MathTech 2025

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Week's agenda

- **Day 1 :** Presentation by EDF : Topic of interest to the company
- **Day 2 :** Choice of our problematic
- **Day 3 - 4 :** Working on our topic
- **Day 5 :** Presentation of our results in pitch form

Choice of a problematic

Presentation from three researchers on linked thematics

- **Energy Production/Consumption:** Y. Goude
- **Electrical Vehicles:** Y. Amara
- **Weather/Climate:** E. Lindas

Our choice: Exploring uncertainty estimation and its impact on electricity production planning

➔ Connects the project’s three main themes
➔ Broad and multidisciplinary approach
➔ Gave us the chance to explore unfamiliar mathematical concepts

Impact of meteorological uncertainties on day-ahead power generation planning

Integration of EVs and minimization of fossil fuels for greater flexibility.

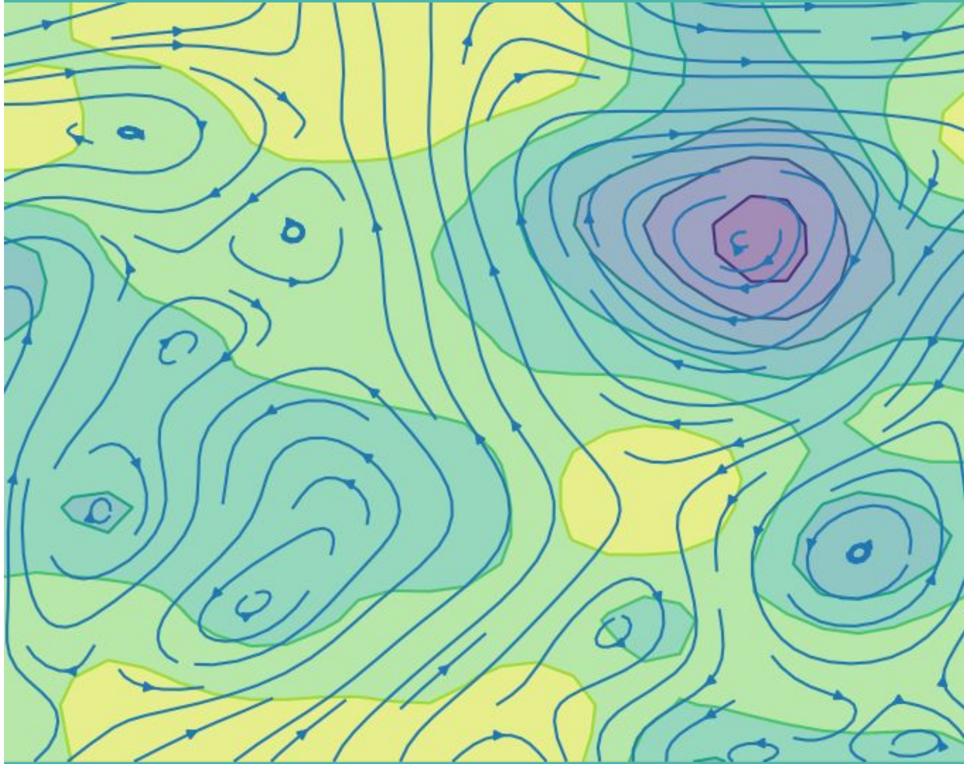
Generate Wind Map

Integrate Navier-Stokes equation

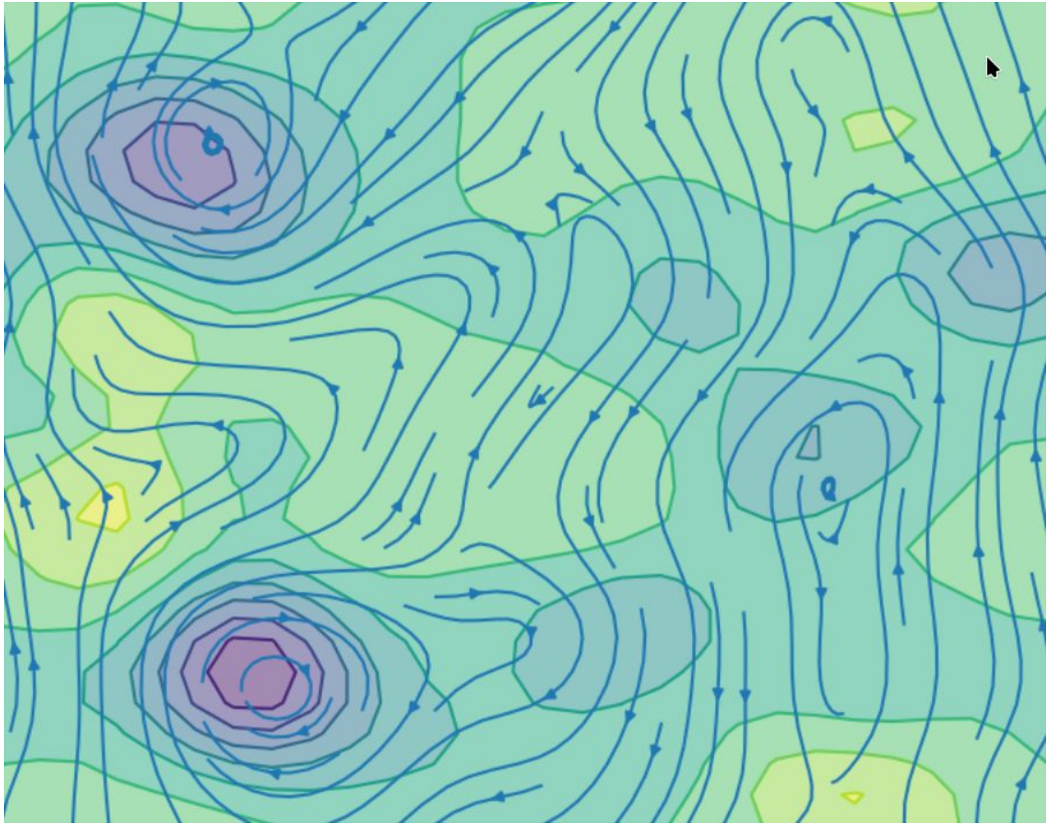
- ➔ ν : **air viscosity.**
- ➔ ϱ : **air volumetric mass density.**
- ➔ **(Gaussian data) Initial data for wind.**

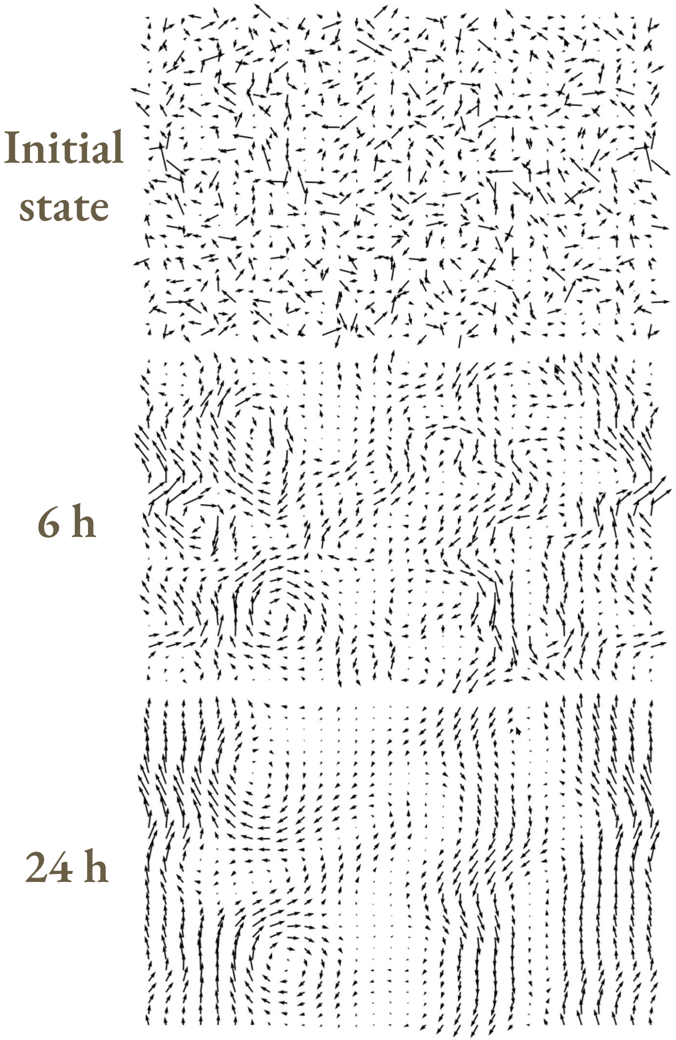
$$\Delta p = -\rho \sum_{j,k} \frac{\partial V_j}{\partial x_k} \frac{\partial V_k}{\partial x_j}$$

$$\partial_t V = -(V \cdot \nabla)V - \frac{1}{\rho}\nabla p + \nu \Delta V$$



Create a Wind map to insert noise





How to generate our data ?

Solar production

$$P_{\text{sol}}(t) = E(t)\exp\left(-\frac{(t-t_z)^2}{(\Delta t_{\text{day}})^2}\right)$$

Wind production

$$\begin{cases} 0 & \text{if } v < v_c \\ \frac{1}{2}\rho C_p v^3 \pi R^2 & \text{if } v_c \leq v \leq v_u \\ P_{\max} & \text{if } v_u \leq v \leq v_m \\ 0 & \text{if } v_m < v \end{cases}$$

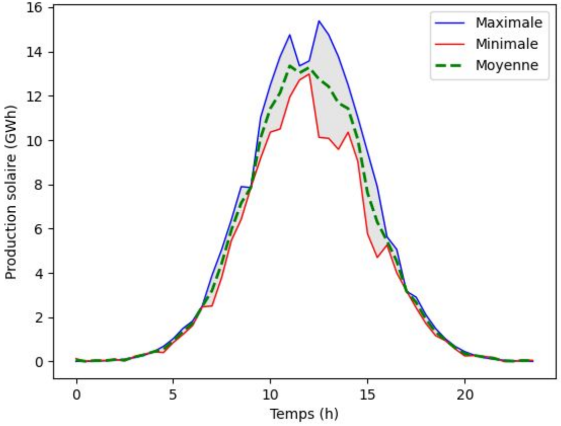
Electricity consumption

$$C(t) = C_{\text{base}} + \alpha(t)T(t)$$

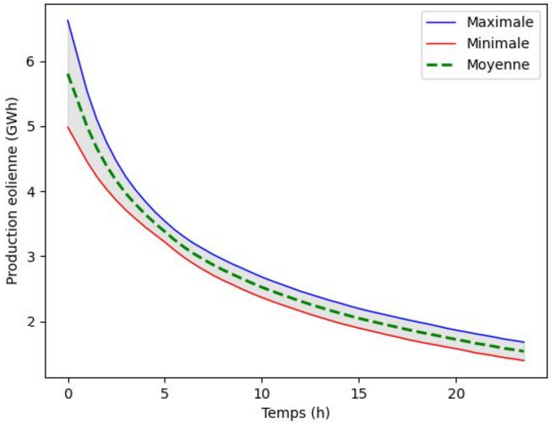
$$C(t) = C_{\text{base}} + \alpha(t)T(t) + \beta\sin\left(\frac{2\pi t}{48}\right) + \gamma\cos\left(\frac{2\pi t}{48}\right)$$

Simple data example

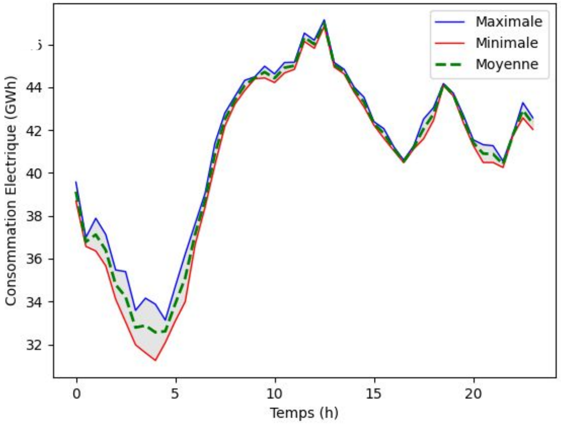
Solar production



Wind production



Electricity Consumption



Optimization problem

Data	**Outputs**
• Wind production: $e(t)$ • Solar production: $s(t)$ • Electric vehicle availability: $b_{\min}, b_{\max}, x_{\max}$ • Consumption: $c(t)$ • Cost of controllable energy production: q	• Controllable energy production program: $p(t)$ • Electric vehicle charge/discharge program: $x(t)$

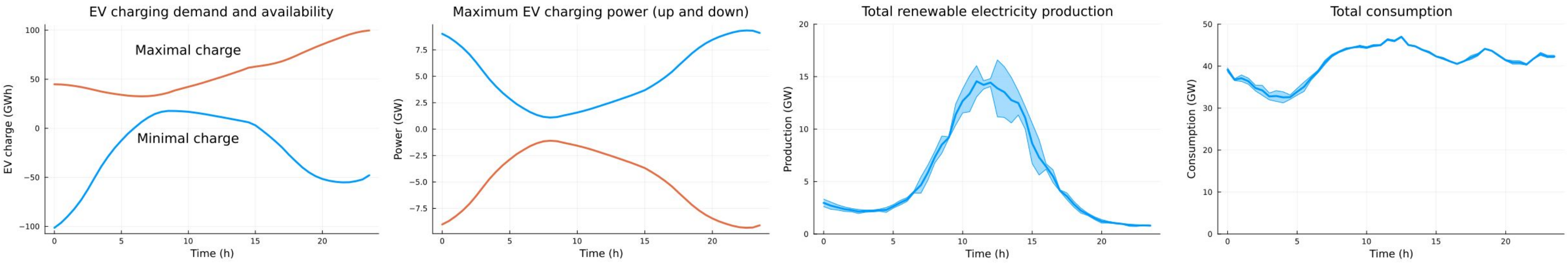
$$\min_{x,p} \int_0^T q(p(t))\mathrm{d}t$$

$$\text{under constraints (for } 0 \leq t \leq T) :$$

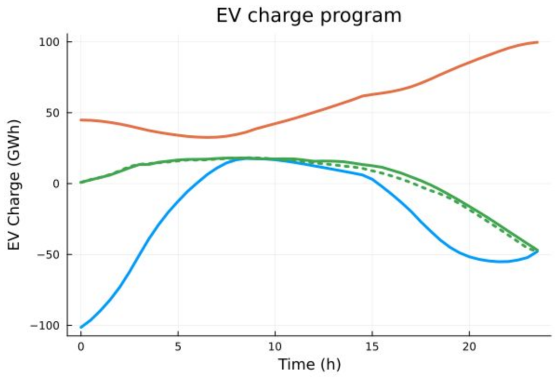
$$s(t) + e(t) + p(t) = c(t) + x(t)$$

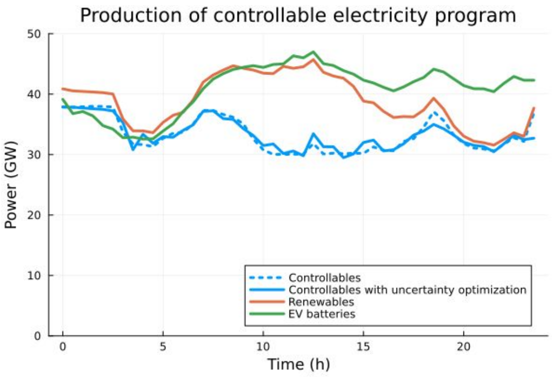
$$b_{\min} \leq \int_0^t x(u)du \leq b_{\max}(t)$$

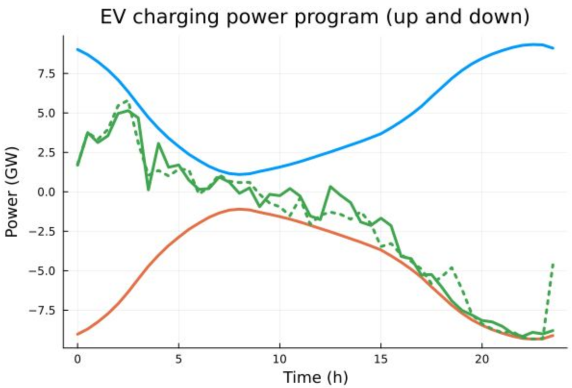
$$|x(t)| \leq x_{\max}(t)$$



Optimal programmation







Additional constraints (uncertainty) :

$$b_{\min} \leq \int_0^t x(u) - \delta s(u) - \delta e(u) - \delta c(u) du$$

$$\int_0^t x(u) + \delta s(u) + \delta e(u) + \delta c(u) du \leq b_{\max}(t)$$

Conclusion

Summary

- Toy model that enabled us to set up an electrical production program from start to end
- More in-depth models :
  - Weather prediction: Numerical Methods, ML, Equations
  - Predictive production models: Big Data, ML
  - Refinement of cost and constraint specifications for optimization
  - Stochastic optimization methods

Mathematical domains involved

- Numerical scheme
- Constrained non-linear optimization
- Statistics, Machine Learning

Outlook

- Insight into the role of mathematics in solving real-world industrial problems
- Bonding experience

Thank you for your attention !