



THERMAL MANAGEMENT OF ELECTRICAL VEHICLE « VEGA/THOP » PROJECT

Valeo



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VEGA / THOP (*) PROJECT FRAMEWORK

- Cooperative Program funded by the “French Department of Energy”



- Review / Build technology “tool box” to enhance EV cruising range
- Specific focus on Thermal Management Architecture
- Battery Thermal Management also of concern
- Demonstrate solutions : at bench / on EV demonstrator
- Assess “Added Value / Added Cost” at Vehicle System level

(*) : Véhicule Electrique à Grande Autonomie / THERMIQUEMENT OPTIMISÉ



IMPACT OF THERMAL COMFORT ON EV RANGE



REFERENCE CONFIGURATION - KEY PARAMETERS

Driving Profile

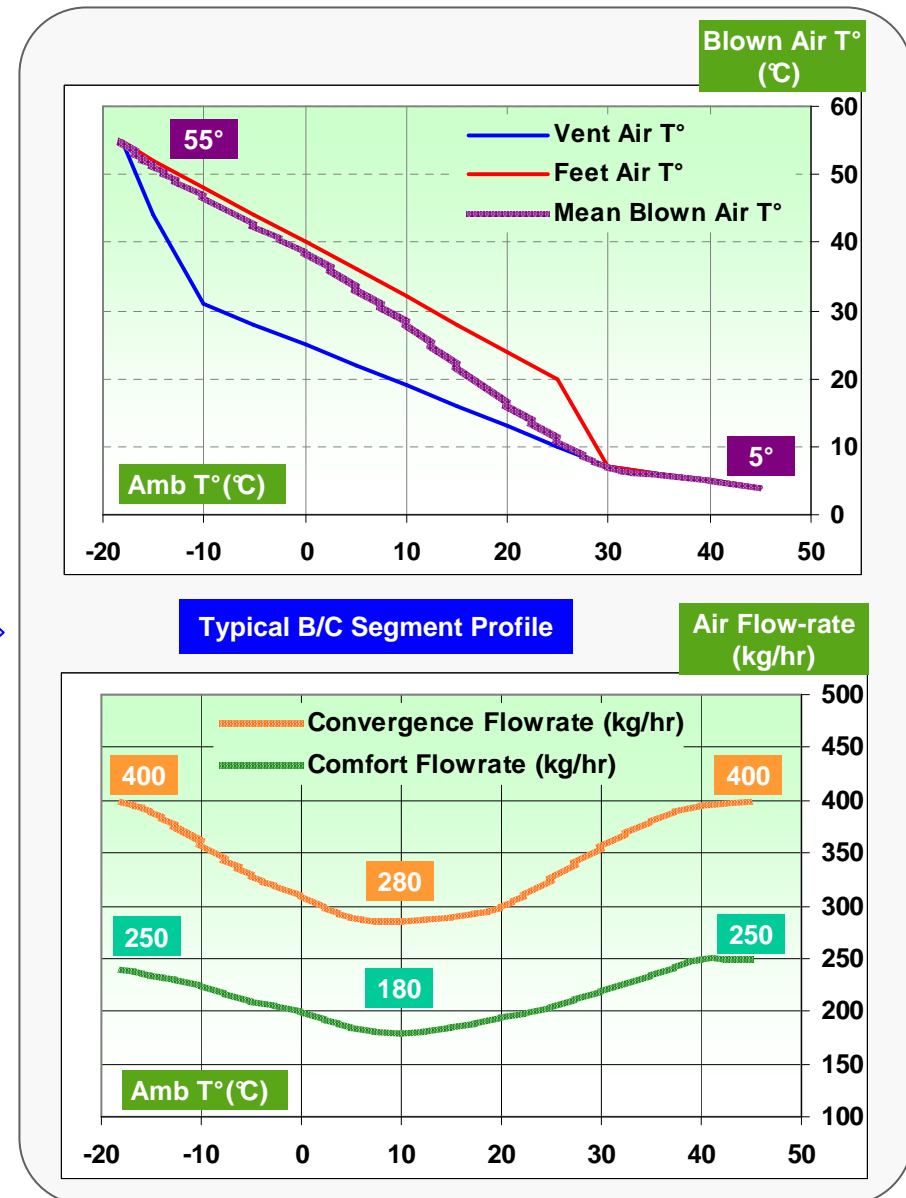
- **Urban Drive :** $P_w \sim 3 \text{ kW}$
- **Periurban Drive :** $P_w \sim 10 \text{ kW}$
- **European** meteorological profile (Hr)
- **Trip ~ 20' : 75% Comfort + 25% Convergence**
- **Comfort :** Preconditioning - Maintain
- **Convergence :** Warm up / Cool down phase

Thermal Comfort Strategy

- **B/C Segment Air Treatment profile**
- **Without / With Dehumidification**
- **Cabin Air renewing :**
 - ➔ **Full Fresh Air** for $T^\circ \text{Amb} < 30^\circ\text{C}$
 - ➔ **Recirc ~ 90 %** for $T^\circ \text{Amb} > 30^\circ\text{C}$

Thermal Architecture

- **R134a Electrical A/C Loop**
- **Direct Electrical Heating (PTC)**



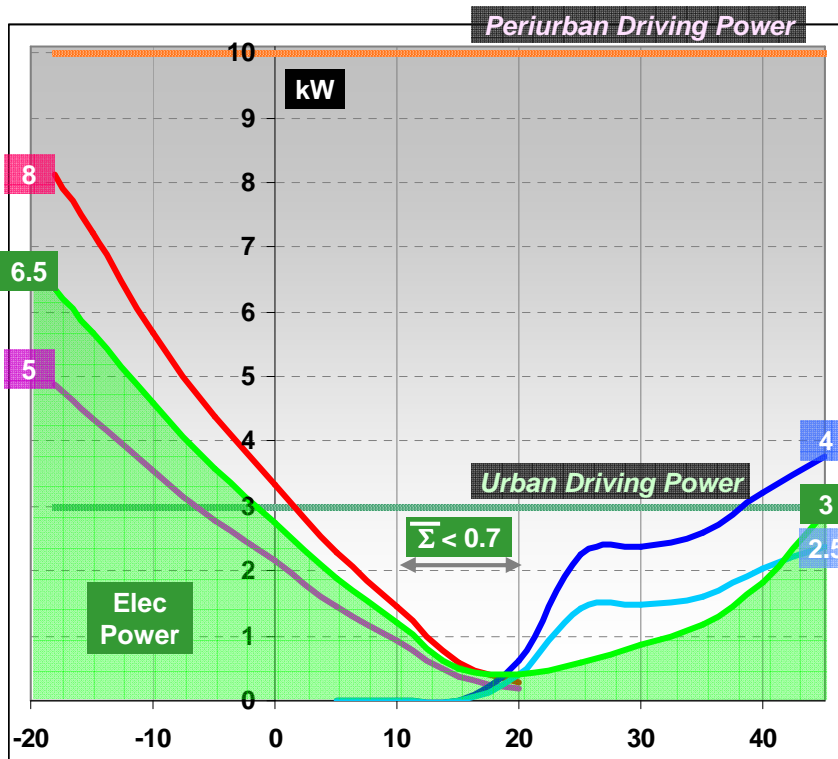
COMFORT POWER NEEDS

- Convergence Heating Needs
- Comfort Heating Needs
- Convergence Cooling Needs
- Comfort Cooling Needs

Reference Configuration

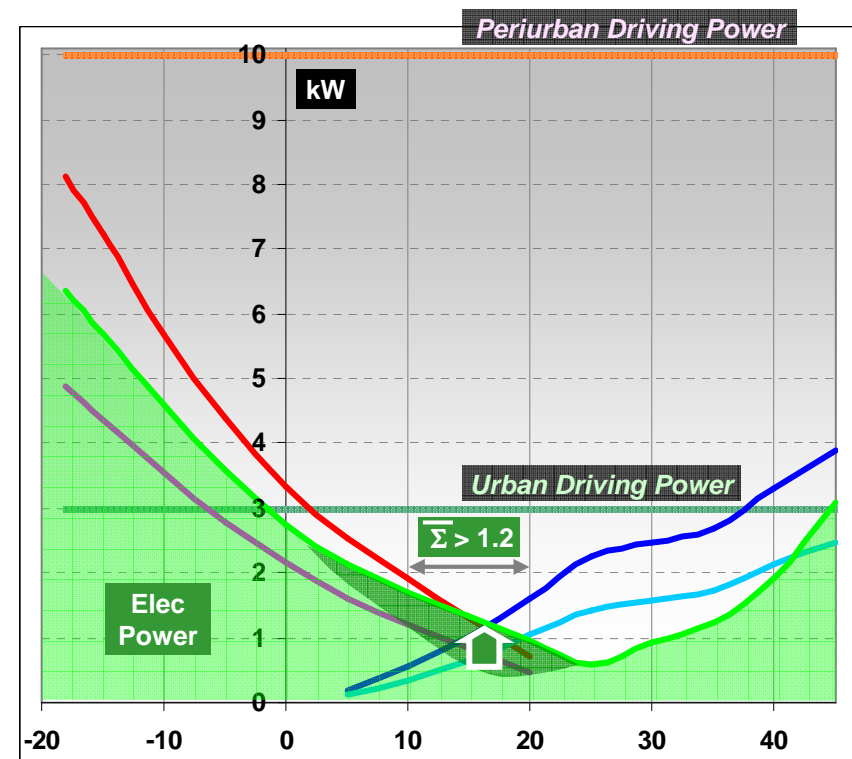
Elec Power for Mixed Trip : 75% Comfort Maintain + 25% Convergence

■ No Dehumidification



e-Power for Thermal Comfort is same order of magnitude than e-Power for Driving

■ With Dehumidification



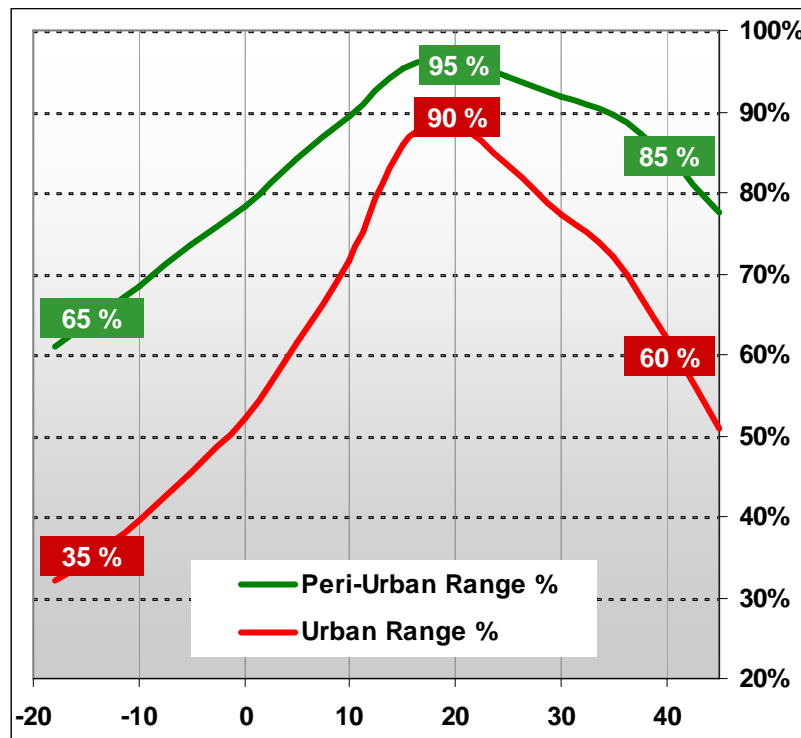
Significant additional power needs in high occurrence T° range

EV CRUISING RANGE

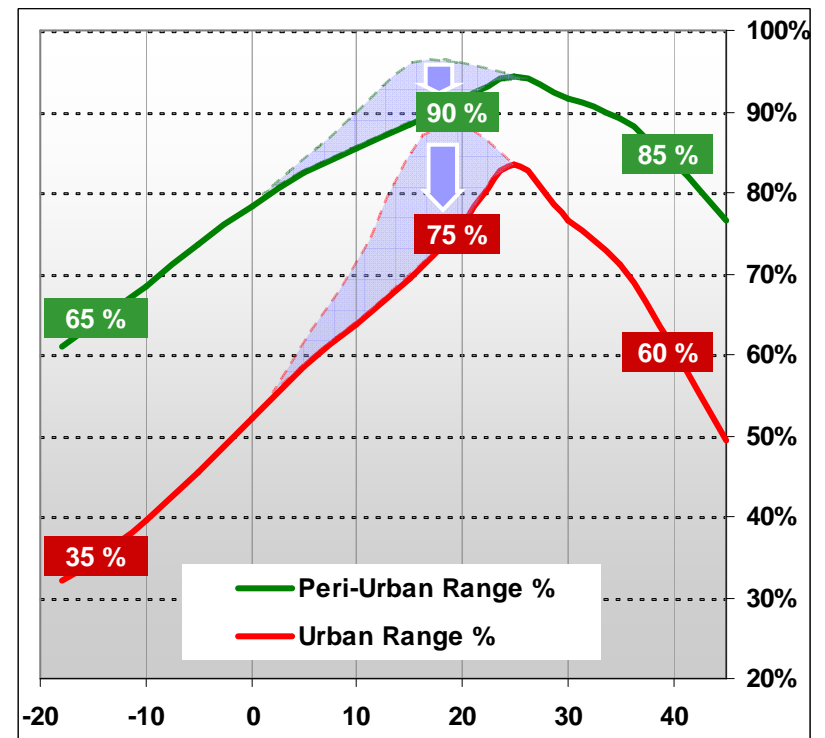
— For Urban Drive power = 3 kW
 — For Periurban Drive power = 10 kW

Reference Configuration :
 Elec Power for Mixed Trip : 75% Comfort Maintain + 25% Convergence

Without Dehumidification



With Dehumidification



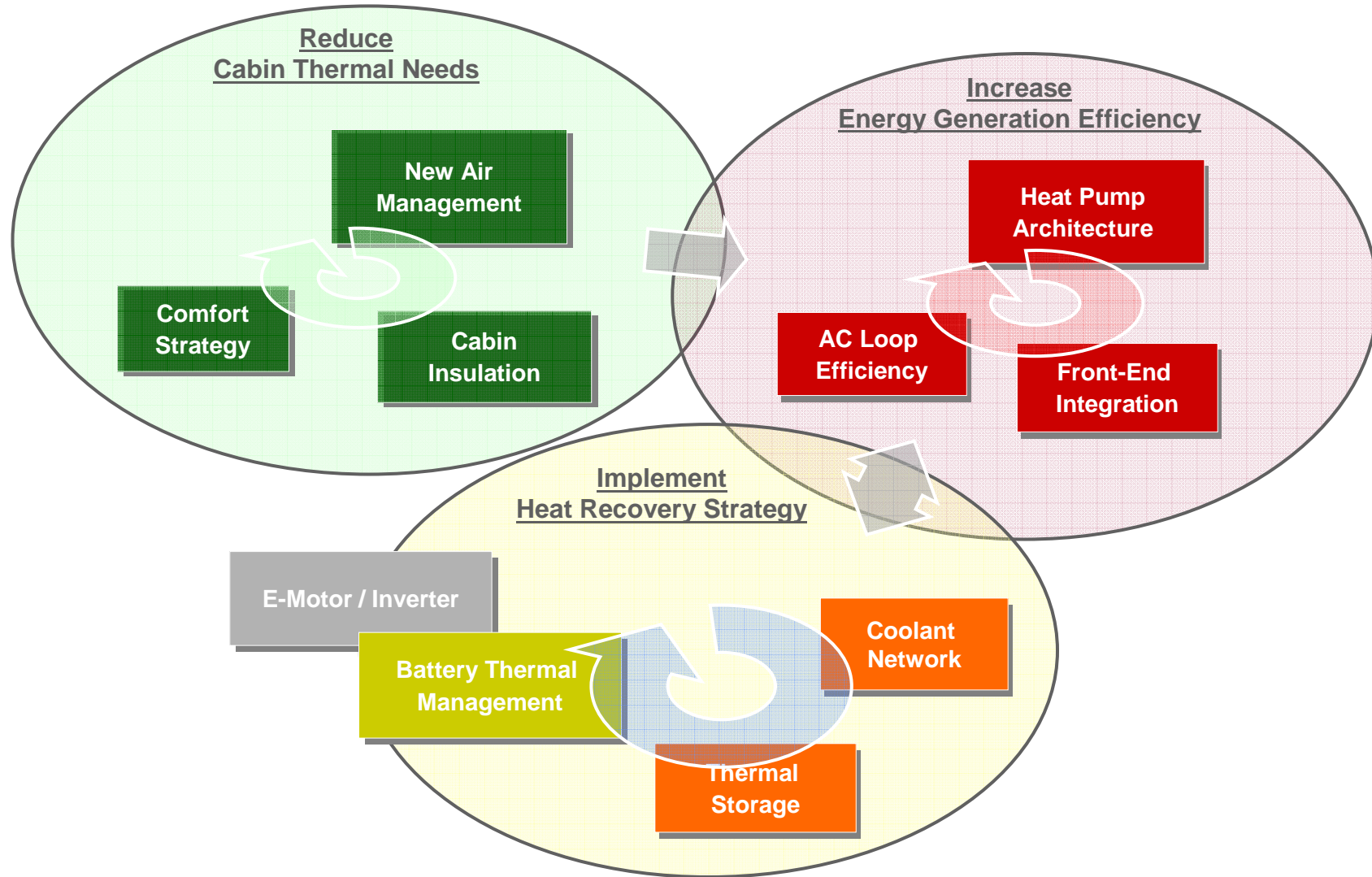
$\% = [\text{Range with Cooling \& Heating} / \text{Maximum Range}]$



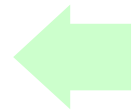
SCREENING OF SOLUTIONS THERMAL ARCHITECTURE



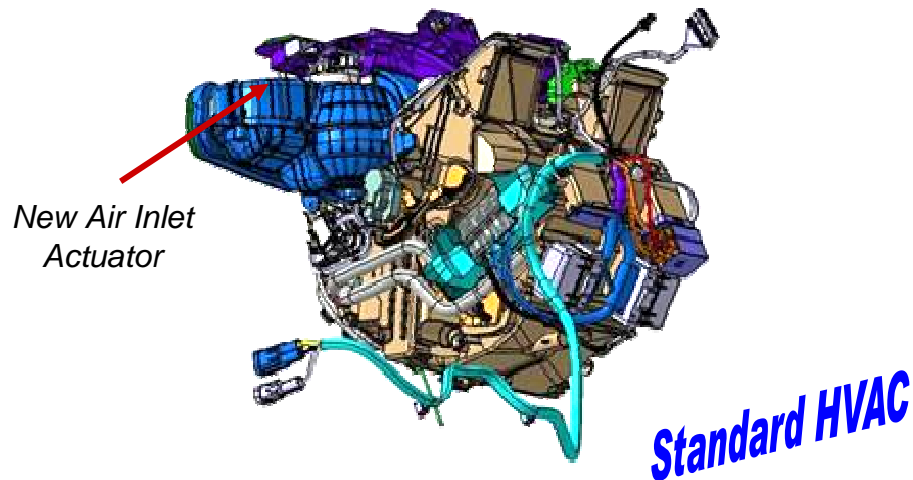
Screening of technology to increase EV autonomy VEGA / THOP Scope



NEW AIR MANAGEMENT

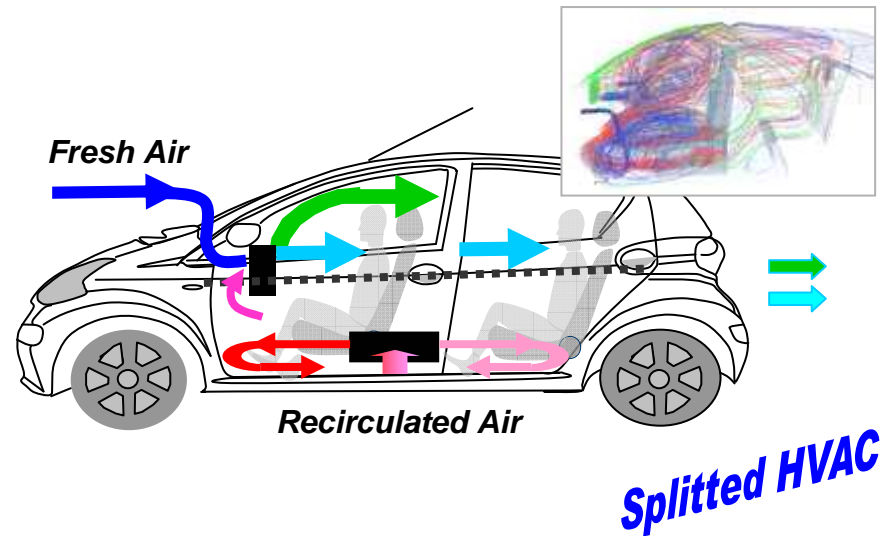


Air Renewing Control



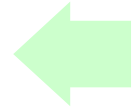
- Control accurate fresh air flow-rate
- Optimize air renewing / misting risk

Air Stratification



- Minimize Air renewing
 - ➔ Dry fresh air flow in upper zone
 - ➔ Recirculated air in bottom zone
- Up to 80% recirculation
 - ➔ Iso Comfort & Iso Misting occurrence

CABIN TREATMENT - COMFORT STRATEGY



New Glazing Technology



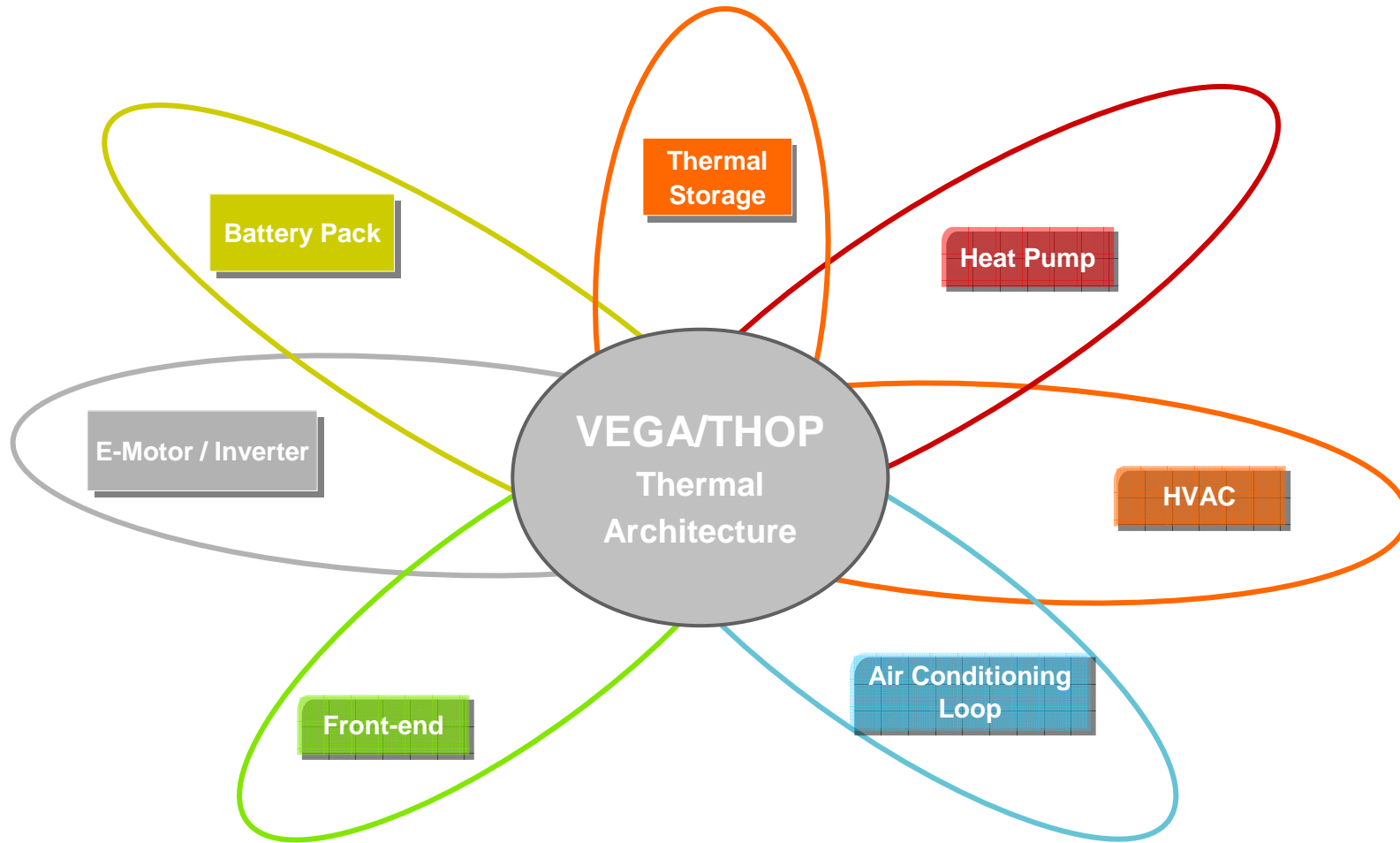
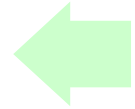
- **Electrical Windshield**
 - Drop Demisting / Defrosting power
- **Low Emissivity coating**
 - Drop inner infrared radiation
- **Anti-Mist treatment**
 - Hydrophilic coating

Local Comfort



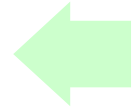
- **Focus on the benefit at Cold & Hot start**
 - Heating seat & steering wheel in winter
 - Cooling seat in summer
- **Individualization of air distribution**

THERMAL MANAGEMENT ARCHITECTURE



- **Refrigerant loop** : Air Conditioning + Heat pump + Dehumidification
- **Coolant network** : Power Train cooling + Battery Thermal Management + Heat Storage & Recovery

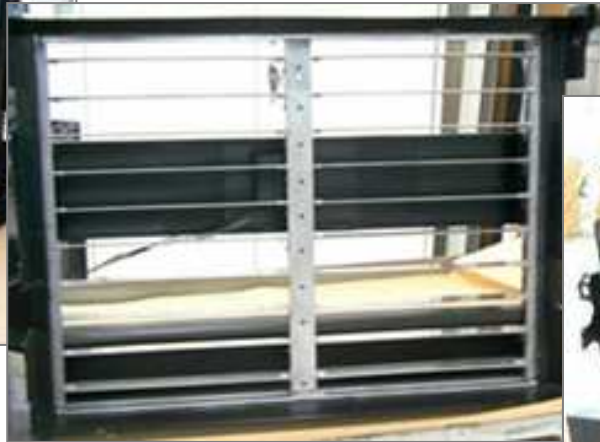
FRONT-END INTEGRATION



Closed shutters



Opened shutters



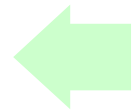
Front View



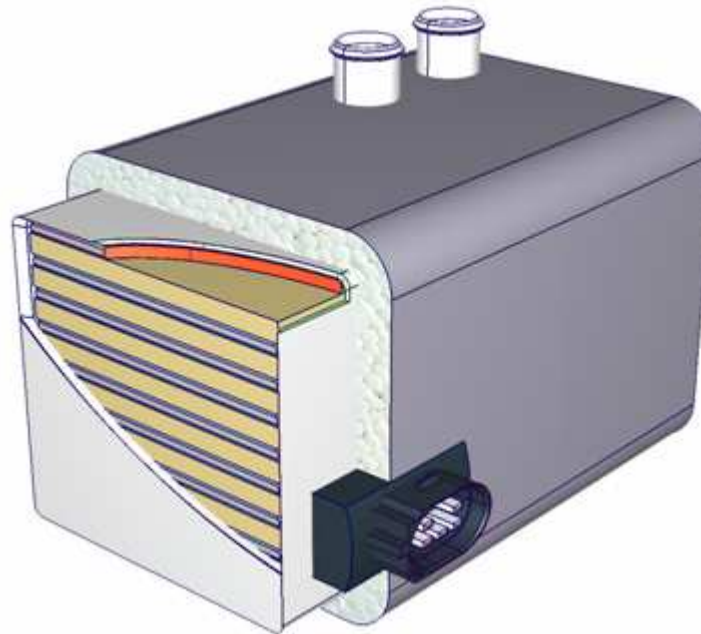
New lay-out & functions to fit EV needs

- Front Shutters to manage heat pump deicing & heat recovery
- Dual T° radiator to balance the cooling of e-Engine & Battery pack

THERMAL STORAGE



Sensible Storage



Latent Storage

From 700 Wh to 1 500 Wh in 10 liters

- **2 operating strategies :**
 - ❖ **Thermal Storage @ Plug :** → to leverage the heating capacity at start
 - ❖ **Thermal Buffer @ Drive :** → to smooth heating efficiency along driving cycle
- **Added Value / Added Cost shall be balanced vs. Battery cells capacity**



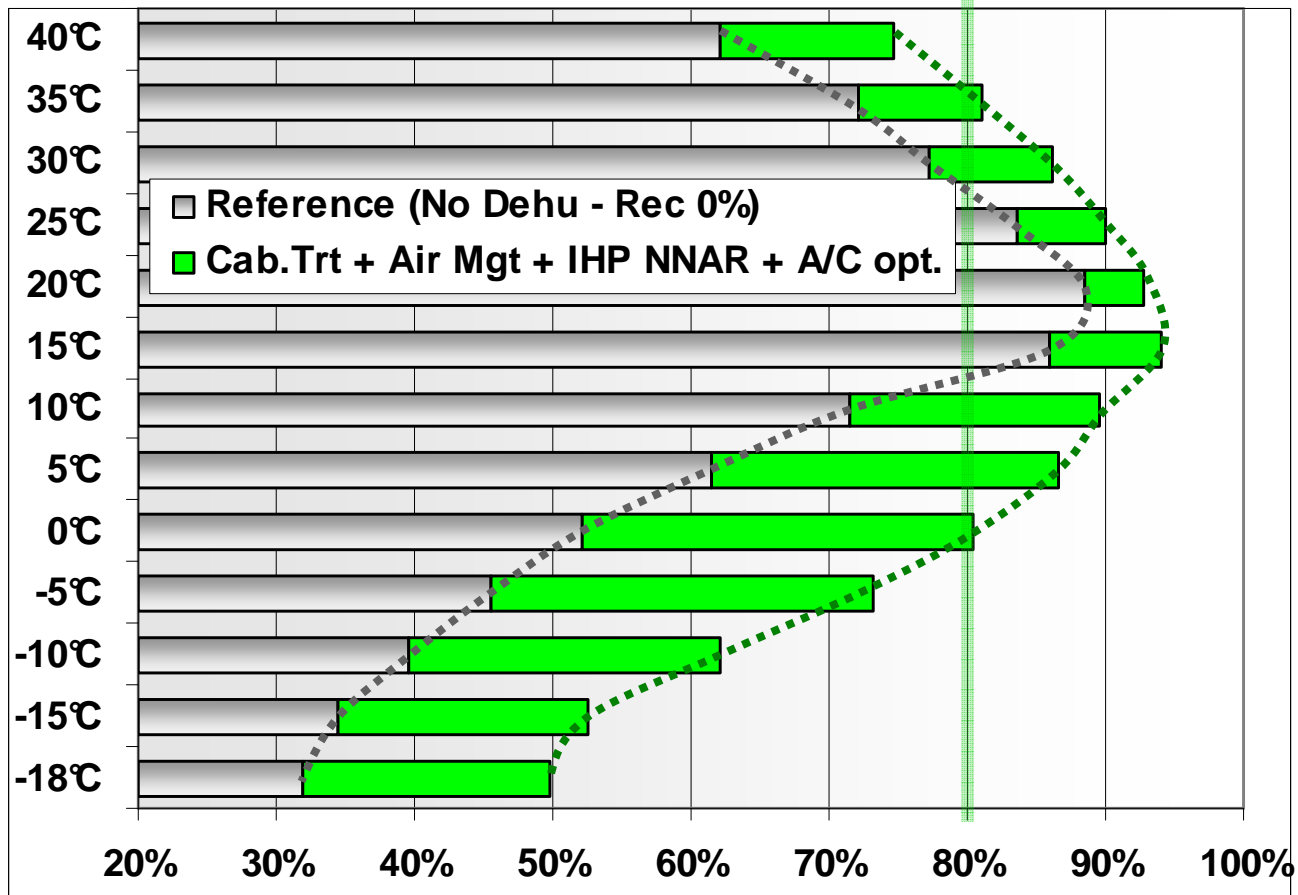
POTENTIAL SAVING ON EV RANGE

NEXT STEPS



POTENTIAL SAVING ON EV CRUISING RANGE

Reference Configuration : Urban Drive
 Mixed Trip : 25% Converg. + 75% Comfort
 Without Dehumidification



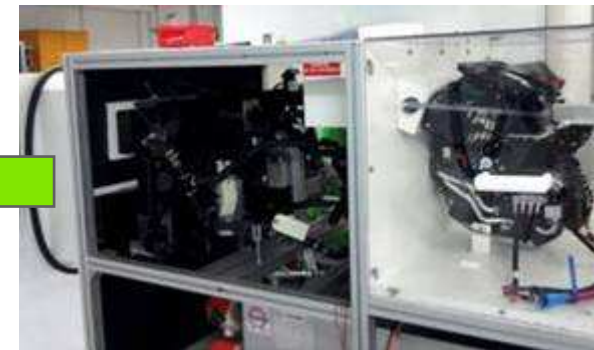
With combination of :

- + Air Management
- + Cabin Treatment
- + Heat Pump
- + A/C Loop Efficiency

+ Additional benefit from : Individualization, Heat Recovery, Storage

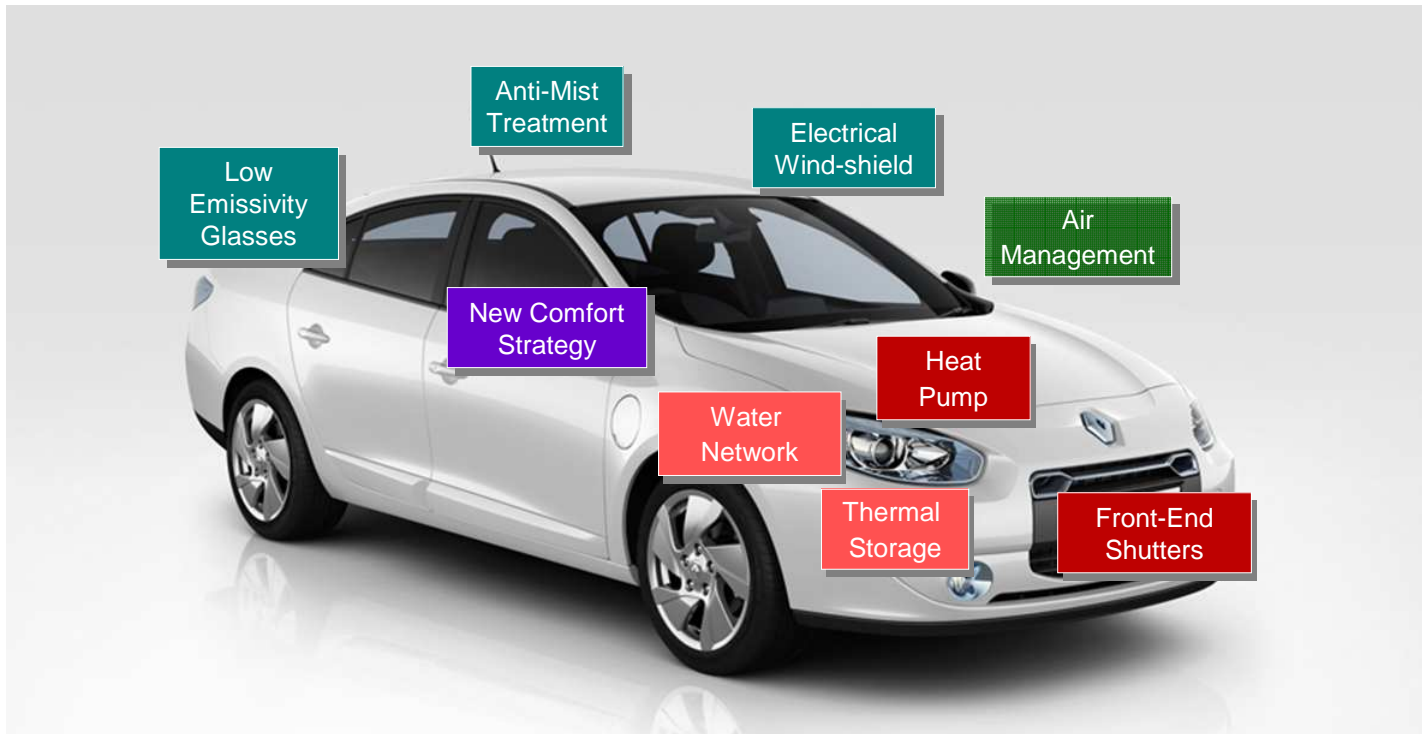
TESTS CAMPAIGN ON THERMAL SYSTEM BENCH

- **Be representative of in vehicle integration**
 - Front-End - HVAC
 - Fluid Circuit
 - Ambient T°
- **Simulation of e-Engine & Battery heat losses**
- **Front air vent :**
 - Low T° range : - 20°/ + 50°C
 - Humidity Control : +/- 5%



Thermal System tests campaign
is planned along Q4 2010 & S1 2011

VEGA / THOP EV DEMONSTRATOR



A FLUENCE ZE is being equipped with a selection of technologies
Tests campaign is planned along 2011 to demonstrate EV range capability

END

THANK YOU FOR YOUR ATTENTION