PENTATONIC

Battery System

Pentatonic

PENTATONIC
Battery System

Kautex has a proven track record in being first to market with innovative solutions. In era of new mobility, our challenge is to reimagine propulsion and expand the perception of the value lightweight, plastic solutions provide.

As vehicles grow in complexity, their components and systems must evolve to work in concert. For full battery system integration with thermal management capabilities, our Pentatonic system is the answer.

Unlike other heavy and unyielding steel and aluminum battery housings, Pentatonic offers a customizable, lightweight solution in either thermoplastic composite or composite-metal hybrid.

Our system can be utilized in electric vehicles, from full hybrid to full battery.

Customer Value

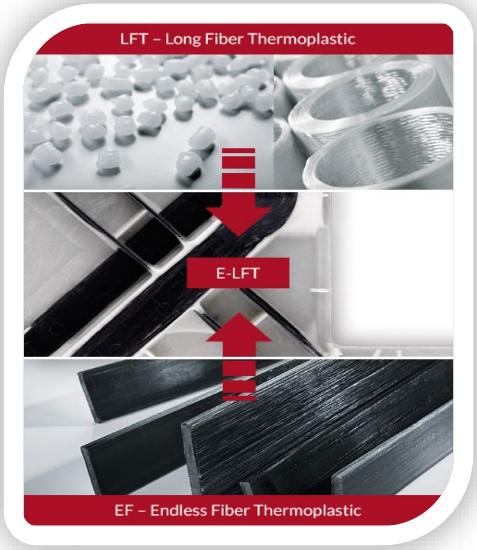
- **Weight Advantage**
- **Integration of Features**
- **Advanced Cooling Systems**
- **CO_2 footprint reduction**

Weight Advantage

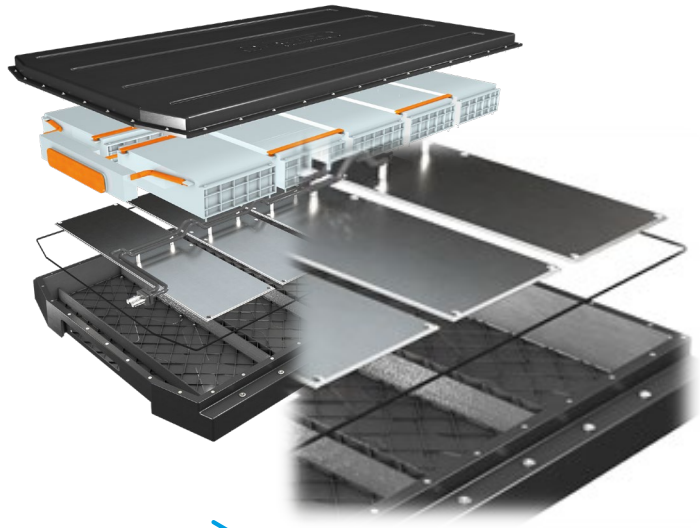
*Take the energy density of your battery to another level_*

Pentatonic improves the range of the battery-driven system

- Adjust chassis components – such as suspension and brake system
- Allows for maximum payload capacity.
- Reduced CO2 emissions and energy consumption for the vehicle and in the supply chain



Thermoplastic fibers offer up to a 60% weight reduction vs. their steel counterparts

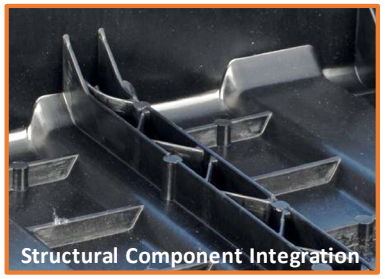


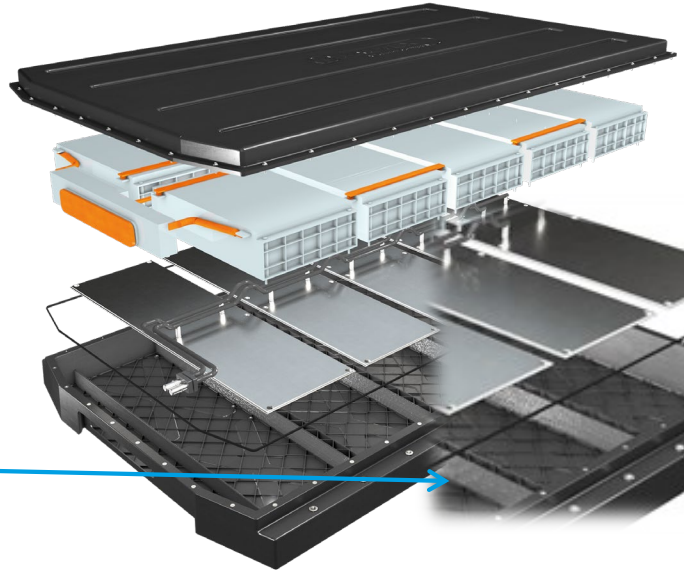
The pack installed in this vehicle is **5.8kg lighter** than its metal counter part (-35%)

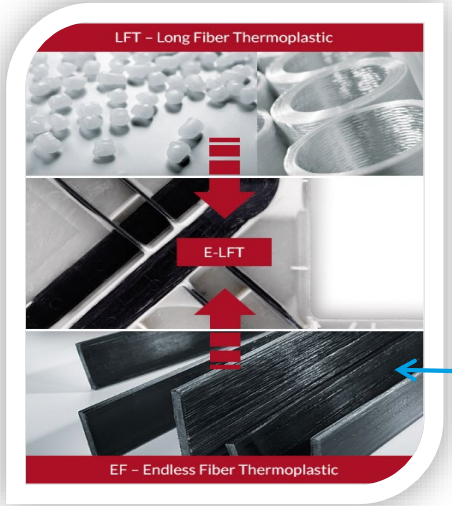
Integration of Features

Exploiting the capabilities of composites

Pentatonic reduces the bill of material costs by up to 30%

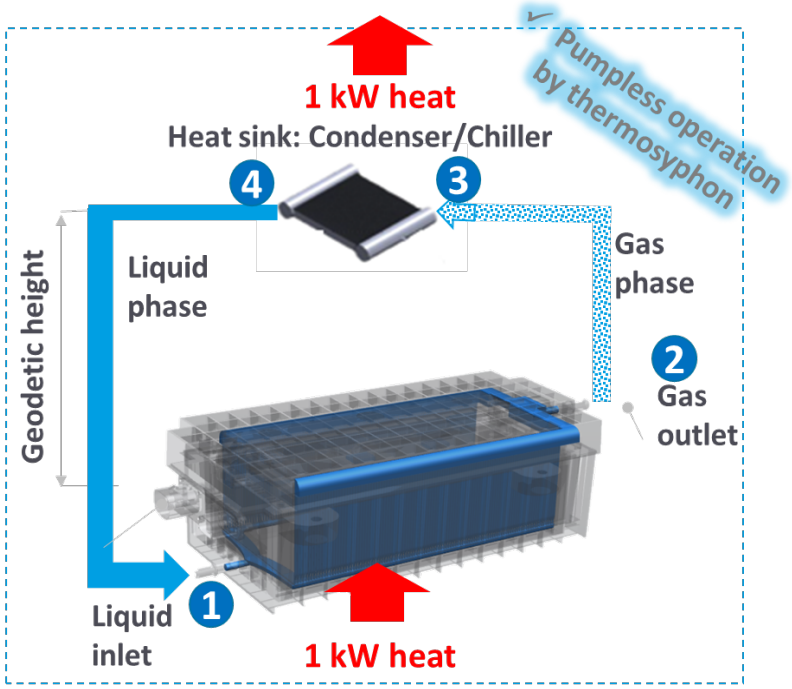






Advanced Cooling Systems

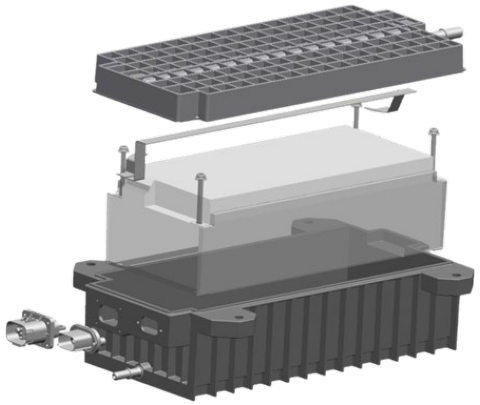
- Fully integrated cooling systems



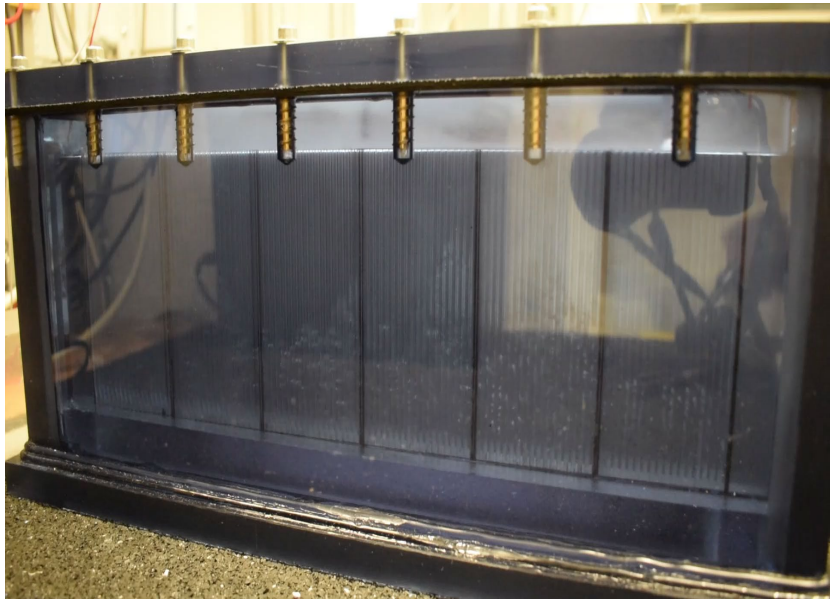
Meeting end-consumer's recharging demands A full charge in 10 minutes

2-Phase dielectric cooling

- Allows for charging with up to 6C

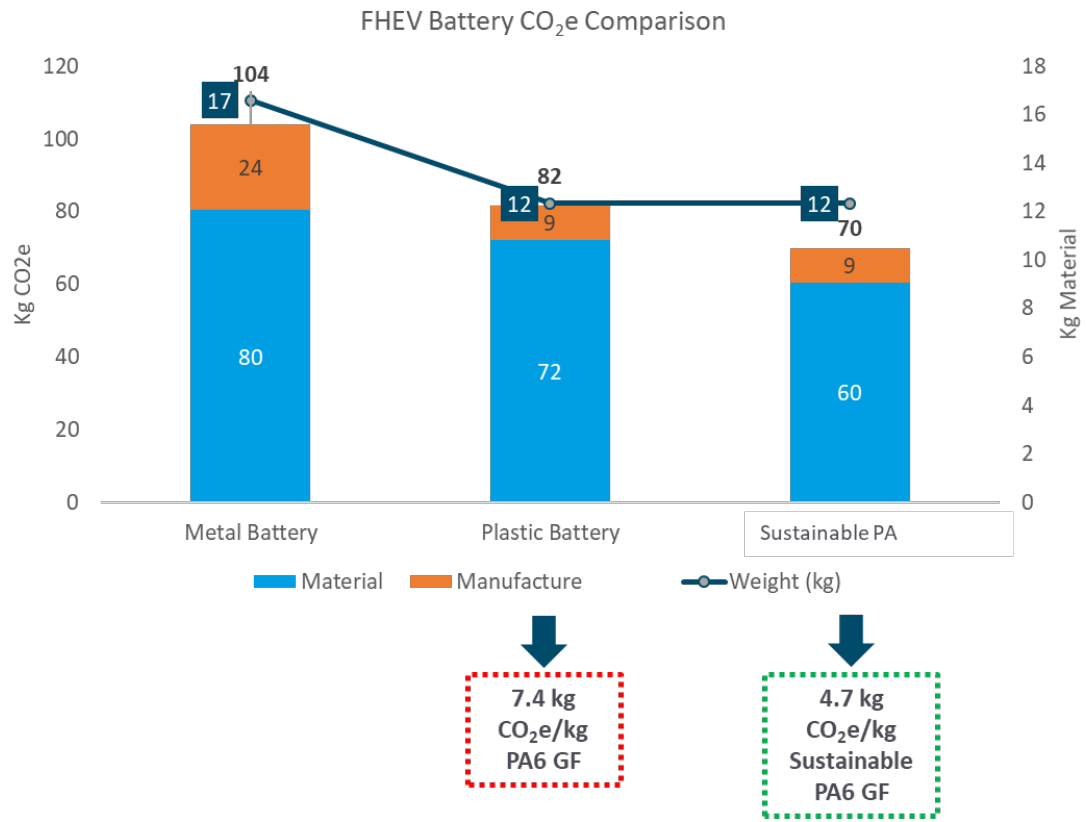


- Unrivaled cooling capabilities



CO2 Footprint Reduction

CO2 Footprint Reduction



- Sustainability improvements by plastics – outperforming metal competition
- Improved CO2 footprint in use-phase due to reduced weight of the Pentatonic system

PA6 material grade and production allow for equivalent CO_2 reduction_

- Produced with carbon-neutral energy
- Meeting todays end-customer expectation in terms of carbon-footprint

Water Generation_

Water Generation

Mobility is lived and perceived in a new way due to a fast-changing society. Passengers' comfort will be the differentiating factor in the travel experience.

Water Generation offers a unique opportunity to provide a new level of comfort to the consumer. By extracting water from the environmental humidity, the Kautex water generation system will bring the vehicle comfort to a new level with multiple services.

Customer Value

Warm and cold drinks anywhere anytime

Available water for many purposes

No water refills, more quality time

Warm or cold beverages anywhere…anytime

New customer delighter

- More quality time and comfort to enjoy your travel
- No need to pull over to the next shop to get your drink
- Enhanced comfort experience while driving autonomously

Freedom, adventure, sports, autonomy…

Water readily available for many uses

Clean your sport equipment

Clean your hands

Clean your pets

Clean your muddy shoes

No water refills, more quality time

No need to refill

No more big canisters

No dirty hands

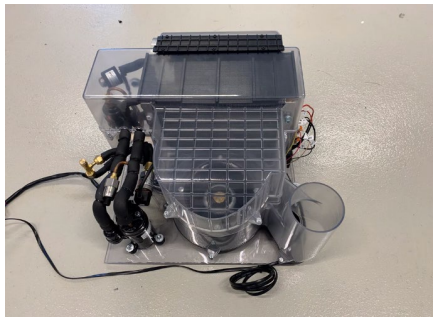
Water promptly available for car sensors

Onboard Water Generation System

Reclaims water from air humidity
Designed to fit in the spare tire compartment
Scalable in terms of size and energy consumption

Initial test results with approx. 160W energy consumption in standalone mode with the Kautex patented solution:

- Approx. 0.13 L/h water can be generated based on 17°C and 70% humidity environmental conditions
- Approx. 0.21 L/h water can be generated based on 27°C and 61% humidity environmental conditions



Potential water generation depending on climate condition – based on calculation

- Approx. 0.09 L/h water at 5°C at 75% humidity
- Approx. 1.60 L/h water at 35°C at 80% humidity

Appendix_

Predicted water generation for Phoenix Arizona (ml/h)

Potential Water Generation
Phoenix Arizona

Wasser @ 20% Lüfterstellung [g/h]	Temperatur [°C]									
Luftfeuchte	0	5	10	15	20	25	30	35	40	45
5										
10									89,5104	118,339
15							71,1648	99,1872	134,266	177,61
20						65,52	94,9536	132,25	179,021	236,88
25						81,8496	118,742	165,312	223,776	295,949
30					63,3024	98,1792	142,531	198,374	268,33	355,219
35					73,9872	114,509	166,118	231,437	313,085	414,49
40				64,1088	84,4704	130,838	189,907	264,499	357,84	473,558
45				71,9712	95,1552	147,168	213,696	297,562	402,595	532,829
50			45,5616	80,0352	105,638	163,498	237,485	330,624	447,35	592,099
55			49,9968	87,8976	116,122	179,827	261,072	363,686	492,106	651,168
60			54,6336	95,9616	126,806	196,358	284,861	396,749	536,861	710,438
65			59,2704	104,026	137,29	212,688	308,65	429,811	581,616	769,709
70			63,7056	111,888	147,773	229,018	332,438	462,874	626,371	828,778
75		29,0304	68,3424	119,952	158,458	245,347	356,227	496,138	671,126	888,048
80		30,8448	72,576	127,814	168,941	261,677	379,814	529,2	715,882	947,318
85		32,8608	77,2128	135,878	179,626	278,006	403,603	562,262	760,435	1006,39
90		34,8768	81,8496	144,144	190,109	294,336	427,392	595,325	805,19	1065,66
95		36,6912	86,2848	152,006	200,592	310,666	451,181	628,387	849,946	1124,93
100		38,7072	90,9216	160,07	211,277	327,197	474,768	661,45	894,701	1184

Wasser @ 100% Lüfterstellung [g/h]	Temperatur [°C]									
Luftfeuchte	0	5	10	15	20	25	30	35	40	45
5										
10									268,531	355,018
15							189,907	297,5616	402,797	532,829
20						165,11	253,411	396,7488	537,062	710,64
25						206,237	316,915	495,936	671,328	887,846
30					189,907	247,363	380,419	595,1232	804,989	1065,66
35					221,962	288,49	443,318	694,3104	939,254	1243,47
40				192,326	253,411	329,616	506,822	793,4976	1073,52	1420,68
45				215,914	285,466	370,742	570,326	892,6848	1207,79	1598,49
50			136,685	240,106	316,915	411,869	633,83	991,872	1342,05	1776,3
55			149,99	263,693	348,365	452,995	696,73	1091,0592	1476,32	1953,5
60			163,901	287,885	380,419	494,726	760,234	1190,2464	1610,58	2131,32
65			177,811	312,077	411,869	535,853	823,738	1289,4336	1744,85	2309,13
70			191,117	335,664	443,318	576,979	887,242	1388,6208	1879,11	2486,33
75		87,0912	205,027	359,856	475,373	618,106	950,746	1488,4128	2013,38	2664,14
80		92,5344	217,728	383,443	506,822	659,837	1014,25	1587,6	2147,64	2841,96
85		98,5824	231,638	407,635	538,877	700,963	1077,75	1686,7872	2281,31	3019,16
90		104,63	245,549	432,432	570,326	742,09	1141,26	1785,9744	2415,57	3196,97
95		110,074	258,854	456,019	601,776	783,216	1204,76	1885,1616	2549,84	3374,78
100		116,122	272,765	480,211	633,83	824,947	1267,66	1984,3488	2684,1	3551,99

Predicted water generation for Bonn, Germany (ml/h)

Potential Water Generation

Bonn, Germany

Wasser @ 20% Lüfterstellung [g/h]	Temperatur [°C]									
Luftfeuchte	0	5	10	15	20	25	30	35	40	45
5										
10									89,5104	118,339
15							71,1648	99,1872	134,266	177,61
20						65,52	94,9536	132,25	179,021	236,88
25						81,8496	118,742	165,312	223,776	295,949
30					63,3024	98,1792	142,531	198,374	268,33	355,219
35					73,9872	114,509	166,118	231,437	313,085	414,49
40				64,1088	84,4704	130,838	189,907	264,499	357,84	473,558
45				71,9712	95,1552	147,168	213,696	297,562	402,595	532,829
50				80,0352	105,638	163,498	237,485	330,624	447,35	592,099
55			49,9968	87,8976	116,122	179,827	261,072	363,686	492,106	651,168
60			54,6336	95,9616	126,806	196,358	284,861	396,749	536,861	710,438
65			59,2704	104,026	137,29	212,688	308,65	429,811	581,616	769,709
70			63,7056	111,888	147,773	229,018	332,438	462,874	626,371	828,778
75		29,0304	68,3424	119,952	158,458	245,347	356,227	496,138	671,126	888,048
80		30,8448	72,576	127,814	168,941	261,677	379,814	529,2	715,882	947,318
85		32,8608	77,2128	135,878	179,626	278,006	403,603	562,262	760,435	1006,39
90		34,8768	81,8496	144,144	190,109	294,336	427,392	595,325	805,19	1065,66
95		36,6912	86,2848	152,006	200,592	310,666	451,181	628,387	849,946	1124,93
100		38,7072	90,9216	160,07	211,277	327,197	474,768	661,45	894,701	1184

Wasser @ 100% Lüfterstellung [g/h]	Temperatur [°C]									
Luftfeuchte	0	5	10	15	20	25	30	35	40	45
5										
10									268,531	355,018
15							189,907	297,5616	402,797	532,829
20						165,11	253,411	396,7488	537,062	710,64
25						206,237	316,915	495,936	671,328	887,846
30					189,907	247,363	380,419	595,1232	804,989	1065,66
35					221,962	288,49	443,318	694,3104	939,254	1243,47
40				192,326	253,411	329,616	506,822	793,4976	1073,52	1420,68
45				215,914	285,466	370,742	570,326	892,6848	1207,79	1598,49
50				240,106	316,915	411,869	633,83	991,872	1342,05	1776,3
55			149,99	263,693	348,365	452,995	696,73	1091,0592	1476,32	1953,5
60			163,901	287,885	380,419	494,726	760,234	1190,2464	1610,58	2131,32
65			177,811	312,077	411,869	535,853	823,738	1289,4336	1744,85	2309,13
70			191,117	335,664	443,318	576,979	887,242	1388,6208	1879,11	2486,33
75		87,0912	205,027	359,856	475,373	618,106	950,746	1488,4128	2013,38	2664,14
80		92,5344	217,728	383,443	506,822	659,837	1014,25	1587,6	2147,64	2841,96
85		98,5824	231,638	407,635	538,877	700,963	1077,75	1686,7872	2281,31	3019,16
90		104,63	245,549	432,432	570,326	742,09	1141,26	1785,9744	2415,57	3196,97
95		110,074	258,854	456,019	601,776	783,216	1204,76	1885,1616	2549,84	3374,78
100		116,122	272,765	480,211	633,83	824,947	1267,66	1984,3488	2684,1	3551,99

Predicted water generation for Beijing, China (ml/h)

Potential Water Generation

Beijing, China

Wasser @ 20% Lüfterstellung [g/h]	Temperatur [°C]									
Luftfeuchte	0	5	10	15	20	25	30	35	40	45
5										
10									89,5104	118,339
15							71,1648	99,1872	134,266	177,61
20						65,52	94,9536	132,25	179,021	236,88
25						81,8496	118,742	165,312	223,776	295,949
30					63,3024	98,1792	142,531	198,374	268,33	355,219
35					73,9872	114,509	166,118	231,437	313,085	414,49
40				64,1088	84,4704	130,838	189,907	264,499	357,84	473,558
45				71,9712	95,1552	147,168	213,696	297,562	402,595	532,829
50				80,0352	105,638	163,498	237,485	330,624	447,35	592,099
55			49,9968	87,8976	116,122	179,827	261,072	363,686	492,106	651,168
60			54,6336	95,9616	126,806	196,358	284,861	396,749	536,861	710,438
65			59,2704	104,026	137,29	212,688	308,65	429,811	581,616	769,709
70			63,7056	111,888	147,773	229,018	332,438	462,874	626,371	828,778
75		29,0304	68,3424	119,952	158,458	245,347	356,227	496,138	671,126	888,048
80		30,8448	72,576	127,814	168,941	261,677	379,814	529,2	715,882	947,318
85		32,8608	77,2128	135,878	179,626	278,006	403,603	562,262	760,435	1006,39
90		34,8768	81,8496	144,144	190,109	294,336	427,392	595,325	805,19	1065,66
95		36,6912	86,2848	152,006	200,592	310,666	451,181	628,387	849,946	1124,93
100		38,7072	90,9216	160,07	211,277	327,197	474,768	661,45	894,701	1184

Wasser @ 100% Lüfterstellung [g/h]	Temperatur [°C]									
Luftfeuchte	0	5	10	15	20	25	30	35	40	45
5										
10									268,531	355,018
15							189,907	297,5616	402,797	532,829
20						165,11	253,411	396,7488	537,062	710,64
25						206,237	316,915	495,936	671,328	887,846
30					189,907	247,363	380,419	595,1232	804,989	1065,66
35					221,962	288,49	443,318	694,3104	939,254	1243,47
40				192,326	253,411	329,616	506,822	793,4976	1073,52	1420,68
45				215,914	285,466	370,742	570,326	892,6848	1207,79	1598,49
50				240,106	316,915	411,869	633,83	991,872	1342,05	1776,3
55			149,99	263,693	348,365	452,995	696,73	1091,0592	1476,32	1953,5
60			163,901	287,885	380,419	494,726	760,234	1190,2464	1610,58	2131,32
65			177,811	312,077	411,869	535,853	823,738	1289,4336	1744,85	2309,13
70			191,117	335,664	443,318	576,979	887,242	1388,6208	1879,11	2486,33
75		87,0912	205,027	359,856	475,373	618,106	950,746	1488,4128	2013,38	2664,14
80		92,5344	217,728	383,443	506,822	659,837	1014,25	1587,6	2147,64	2841,96
85		98,5824	231,638	407,635	538,877	700,963	1077,75	1686,7872	2281,31	3019,16
90		104,63	245,549	432,432	570,326	742,09	1141,26	1785,9744	2415,57	3196,97
95		110,074	258,854	456,019	601,776	783,216	1204,76	1885,1616	2549,84	3374,78
100		116,122	272,765	480,211	633,83	824,947	1267,66	1984,3488	2684,1	3551,99

Cabin Comfort_

Virtuoso

Technology advancements are changing consumers' expectations of automotive industry. Vehicle interior offerings and cabin comfort will be differentiating factors in the passenger's mobility experience.

Virtuoso offers unique thermal comfort and healthy air quality for peace of mind during travel. A smart headliner with an integrated, vertical, draft-free air distribution system cocoons each passenger with a gentle flow of fresh air. The air-shower allows each passenger to set their own microclimate, creating an individual and comfortable experience.

Additionally, Virtuoso offers a reduced CO_2 footprint throughout the product lifecycle.

Customer Value

Individual cocooning effect

Compartmentalized cabin air

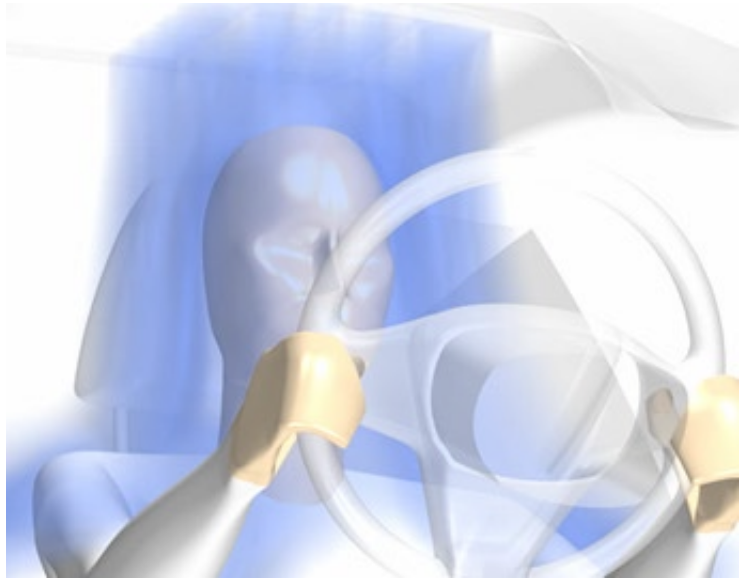
Energy efficiency

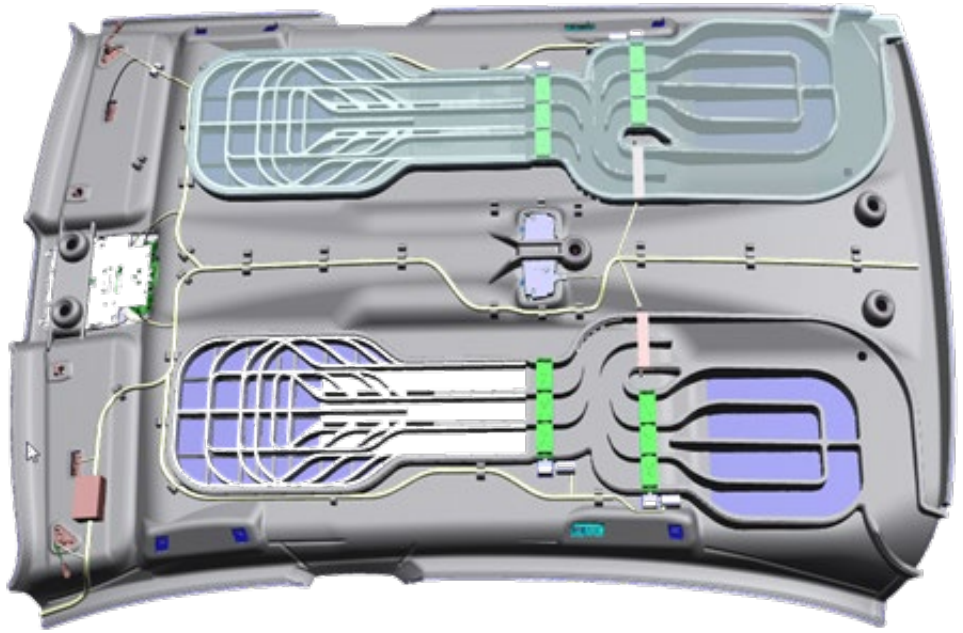
CO_2 footprint reduction

Individual Cocooning Effect_

The air-shower allows each passenger to set their own microclimate

- Register controls the air flow
- Integrated heater fine-tunes the temperature
- Head and body zone allows further individualization
- Automatic setting through integrated, personal recognition and thermal sensors



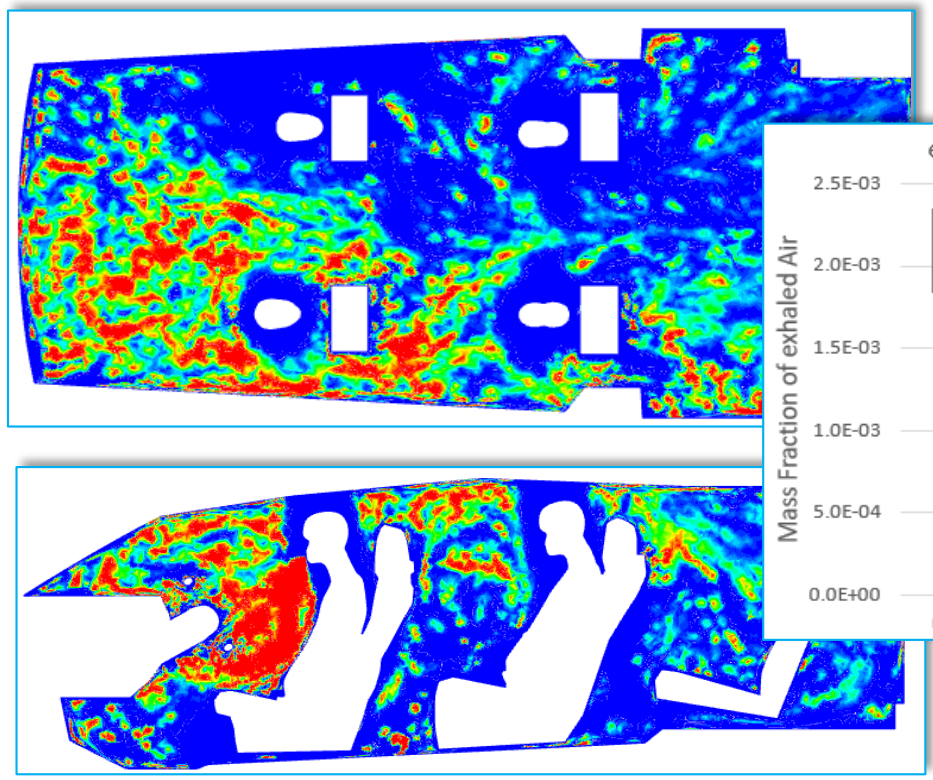


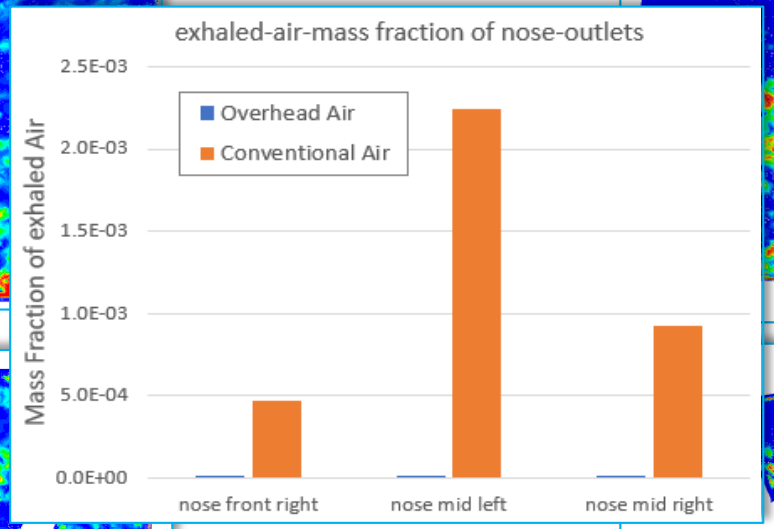
Compartmentalized Cabin Air_

Vehicle air drift around the head is avoided by the air-shower

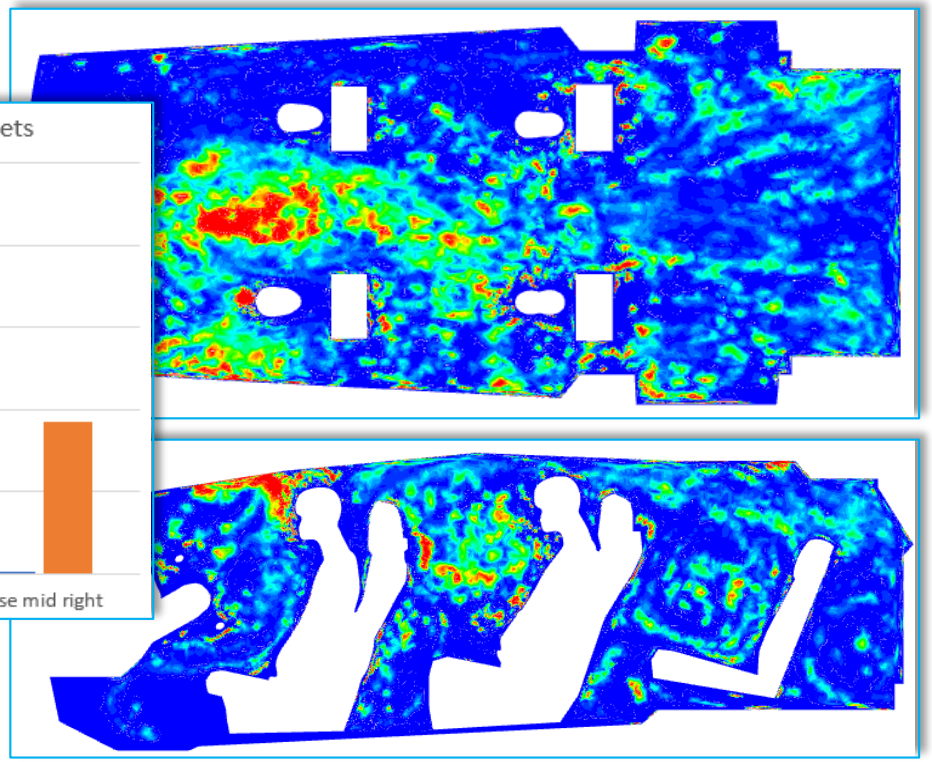
Reduction of particles (e.g. dust, pollen, etc.) and pathogens inhaled during the drive

KAUTEX Solution





Conventional Solution



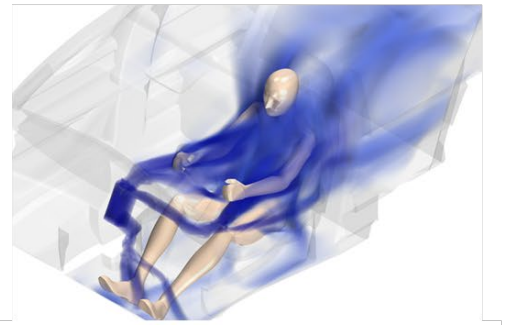
Energy Efficiency

*Climatizing the passenger not the cabin_*

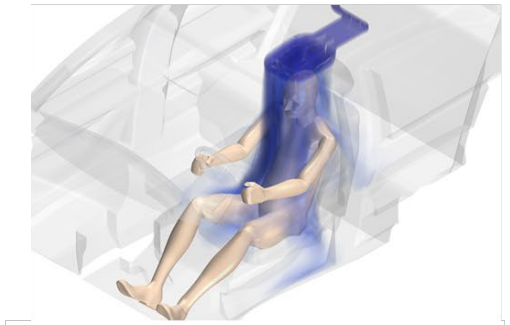
- Faster climatization time
- Up to 50% of energy reduction compared to conventional climatization systems

Average Cooldown USA

- Temperature: 25°C
- Humidity: 50%
- Radiation: 350W

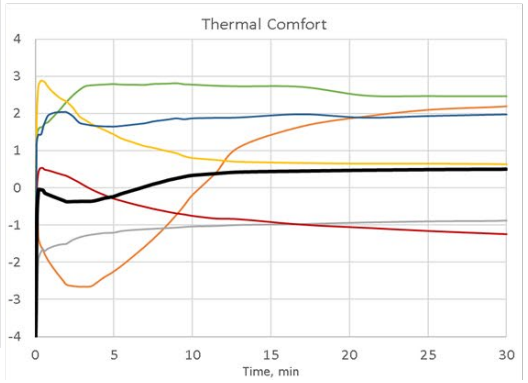


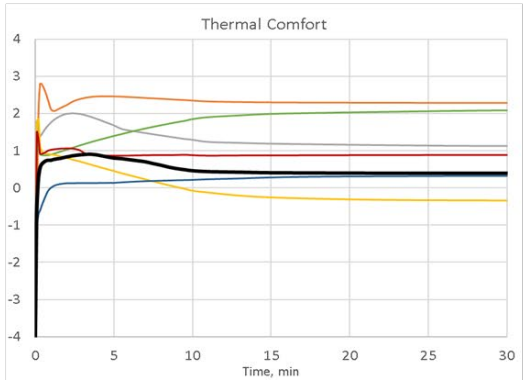
$\dot{m} = 5{,}2\ kg/min; T = 20°C$

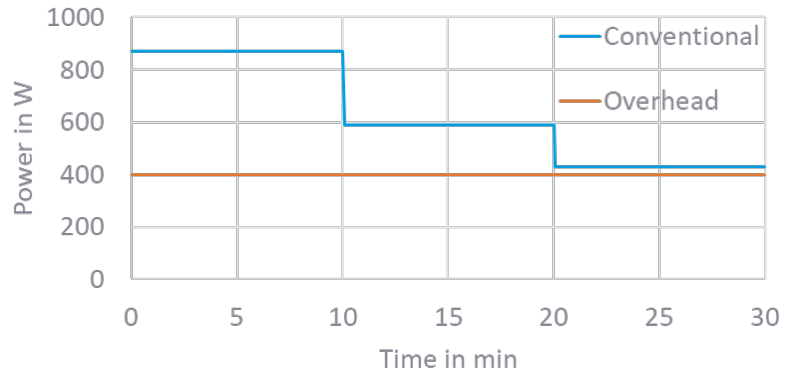


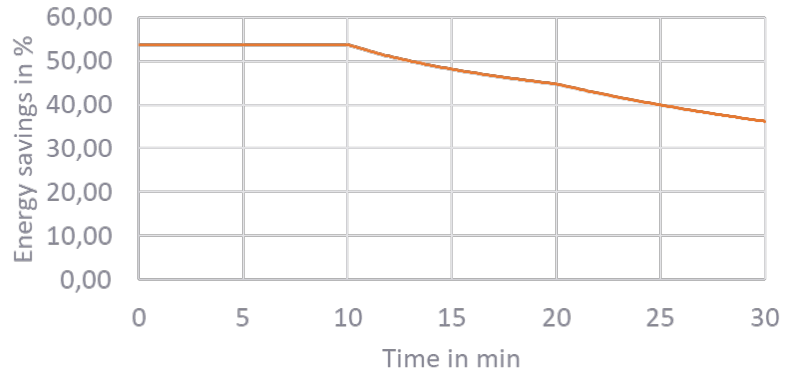
$\dot{m} = 2{,}4\ kg/min; T = 20°C$

Interpretation
Perfect
Very comfortable
Comfortable
Slightly comfortable
(Neutral)*
Slightly uncomfortable
Uncomfortable
Very uncomfortable
Extremely uncomfortable





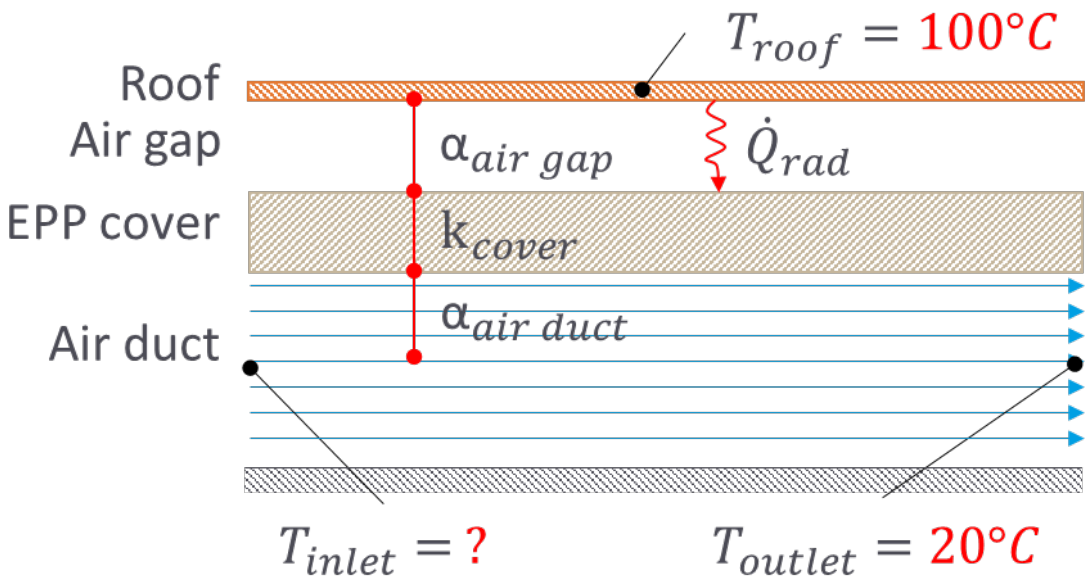




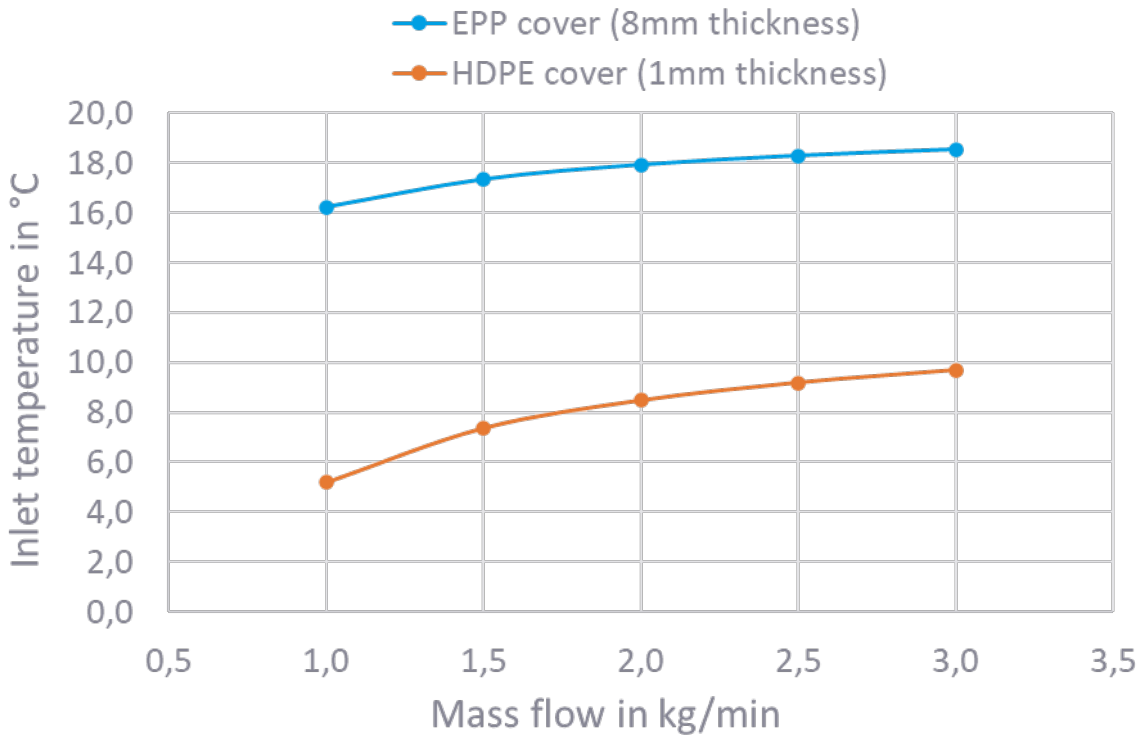
Energy Efficiency

*Expanded Polypropylen (EPP) reduces the heat pick up significantly_*

Material enables air-shower technology



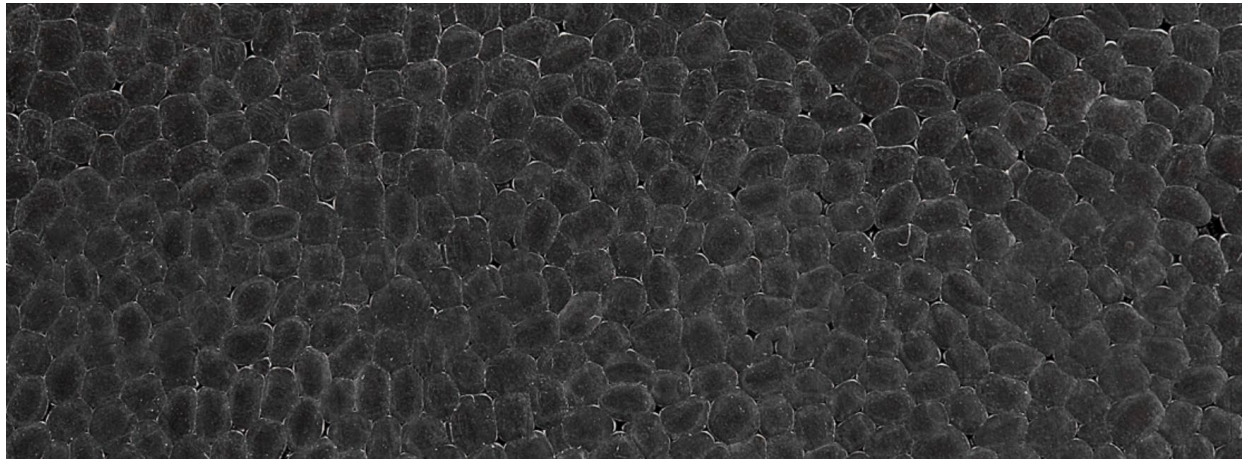
Channel: 1000mm length, 200mm width

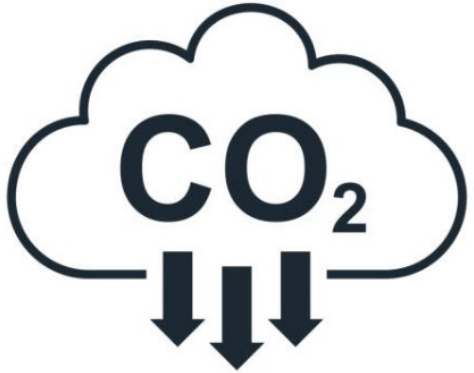


CO_2 Footprint Reduction

*Expanded Polypropylen (EPP) improves the CO_2 footprint through vehicle life cycle_*

- Thermoplastic process with lowest production footprint
- Up to 10% Post Consumer Recycled (PCR) Material can be integrated
- Low material density (60g/l) lowers product/vehicle weight and reduces emissions
- Thermal characteristic reduces heat loss
- Headliner can be recycled at the end of vehicle life





Thank You_

KAUTEX
A Textron Company