Concordia, (*Roussos Dimitrakopoulos et Erick Delage*)

Contextual Stochastic Optimization of Industrial Mining Complexes

In mining complexes or mineral value chains, materials flow from extraction sites (mines) through crushers, stockpiles, waste dump and tailings, and processing plants to supply minerals to customers and market. New developments over the last decade have developed new advanced technologies for the simultaneous stochastic optimization of a mining complex, integrating upstream and downstream decisions into a single stochastic optimization model, that also manages the related supply (geological) and demand (market) uncertainties. This comprehensive approach addresses shared resources and operational interdependencies but results in large-scale, NP-hard problem that challenges existing solvers. To further tackle computational complexities, a novel framework leveraging contextual stochastic optimization is proposed to decompose the simultaneous stochastic model into interconnected upstream and downstream components. The proposed upstream model relies on pertinent block properties treated as random variables influenced by simultaneous model parameters, effectively capturing blending and processing activities. In particular, decision rules and end-to-end methods of contextual stochastic optimization are proposed. This framework enhances decision quality, manages risks, and offers a scalable solution for optimizing mining complexes under uncertainty.

Said André Umetzu Caballero, Polytechnique Montréal (*Hanane Dagdougui*)

Optimising Electric Vehicle Wireless Charging Systems Using Neural Networks to Enable Free-Position Parking

Le projet vise à développer un logiciel interactif pour optimiser la gestion des charges électriques résidentielles.
Objectifs :
* Réduire le gaspillage énergétique (jusqu'à 30 %).
* Optimiser la consommation et équilibrer l’offre et la demande.
* Encourager la participation active des utilisateurs grâce à une interface intuitive.
* Promouvoir l’efficacité énergétique et réduire l’empreinte carbone.
Le projet contribue à une gestion énergétique durable et à la réduction des coûts pour les utilisateurs.

Session 2

Salle | Room: 4488
Présidée par | Chaired by: Olivier Bahn, GERAD/HEC

16h20 Advances in the Trustworthy Machine Learning Pipeline for Virtual Power Plants

Pallage, Julien, *pres.*, Polytechnique Montréal, Mila & GERAD
Lesage-Landry, Antoine, Polytechnique Montréal

Virtual power plants (VPPs) are decentralized networks of distributed energy resources (DERs), e.g., photovoltaic panels, wind farms, electric vehicle batteries, thermostats, and other controllable grid-edge energy resources, that are collectively managed and operated as a unified entity through a central control system. Instead of generating electricity from a single location like typical power plants, VPPs mobilize and incentivize geographically dispersed generation, storage, and consumption to offer a vast range of grid services. It relies on the forecast, the optimization, and the control of these distributed assets to exploit flexibility and meet grid needs with very limited infrastructure change. The VPP is essential for a green and resilient grid and algorithms are fundamental in its making: optimization methods need complex machine learning (cML) to forecast and model the intricacy of the system, and ML models need to be integrable in control methods to exploit them while enforcing safety constraints. As much as the future success of the VPP stands on cML, the sensitivity of the application and the scale of potential failures slow down its industrial acceptability. The issue is that cML historically lacks explainability and interpretability, has limited out-of-the-box performance guarantees, can be unpredictable and thus hard to control, requires a lot of data to perform as expected, is sensitive to data corruption, and is associated with complex training procedures that do not scale well with large deployments. These flaws have labeled it as unreliable for critical applications such as the VPP. In this presentation, we overview the requirements to create a trustworthy ML pipeline for the VPP from pre-processing to exploitation and cover some of our contributions.

16h30 Spatial Pattern Regression for Gridded Meteorological Data: A Precipitation and Temperatures Case Study

Houssou, Vihotogbé, *pres.*, Polytechnique Montréal

Water resources are significantly affected by climate change, particularly through the increasing occurrence of extreme events (flood in this case). To study the impacts of these changes, hydrological models powered mainly by spatialized precipitation and temperature data (i.e., available on a grid) are used. Generally, they are obtained either by re-analysis techniques or by spatial interpolation of observations, and must account for extreme events and spatial heterogeneity. The most widely used spatial interpolation methods such as inverse distance weighting and kriging are limited by isotropic effects that do not allow them to take spatial variability into account. To do this, some of these methods (kriging with external drift, thin plate splines) use auxiliary information (altitude, climatology) to compensate for the low density of the station network. We propose a new method for estimating spatialized meteorological data that exclusively and systematically exploits spatial patterns to interpolate observations. Spatial patterns are extracted from regional climate model data using principal component analysis. This method ensures the consistency of spatial information between the past and the future in hydrological modeling. It is applied in different watershed contexts (low or high station density, small or large watershed, mountainous or non-mountainous region) and the results are compared to those obtained with existing methods.

16h40 Robust Pathways to Hydrogen Integration: Leveraging ETEM Framework

Ghaboulian Zare, Sara, *pres.*, Université de Montréal
Bahn, Olivier, HEC Montréal
Mousseau, Normand, Université de Montréal
Trépanier, Martin, Polytechnique Montréal, CIRRELT

Hydrogen is becoming a key energy source in the transition away from fossil fuels and the pursuit of climate goals. Its integration into long-term energy system models like Integrated Assessment Models (IAMs) and Energy System Optimization Models (ESOMs) is critical for assessing its potential and guiding policy. These models evaluate hydrogen's impact on emissions and economic feasibility but face uncertainties related to technology, economics, politics, and external factors. This research uses the Energy–Technology–

Environment Model (ETEM) to explore net-zero pathways, focusing on developing a robust ETEM-H_2 framework with robust optimization methods to address uncertainties. A case study for Greater Montréal and Canada incorporates hydrogen technologies, creating tools and roadmaps to reduce emissions, particularly in hard-to-abate sectors.

16h50 Communautés locales en transition: Modélisation, optimisation et circularisation de l'écosystème énergétique local (Local Communities in Transition: Modeling, Optimizing and Circularizing of the Local Energy Ecosystem)

Lachapelle, Patrick, *pres.*, ÉTS

Une transition énergétique est nécessaire pour lutter contre les dérèglements climatiques et écologiques. Alors que la transition énergétique exige de diminuer les demandes en énergie, le Québec est en situation d'ébriété énergétique, cherchant à accroître sa production plutôt que de viser une plus grande sobriété et efficacité énergétique. Dans ce contexte, le présent projet de recherche pose un regard sur la place des collectivités locales dans la transition énergétique québécoise. Ces dernières sont au cœur de l'écosystème énergétique territorial, et peuvent agir de diverses manières sur l'offre et la demande énergétique, notamment à travers leurs compétences en aménagement du territoire, leur gestion d'infrastructures névralgiques (transport, bâtiments, etc.) ainsi que leur capacité d'influence sur les acteurs locaux. Toutefois, les actions des collectivités québécoises en matière énergétique demeurent timides et, contrairement à plusieurs municipalités européennes ou américaines, elles sont peu enclines à réaliser des planifications énergétiques de leur territoire. Pourtant, il semble subsister d'importants gisements énergétiques (énergies renouvelables, énergies valorisées et économie d'énergie) à l'échelle locale. De plus, la littérature fait état de l'importance des pratiques d'aménagement du territoire (densité du cadre bâti, mobilité durable, mixité des usages, canopée et verdissement urbain, réseaux thermiques et boucles énergétiques, etc.) qui, en tant que « moteurs » de demandes énergétiques, peuvent avoir un impact important sur les demandes performances énergétiques des territoires. En ce sens, le projet propose d'évaluer l'ampleur des gisements, particulièrement d'économie d'énergie, qui sommeillent dans les collectivités locales québécoises. Toutefois, les données énergétiques à l'échelle locale sont rares et les outils d'analyse des flux énergétiques locaux sont presque inexistants en contexte québécois. Le projet cherche ainsi à combler un vide dans la littérature en proposant, à partir des concepts de métabolisme urbain et de ville circulaire, une méthode d'analyse du système énergétique local qui s'appuiera sur les principes de sobriété, d'efficacité et de circularité énergétiques. À l'aide d'une étude de cas (Arrondissement Saint-Laurent, à Montréal), une modélisation de l'écosystème énergétique local sera faite afin d'évaluer la contribution potentielle des collectivités locales à l'atteinte des objectifs de carboneutralité du Québec.

17h Cocktail & Prix | Awards

Salle | Room: 6214