CONCEPTION, DESIGN AND IMPLEMENTATION OF A SMART VENTILATION MANAGEMENT SYSTEM

Área de Ingeniería de Instalaciones

Metro de Madrid facts & figures:

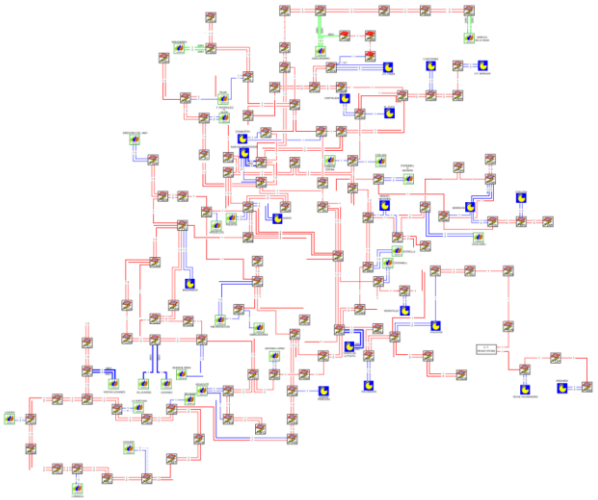
302 stations, **294** Km track length

12 Heavy rail lines+ **1** Branch Line + **1** Light rail line

677 million travellers/year (2019)

2400 Cars. **183** million cars·km (2019)

1 GVA installed capacity



Energy Consumption (2019) : **546 GW/year**

≅ 160.000 households

TUNNEL & STATIONS VENTILATION SYSTEM

- **Inlet-air in stations**
- **Exhaust-air in tunnels**
- **Overpressure compensation (piston effect)**

640 FAN SHAFTS / **544** BLAST SHAFTS

913 FAN & THEIR ACCOUSTIC EQUIPMENT

VARIABLE FREQUENCY DRIVE

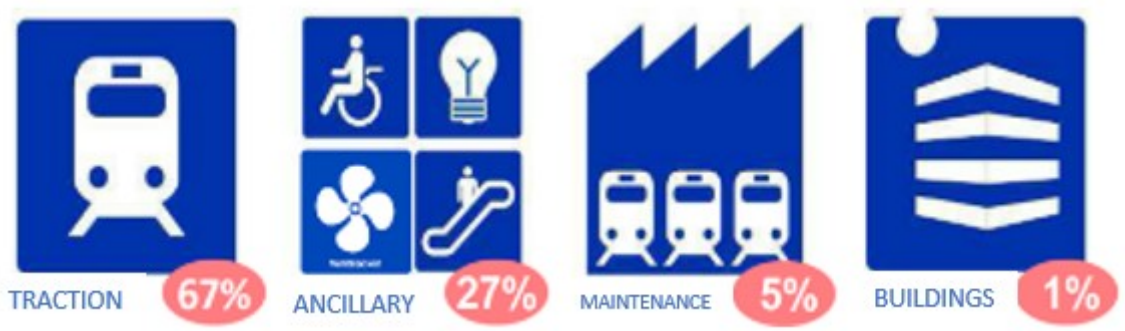
> 20 MW POWER CAPACITY

Energy Saving Plan [PAE] (SINCE 2012)

PAE

SET OF ACTIONS to REDUCE ENERGY CONSUMPTION and IMPROVE SUSTAINABILITY

Designed and developed entirely by Metro de Madrid



ENERGY CONSUMPTION 2012: 713,2 GWh

Equivalent annual electricity consumption CITY OF ZARAGOZA

CHALLENGE

ENERGY SAVING 25%

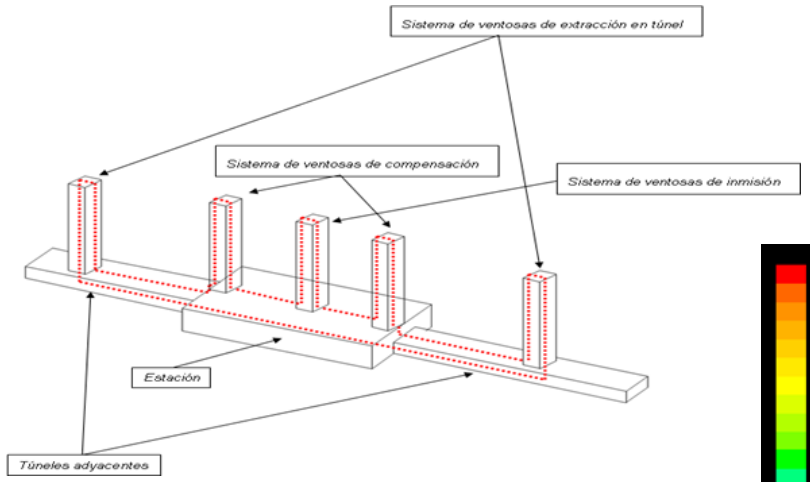
COMFORT: optimization of the tunnel & stations ventilation system

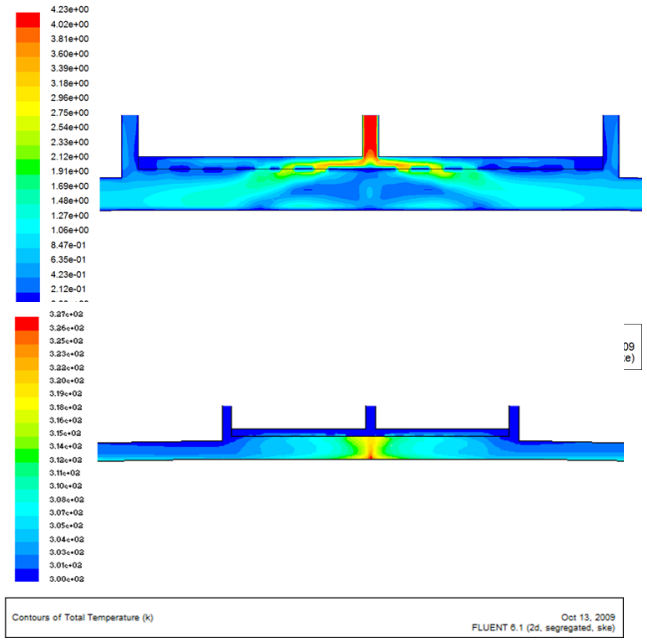
LIGHTING: implementation of LED technology in stations, manteinance buildings and trains

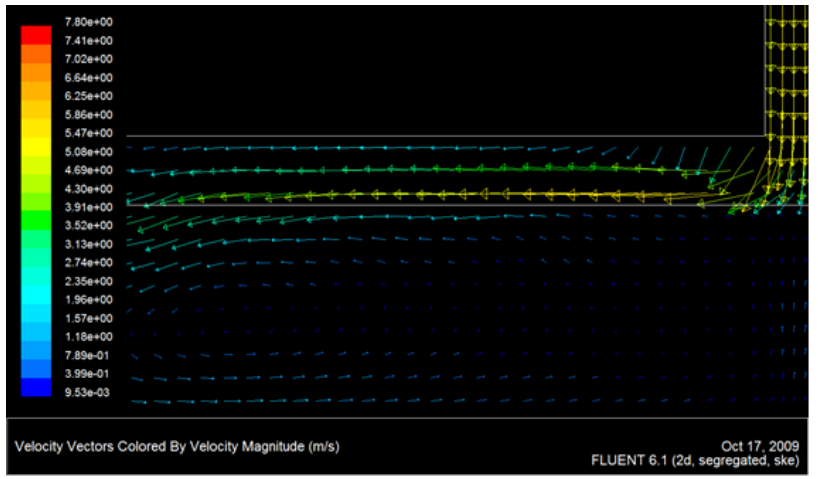
TRACTION: optimization of consumption and increasing of regenerative braking

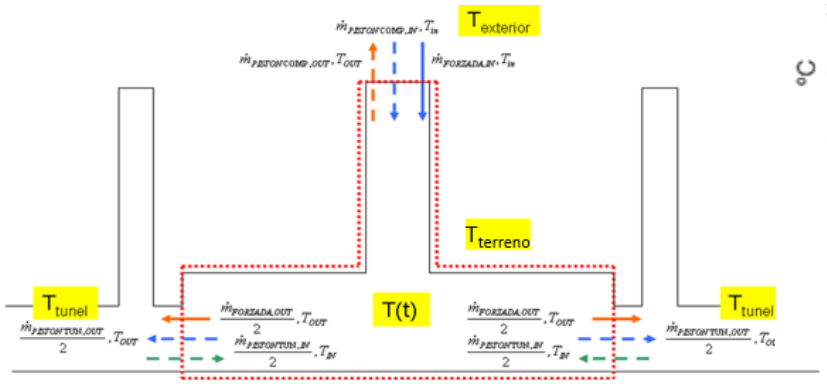
DESIGN & SIZING

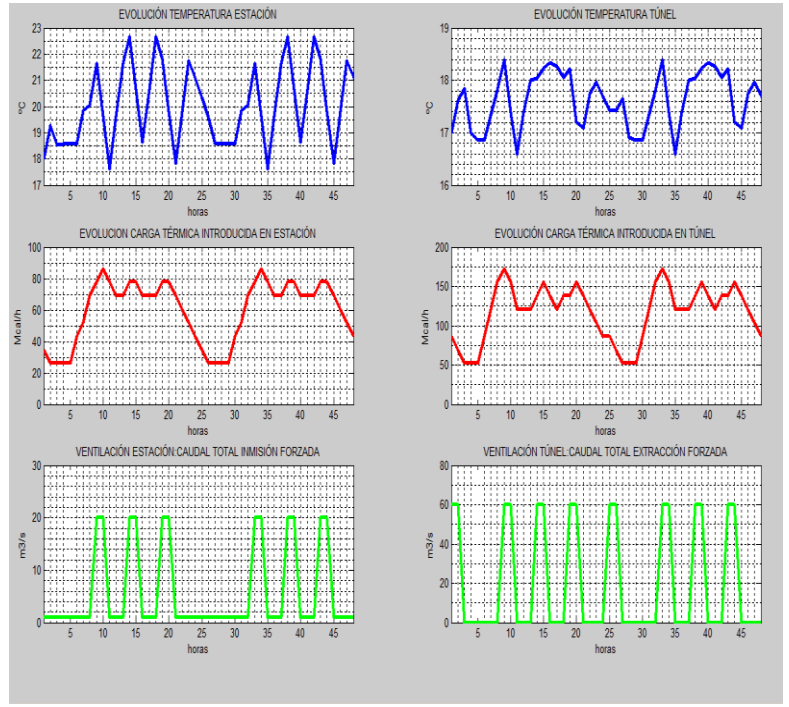
HIGH COMPLEXITY

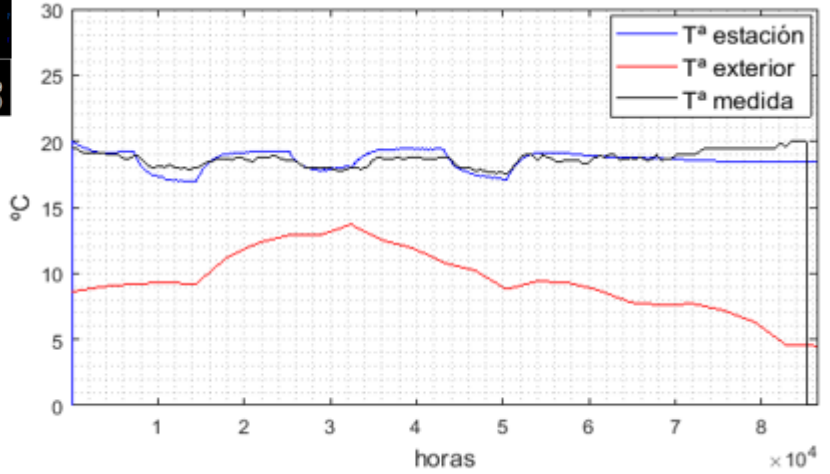












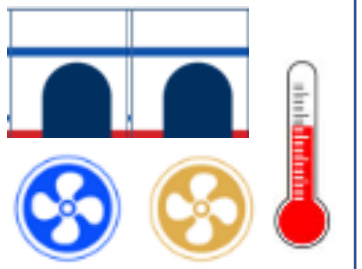
PAE

GIV

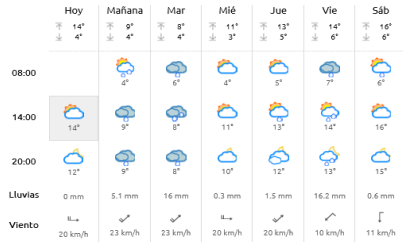
TRAINS

USERS

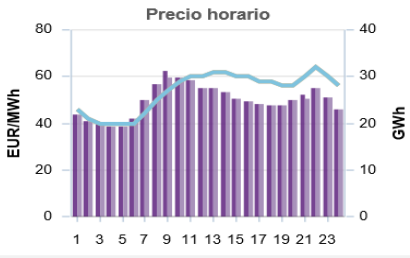
TUNNEL EQ.

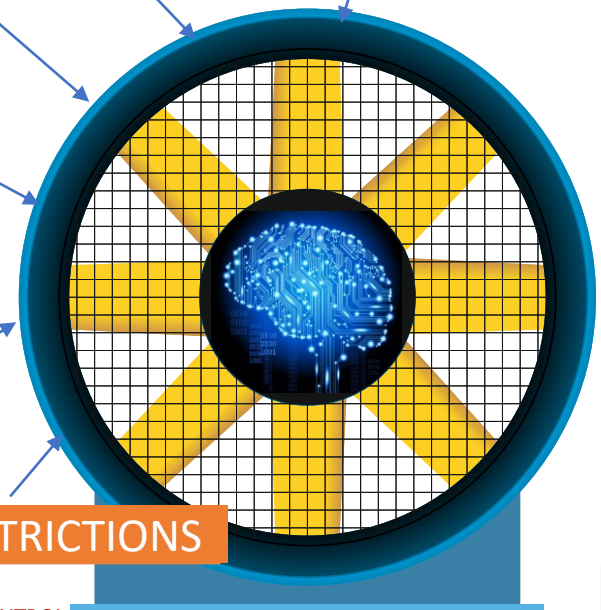


WEATHER FORECAST



ENERGY COST





RESTRICTIONS

NOISE CONTROL
MAINTENANCE PLAN
OPERATIVE NEEDS...

CHALLENGE MAIN PARAMETERS

Not enough to anticipate the behavior of some of the factors…

OPTIMIZING implies finding the BEST SOLUTION in a complex, high dimensional & multivariable search domain.

GIV

A.I. CONCEPTUAL MODEL

?

VENTILATION SCHEDULE

OPTIMIZATION

METAHEURISTICS

- CONSTRAINTS
- VARIABLE INPUT
- RESTRICTIONS

PREDICTIVE ANALYTICS

- PHYSICAL APPROACH
- NUMERICAL SIMULATION (SES)
- MEASUREMENTS DATABASE

- WEATHER FORECAST
- TRAIN FREQUENCY
- TRAVELLERS FLOW

- PLATFORM TEMPERATURE

REINFORCEMENT

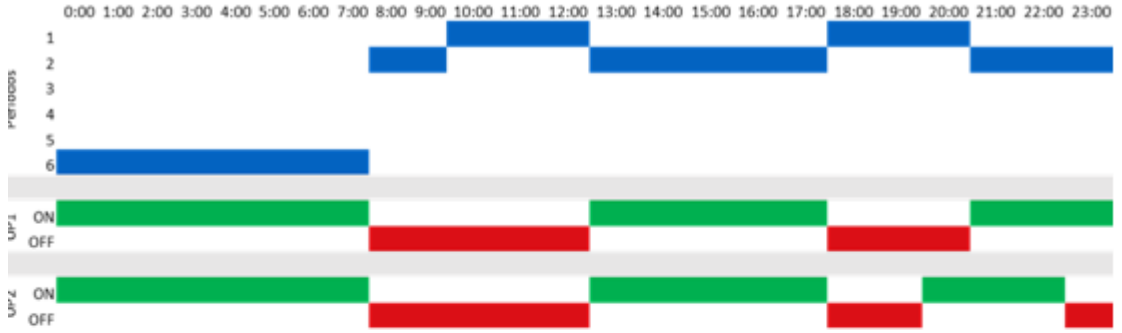
LEARNING

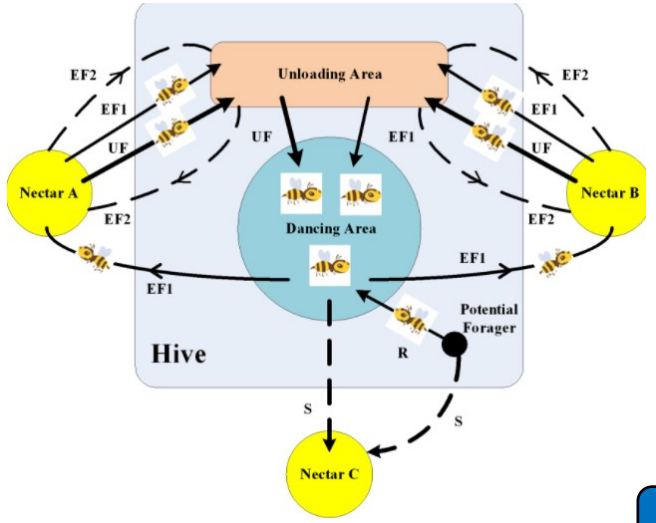
ARTIFICIAL BEE COLONY (ABC)

[KARABOGA, 2005]

METAHEURISTIC APPROACH…
…ESTRICTLY OPTIMAL [MATH SENSE]…
NOT WARRANTED

Flower fields → FEASIBLE SOLUTIONS DOMAIN
Nectar quality → FUNCTIONAL TARGET VALUE



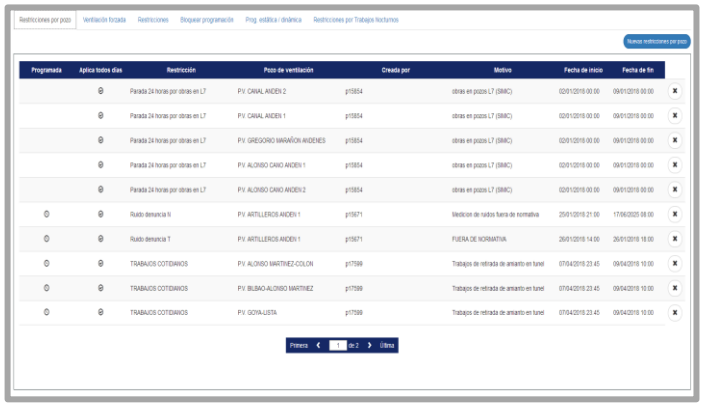


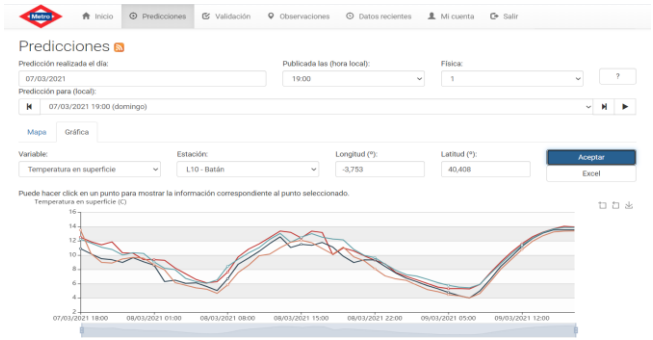
OPTIMAL SCHEDULE PROCCESING

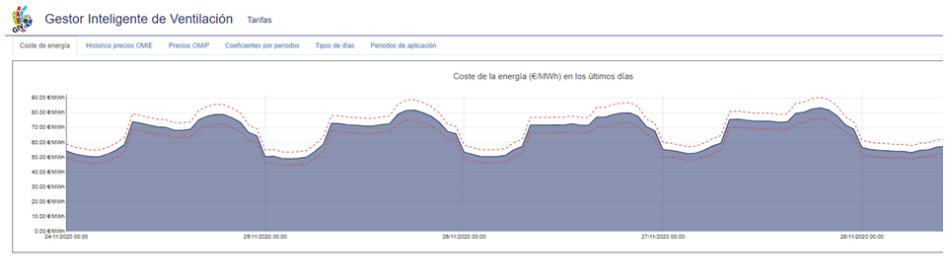
			Selected
OP1	22º C	1000€	
OP2	22º C	1100€	

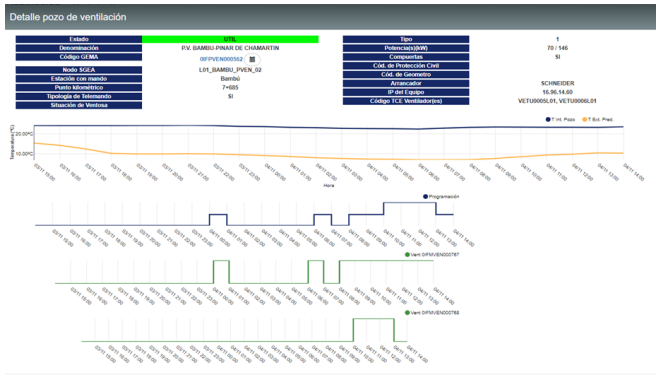
…BUT HIGH COMPUTATIONAL EFFICIENCY…

Control Panel







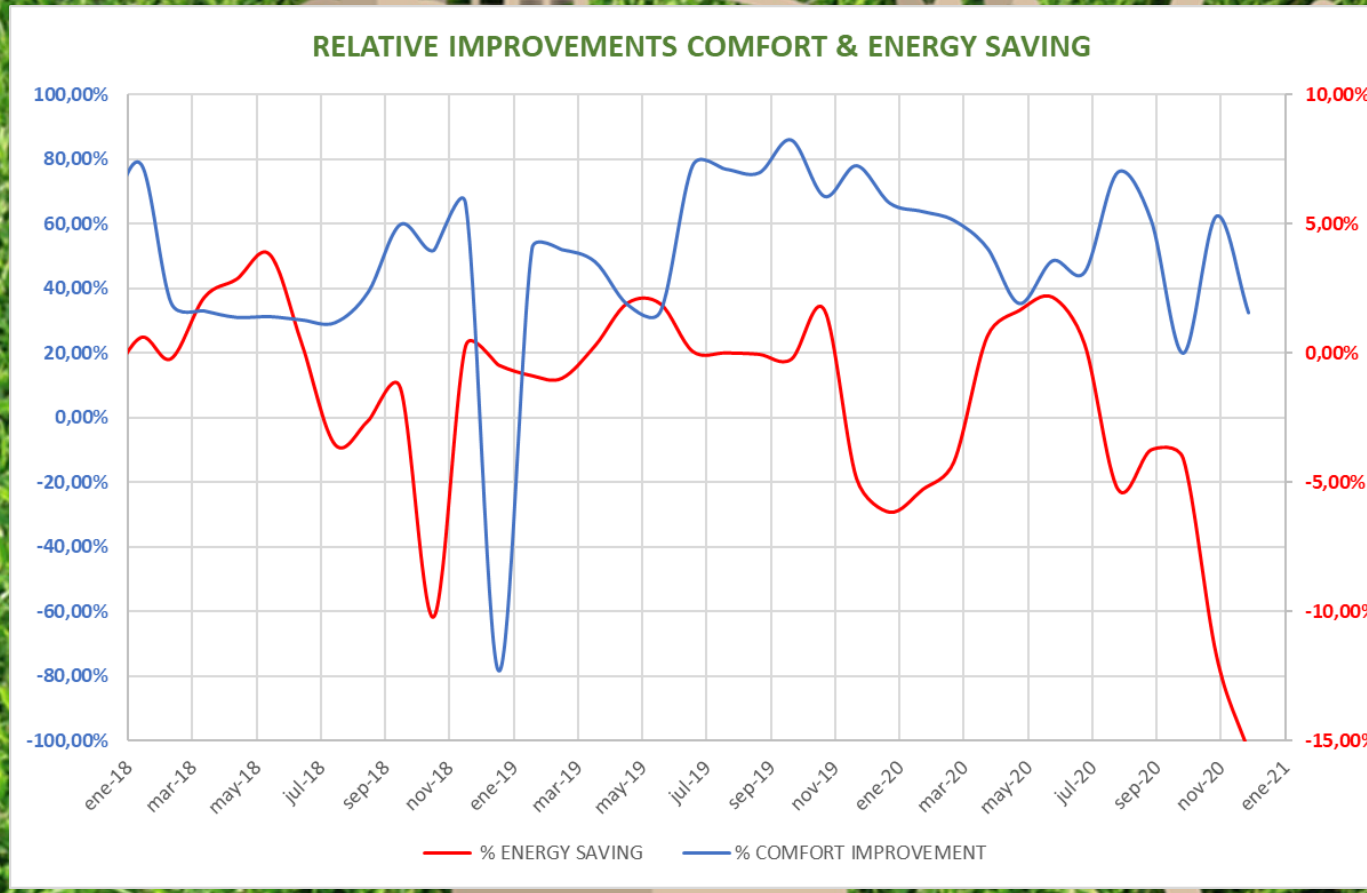


CHALLENGE RESULTS

Reduction in ancillary comsumption over **19.6%** (before July 2020 - COVID)

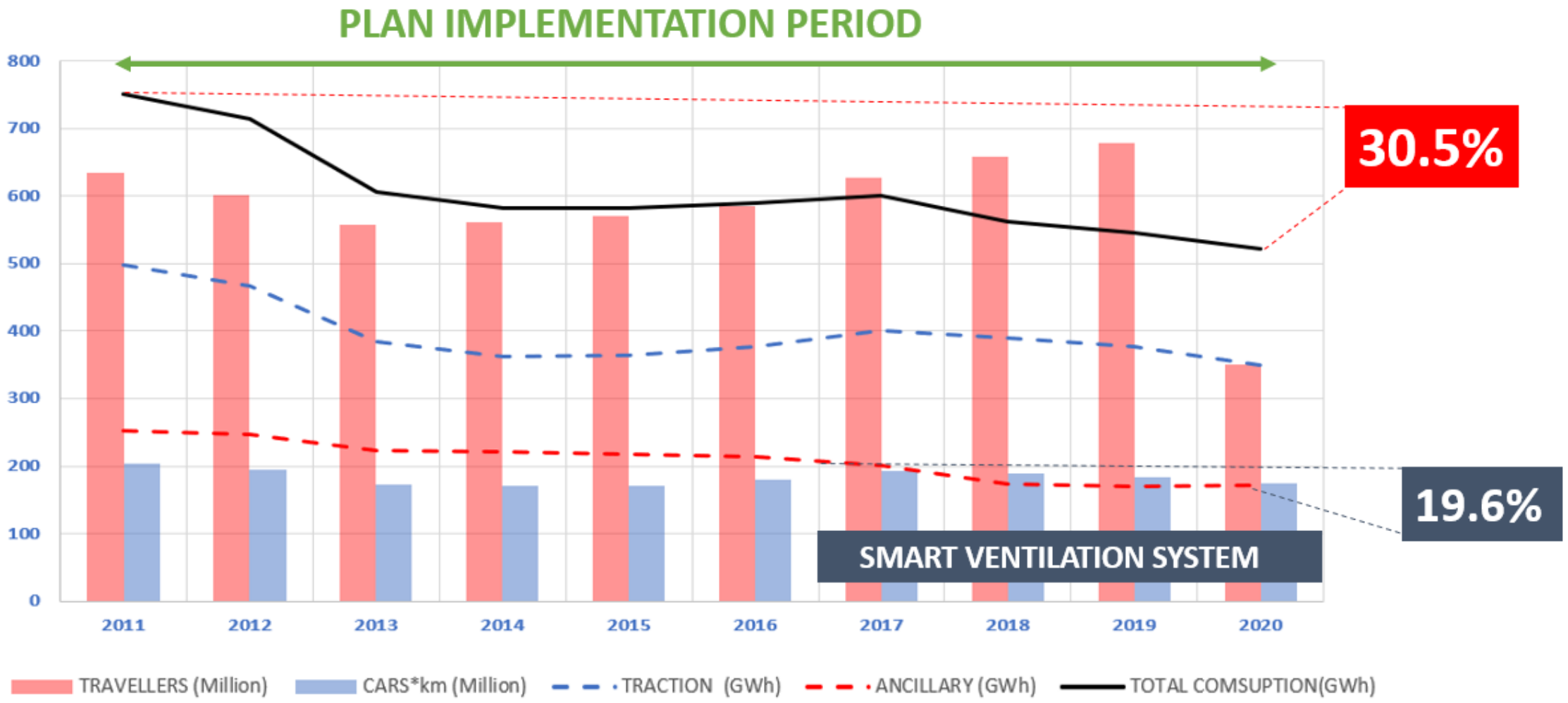
Equivalent Reduction in CO_2 footprint

Improvement customer comfort (% hours into comfort range) **over 4%**



MAE Temperature Forecast **0.9ºC**

Global Results Energy Saving Plan



THANK YOU

GESTOR
INTELIGENTE
DE VENTILACIÓN