

# Extraordinary Motor Vehicle Leadership and Progress

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# 40 Years of MAC Community Ozone & Climate Leadership

- United Nations, Governments, Automobile Manufacturers, System and Parts Suppliers, Service and Tool Companies, Industry and Professional Associations, and Environmental NGOs
- Progressively Ozone-Safe, Climate Friendly, Leak-Tight, Life Cycle Refrigerant Management (LRM), and Superior All-Electric Vehicle Performance
- Documented by IGSD, SAE, and MACS in a 100-page history of automotive leadership protecting stratospheric ozone and climate:
  - <https://www.igsd.org/industry-leadership-in-motor-vehicle-air-conditioning/>
    - Lead Authors: Stephen O. Andersen, James A. Baker, Timothy D. Craig, Sangeet H. Kapoor, and Steven G. Schaeber

# Safety of R-290 Dual SL Heat Pumps in Battery Electric Vehicles (BEVs)

- Dual Secondary-Loop (SL) heat pumps evaluated by the SAE Cooperative Research Project are shown to be effective and safe to heat and cool occupants, batteries, and inverters for Battery Electric Vehicles (BEVs) while increasing vehicle driving range and battery life (NOT Internal Combustion or Hybrid – see glossary below)
- Ford Motor Company, on behalf of global automobile companies, has petitioned US EPA SNAP for listing of R-290 as acceptable for dual SL heat pumps in BEVs
- Tata Motors is demonstrating the safe use of R-290 in ACs of BEVs that operate in Indian ambient conditions
- No refrigerant in occupied space, small charge in leak-tight monoblock compressor, and in refrigerant-to-coolant heat exchangers

# Economy, Environment, Health, and Safety

- R-290 SL heat pump safety and system performance in battery electric vehicles (BEVs) DOES NOT imply safety in other vehicle and stationary applications with different accident scenarios, ignition sources, and operating conditions
- Every cooling system design requires careful consideration of all aspects of economic, environmental, health, and safety acceptability

# SL Architecture for Stationary Applications

- SL designs being perfected for heat pumps in all-electric motor vehicles and for transitional internal combustion AC systems have already achieved economy of scale and competitive prices
- Automotive SL components at competitive prices can be utilized in new designs of stationary equipment such as room air conditioners safely using flammable refrigerants like R-32, R-152a, and R-290 that do not atmospherically degrade to trifluoroacetic acid (TFA)
- The non-flammable coolant can transfer cold and heat for other purposes such as heating water during cooling seasons or refrigerating food during heating seasons. Integration saves energy and money spent on energy

# Balanced Way Forward

- Globally train service technicians for life cycle refrigerant management (LRM) of existing R-134a and R-1234yf refrigerants mindful of transition to R-290
- Stop marketing of obsolete R-134a in developing country markets
- Where possible, leapfrog R-1234yf to R-290 in BEVs taking full advantage of environmental and ownership advantages, and capturing national security advantages of clean and reliable solar and wind energy produced locally

# All Eyes on a Graceful MAC HFC Phaseout

- >85% of original ODS use has been replaced by not-in-kind (NIK)
- <15% depends on HFCs and HFOs that degrade to TFA
  - R-32 and R-152a and HFC-143a do not degrade to TFA
- Next, high-GWP HFCs and HFOs degrading to TFA will be replaced by natural refrigerants and TFA-safe fluorocarbons
- Will the fluorocarbon industry gracefully exit MAC refrigerant markets?
  - Withdraw exaggerated risk of flammability if mitigated by engineering
  - Dismantle opposition marketing and other unethical business practices
  - Stop dumping obsolete refrigerants and take responsibility for LRM
  - Respect automotive choice of R-290

# Market Drivers of Graceful MAC HFC Phaseout

- Montreal Protocol Decisions such as shared responsibility of exporters and importers to stop dumping
- National Implementation such as EU f-gas rules that refrigerants in exported cooling products must satisfy domestic HFC GWP caps
- Consumer boycotts, divestment, and name-and-shame
- Injunctive, restitution, or monetary remedy and criminal charges
- Accountability for global damage by industry delay in ODS and HFC phaseout

# Backup slides

# HFCs/HFOs with Low or No TFA Degradation (Edits and additions welcome)

| Chemical Name         | Commercial Use                                      | Degradation Product                                          | TFA Yield       |
|-----------------------|-----------------------------------------------------|--------------------------------------------------------------|-----------------|
| <b>HFC-32</b>         | Mini-split and central AC, heat pumps, and chillers | Fluoride and carbon dioxide (CO <sub>2</sub> )               | None            |
| <b>HFC-152a</b>       | Aerosols, AC                                        | CO <sub>2</sub> , carbon monoxide (CO) and hydrogen fluoride | None            |
| <b>HFO-1234ze(E)</b>  | Aerosols, foam blowing, chillers                    | Trifluoroacetaldehyde (CF <sub>3</sub> CHO)                  | Minor / Partial |
| <b>HCFO-1233zd(E)</b> | Foam blowing, chillers, solvents                    | Trifluoroacetyl fluoride / Trifluoroacetaldehyde             | None to Minor   |
| <b>HFO-1336mzz(Z)</b> | High-temp heat pumps, foam blowing                  | Trifluoroacetaldehyde                                        | None to Minor   |

# 3000 Climate Litigations in >55+ Jurisdictions: Accountability, Greenwashing, and Human Rights

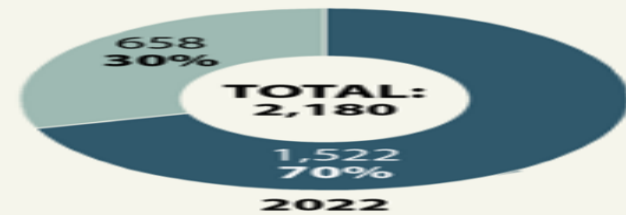
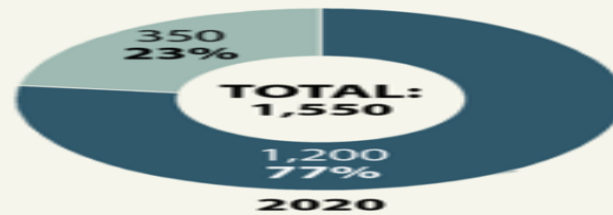
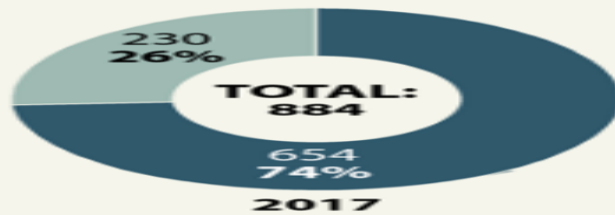
## Climate Litigation by the Numbers

The number lawsuits related to climate change has more than doubled over the last five years as litigants see courts as a way to enhance, and delay, climate action.

### TOTAL NUMBER OF CLIMATE CHANGE CASES FILED

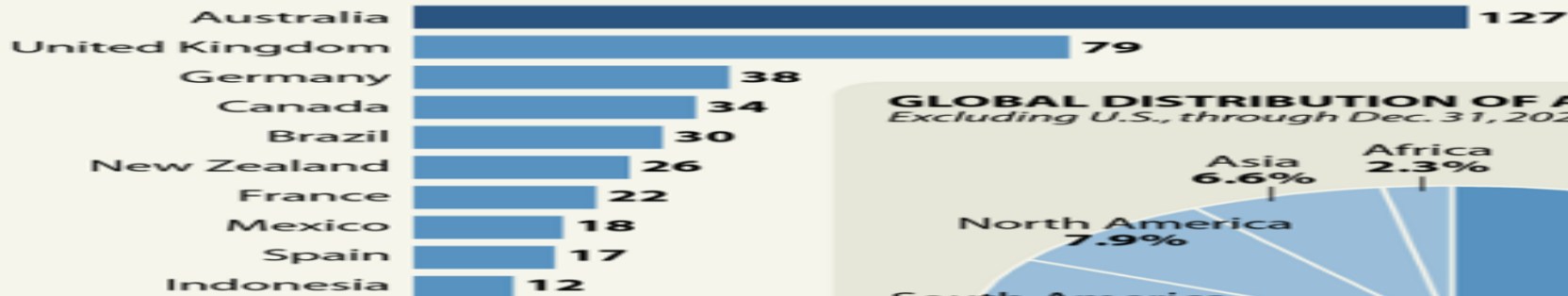
All jurisdictions, 2017, 2020 and 2022

■ U.S. ■ ALL OTHER JURISDICTIONS

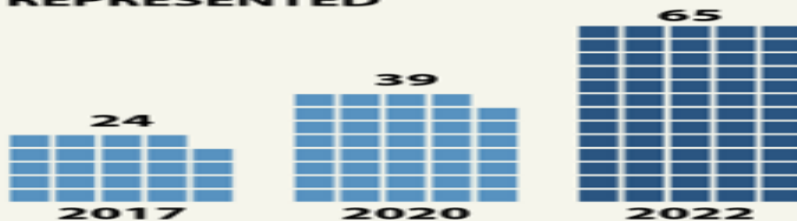


### TOP 10 JURISDICTIONS WITH HIGHEST NUMBER OF CUMULATIVE CASES

Excluding U.S. and European Union, through Dec. 31, 2022

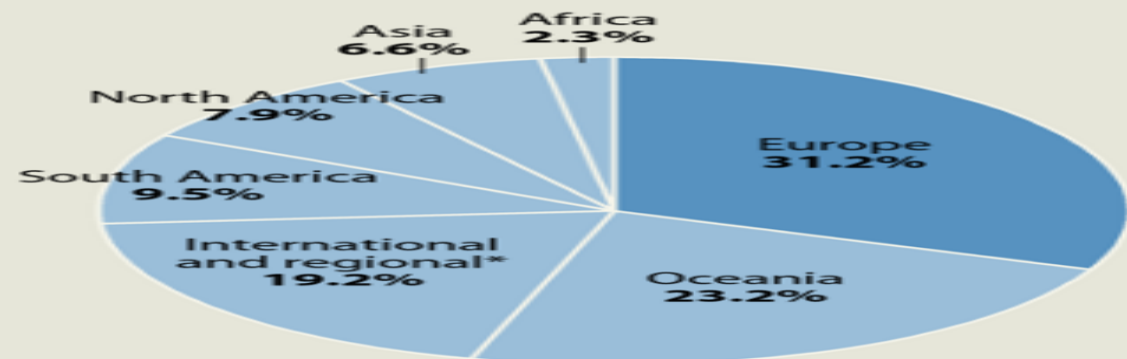


### NUMBER OF JURISDICTIONS REPRESENTED



### GLOBAL DISTRIBUTION OF ALL CASES

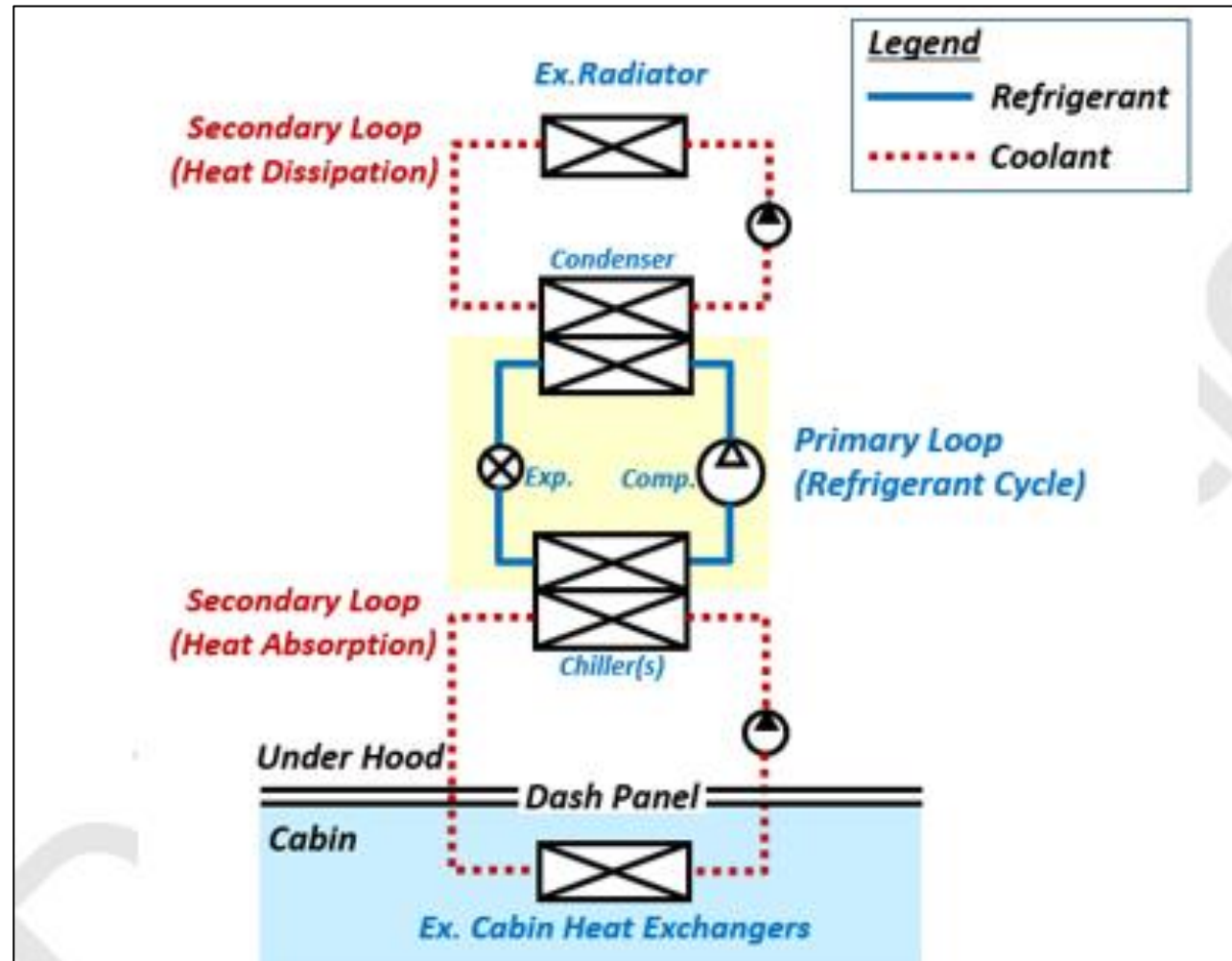
Excluding U.S., through Dec. 31, 2022



\*International or regional courts, tribunals, quasi-judicial bodies or other adjudicatory bodies

NOTE: Sum does not equal 100% due to rounding.

# Dual Secondary Loop Architecture



# Glossary of Terms

- **Battery Electric Vehicle (BEV):** Pure electric vehicles that run solely on battery power; plugged into an electrical source to recharge – energy efficient and safe with R-290 SL air conditioner or heat pump
- **Internal Combustion** Burning fossil or biomass fuels
- **Hybrid Electric Vehicles (HEVs):** Both IC engine and electric motor can drive the wheels; regenerative braking; sometimes called Full HEV or FHEV; R-290 SL air conditioner and heat pump designs for HEVs have not yet been evaluated by SAE for safety
  - **MHEV – Mild HEV:** IC engine assisted by small electric motor and battery
  - **Plug in Hybrid Electric Vehicle (PHEV):** A larger battery than HEVs for pure electric driving over short distances; plugged into an electrical source to recharge; IC engine powers vehicle when the battery is depleted
  - **EREV – Extended Range EV:** vehicle that has a small IC engine only to charge the battery for extending the driving range