

Significance of Glazing Thermal Conductivity for MAC Indirect Emissions and EV Battery Performance

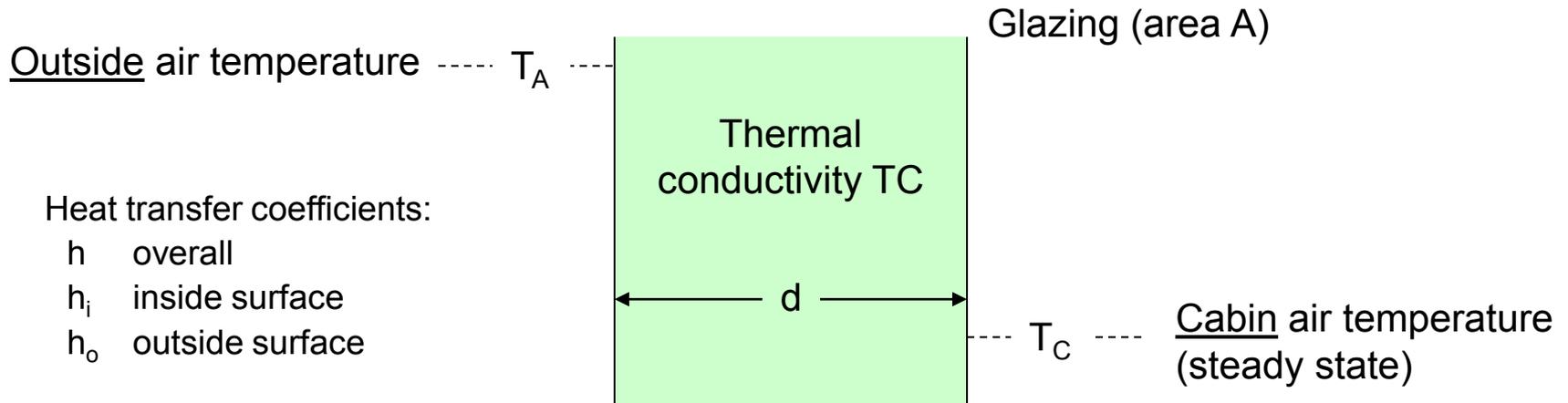
Steve Gasworth and Triloka Tankala

SABIC Innovative Plastics

sgasworth@exatec.biz
steven.gasworth@sabic.com

(as presented)

Reduced glazing thermal conductivity reduces steady state MAC indirect emissions



Total heat transfer = Conduction + Radiation
= $h \cdot A \cdot (T_A - T_C)$ + Radiation

where $1/h = 1/h_o + d/TC + 1/h_i$

Fix d , Radiation to isolate TC effect

Reduced thermal conductivity means

- reduced Total heat transfer
- reduced HVAC cooling load
- reduced MAC indirect emissions

Computational Fluid Dynamics case study:

Phoenix, mid-day, Apr - Oct, 100 kmph vehicle speed

Reduced roof & backlite thermal conductivity from

1 W/m-°K (glass) to 0.2 W/m-°K (polycarbonate)

→ 5.5% reduction HVAC load (kW)

→ 4.5 gCO₂/mile reduction MAC indirect emissions

Reduced thermal conductivity glazing materials like polycarbonate can help reduce MAC indirect emissions ... 5.5% load reduction achievable

Significance of Glazing Thermal Conductivity for MAC Indirect Emissions and EV Battery Performance

Steve Gasworth and Triloka Tankala

SABIC Innovative Plastics

sgasworth@exatec.biz
steven.gasworth@sabic.com

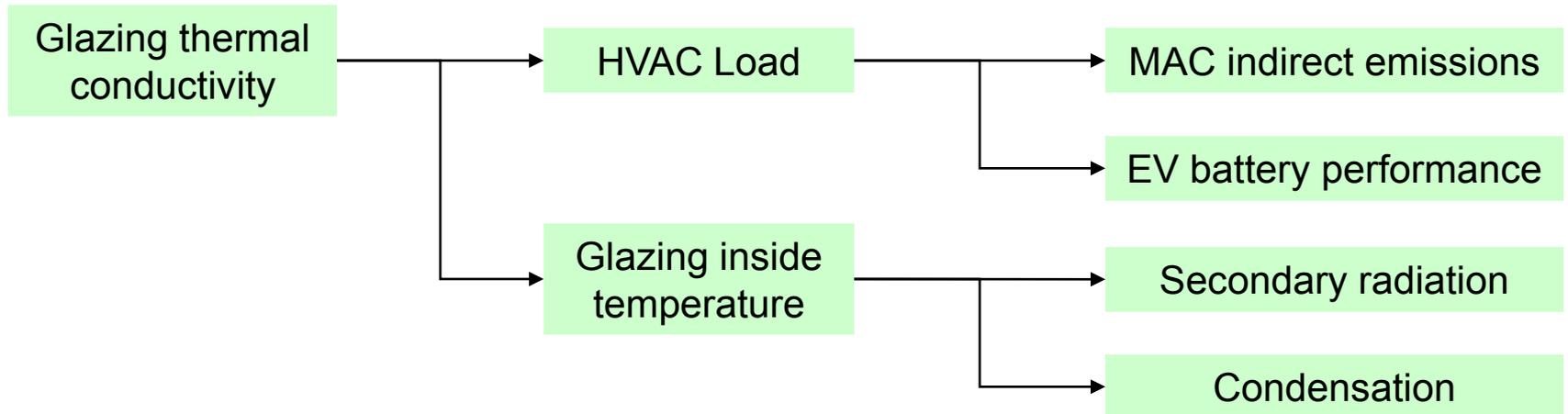
(expanded version)

Approach and Scope

- Isolate glazing thermal conductivity (TC) effect
- Hot and cold climates
- Stationary and moving vehicles
- Thermal steady state
- CFD (Computational Fluid Dynamics) model of generic car

Baseline TC: 1 W/m-°K (Glass) all around

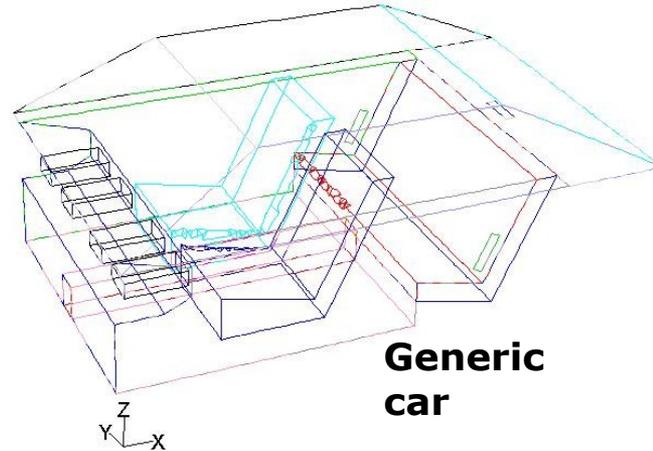
Reduced TC: 0.2 W/m-°K (Polycarbonate) applied to rooflite and backlite



CFD Model

Vehicle/Air speed (0, 100 kmph)
Temperature and radiation data, monthly, mid-day
(NREL)
Phoenix
Minneapolis ↓

Glazing parameters
Area
Orientation
Solar transmission
Thermal transmission
Thermal conductivity
Thickness (5 mm)



Generic car



3D air flow & heat transfer
Steady state HVAC load
Glazing temperature



Cabin parameters
Volume
Non-glazing areas (doors, etc.)
Interior surfaces (IP, seats)



HVAC parameters
Vent locations
Air velocity
Air mass flow rate
Temperature set point (22 °C)

CFD Results - Phoenix - Moving Vehicle

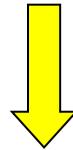
HVAC load (kW), Apr - Oct (cooling)	
Baseline TC	1.193
Reduced TC	1.128
% reduction	5.45

*Battery
parameters*



EV range, Apr - Oct	
% increase	4.4

*NREL fuel
economy
data*



MAC indirect emissions (gCO ₂ /mi), Apr - Oct	
Reduction	4.5

Roof inside temperature (°C) - Jul	
Baseline TC	37.7
Reduced TC*	33.8
Cabin air	22.0
Ambient	40.6

**Glazing temp. closer to cabin temp.
(relevant to secondary radiation)*

CFD Results - Minneapolis - Moving Vehicle

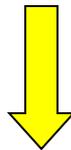
HVAC load (kW)	Jun - Aug (cooling)	Oct - Apr (heating)
Baseline TC	0.442	1.303
Reduced TC	0.421	1.217
% reduction	4.75	6.60

Battery parameters



EV range, Oct - Apr	
% increase	5.5

NREL fuel economy data



MAC indirect emissions (gCO ₂ /mi), Jun - Aug	
Reduction	3.9

Roof inside temperature (°C) - Jan	
Baseline TC	-0.8
Reduced TC*	4.9
Cabin air	22.0
Ambient	-5.2

*Glazing temp. closer to cabin air temp. (relevant to condensation)

Perspective

Reductions in MAC indirect emissions (gCO ₂ /mile) due to ...	
Reduced glazing thermal conductivity, Phoenix, Apr - Oct	4.5
Reduced glazing thermal conductivity, Minneapolis, Jun - Aug	3.9
Weight reduction (glass → polycarbonate, roof & backlite, 3960 lbs curb wt.)	4.0
Improved MAC system, large car (CARB Staff Proposal, AB 1493, 6/14/04, p64)	8.1

- *Thermal conductivity effect on steady state gCO₂/mile is on par with weight & MAC effects*
- *Thermal conductivity reduction decreases EV battery discharge rate, increases EV range*
- *Thermal conductivity and weight effects are additive*
- *Drive cycle should include steady state cabin temperature and air flow over car*
- *Thermal conductivity role is reduced for stationary vehicle due to reduced outside air speed*
- *Thermal conductivity reduction → steady state glazing inside temperature closer to cabin temperature → reduced secondary radiation (summer) & tendency for condensation (winter)*