efficacity

EFFICACITY
L'Institut pour la transition énergétique de la ville

Energy and Climate Management of a Subway Station

Tristan Rigaut[1]

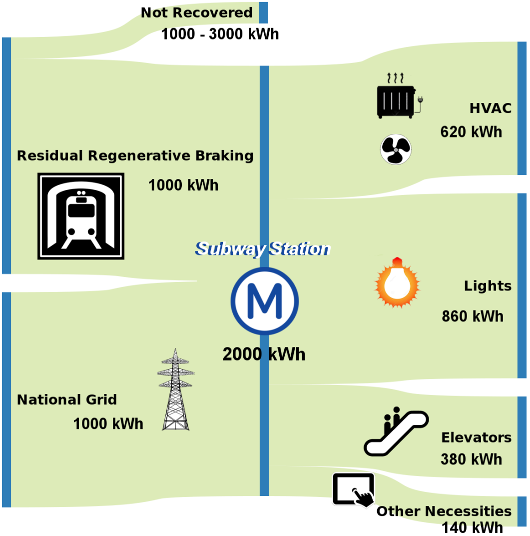
[1]Pôle Gare, Lot 1
Efficacity, Institute for the Energy Transition

October 22, 2015

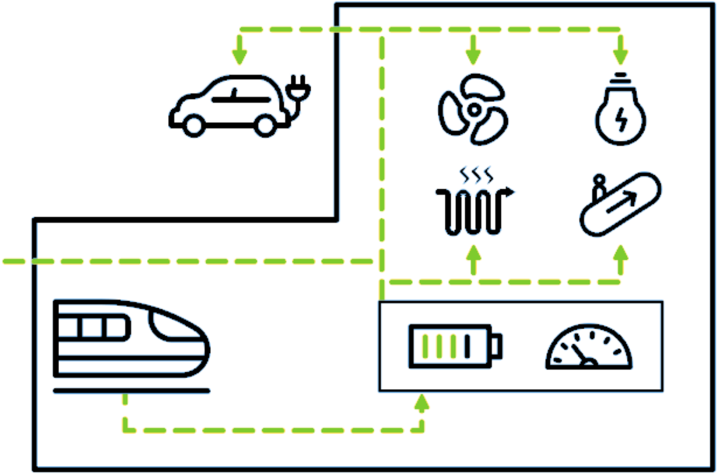
Outline

1. A subway station microgrid
   - A subway station Microgrid
2. Dynamic modelling of the station
   - Supply/demand balance
   - Particles dynamics
   - Battery dynamics
   - Economic criterion
3. Optimization of the energy and climate management
   - Results

Subway stations potential energetic flows



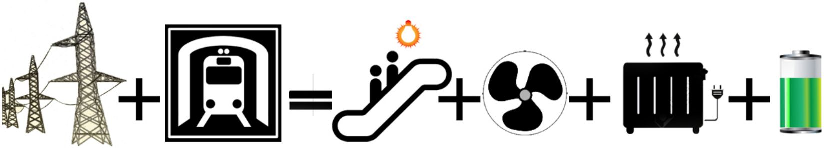
A subway station Microgrid



Supply/Demand balance

Over $\tau = 24$ hours we have to ensure :

$$\underbrace{P_G(t)}_{\text{Main Grid Power}} + \underbrace{P_{Train}(t)}_{\text{Brakes Power}} = \underbrace{P_L(t)}_{\text{Lights, Elevators}} + \underbrace{P_V(t)}_{\text{Ventilation}} + \underbrace{P_H(t)}_{\text{Heating}} + \underbrace{P_B(t)}_{\text{Battery}}$$



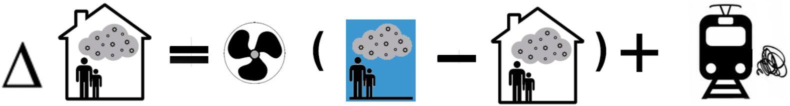
Particles Dynamics

We have to ensure the occupants safety regarding air quality :

$$\boxed{Q_{PM}min < Q_{PM}(t) < Q_{PM}max}$$

Knowing the PM10 dynamics :

$$\underbrace{\overbrace{V_z}^{\text{Zone Volume}} \frac{dQ_{PM}}{dt}(t)}_{\text{Particulate Matters Dynamics}} = \underbrace{\overbrace{r_v \color{red}{P_V(t)}}^{\text{Fan Air Flow}} \left(Q_{PM_e}(t) - Q_{PM}(t)\right)}_{\text{Ventilation}} + \underbrace{V_z Q_{PM_{Brakes}}(t)}_{\text{Braking Emissions}}$$



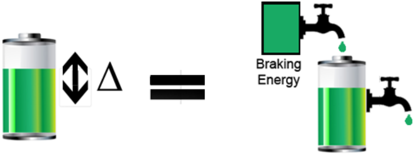
Battery Dynamics

We can control the battery knowing its dynamic :

$$\frac{dS_{OC}}{dt}(t) = \frac{\overbrace{\rho_B}^{\text{Charge/Discharge Efficiency}}}{\underbrace{V_0 Q_{max}}_{\text{Tension} \times \text{Maximum Charge}}} \times \underbrace{P_B(t)}_{\text{Charge/Discharge Power}}$$

Which are valid between bounds that ensure good ageing of the battery

$$\boxed{S_{OC\,min} \leq S_{OC}(t) \leq S_{OC\,max}}$$



efficacity

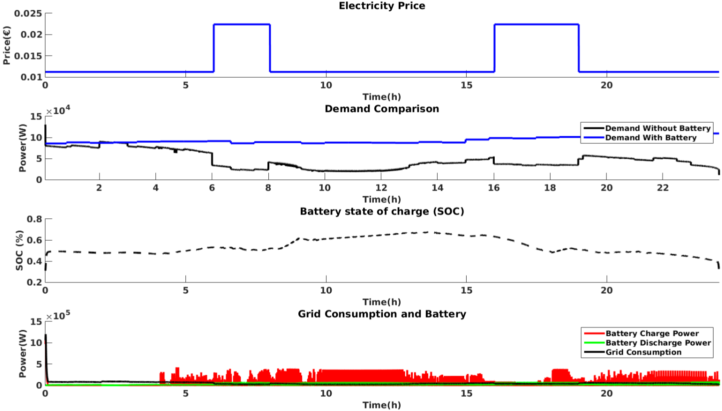
Economic criterion

Here is the criterion :

$$J(u(.)) = \overbrace{\int_0^{T} \underbrace{C(t)}_{\text{Cost (€/ Watt)}} \times \underbrace{P_G(t)}_{\text{Main Grid Power}} \, dt}^{\text{Total cost of consumed electricity}}$$

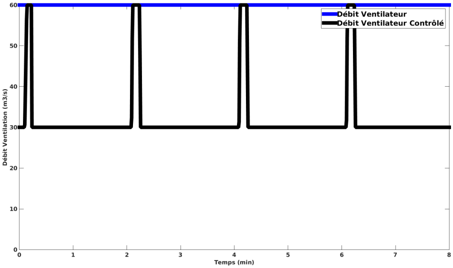
No battery vs. Battery controlled

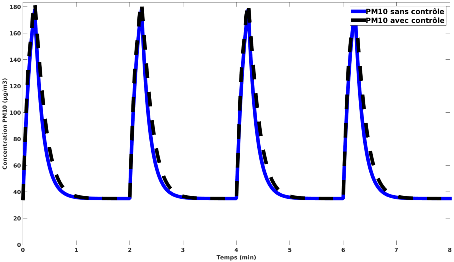
We could save 55% of money everyday with a battery



efficacity

We could save 45% of money everyday with a proper control of ventilation.





Perspectives