Overview and Progress of the Nano Cellulose Vehicle (NCV) Project

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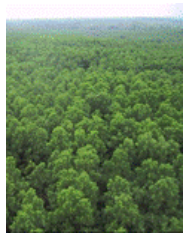
Objectives of the NCV Project

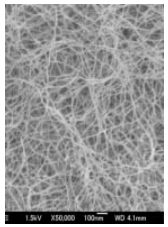
(NCV: Nano Cellulose Vehicle)

Performance evaluation of cellulose nanofibers (CNF) for vehicles to reduce the emission of CO_2



Forest

Tree



CNF

CNF composite resin

CNF lightweight parts

CNF lightweight components

Vehicles

Why Cellulose Nanofibers?

- **Reduce the emission of CO_2 from vehicles**
  - **Light weight and high strength**
  - **Light weighting of vehicles (by using CNF reinforced polymer)**
  - **Carbon neutral**

- **Security of supply**
  - **Most abundant natural polymer**
  - **Sustainable, renewable, and recyclable**

- **Reduce the use of plastics**

- **Government policy (in Japan)**

Corporation of relevant ministries/agencies and industry/academia/government

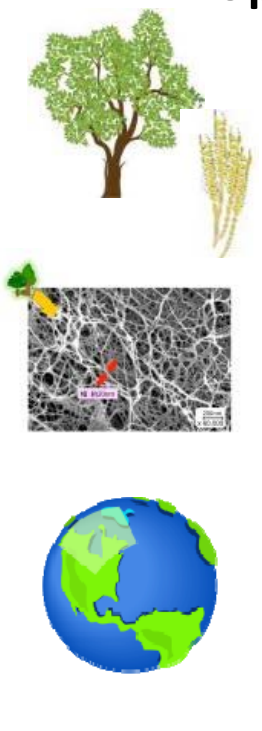
- Jun 1, 2014 : ”Nano-cellulose Forum “ was set up at AIST, which is an industry-academic-government consortium under “All-Japan” system for accelerating the development, commercialization and standardization of nano-cellulose.
- Jun 24, 2014 : ”Japan Revitalization Strategy” revised in 2014 – Challenge for the Future- Turns forestry into growth industry, and promotes activities to facilitate material utilization through the research and development of CNF.
- Aug 1, 2014 : For the policy collaboration on Nano-cellulose, Liaison Committee among ministries and agencies on Nano-cellulose was set up by MAFF (Ministry of Agriculture, Forestry and Fisheries in Japan), MEXT (Ministry of Education, Culture, Sports, Science and Technology) , METI (Ministry of Economy, Trade and Industry) , MOE. Meeting is held periodically.

（Ministry of the Environment）

Corporation of relevant ministries/agencies and industry/academia/government

- Jun 19, 2015 : "Comprehensive Strategy on STI 2015"
- Jun 30, 2015 : "Japan Revitalization Strategy" revised in 2015
- June 7, 2016: "Japan Revitalization Strategy" revised in 2016
- June 9, 2017: "Investments for the Future Strategy 2017"
- June 15, 2018: "Future Investment Strategy 2018"
- April 17, 2018: "The fifth Basic Environment Plan"

Corporation of relevant ministries and the policy collaboration



Ministry	Main role in charge
MAFF Ministry of Agriculture, Forestry and Fisheries	Provision of raw materials for nano-cellulose
MEXT Ministry of Education, Culture, Sports, Science and Technology	Basic research on CNF
METI Ministry of Economy, Trade and Industry	Manufacturing of CNF (Technology development etc.)
MOE Ministry of the Environment	Expansion into promising fields for global warming prevention

（Ministry of the Environment）

Overview of NCV Project

Consortium established: October 26, 2016

Period: FY2016 to FY2019

Participating organizations: 22 companies and institutions (FY2019)

Aisin Seiki Co., Ltd. *
Akita Prefectural University
DaikyoNishikawa Corporation
DENSO CORPORATION
INOAC CORPORATION
Kyoraku Co., Ltd.
Kyoto Municipal Institute of Industrial Technology and Culture
Kyoto University
Japan Environmental Management Association for Industry
Kanazawa Institute of Technology
Maxell, Ltd.

Nagoya Institute of Technology
National Institute of Advanced Industrial Science and Technology
RISHO KOGYO CO., LTD.
SANWA KAKO CO., LTD.
Showa Marutsutsu Co., Ltd.
Showa Products Co., Ltd.
TOYOTA BOSHOKU CORPORATION
TOYOTA CUSTOMIZING & DEVELOPMENT Co. Ltd.
Toyota Motor East Japan, Inc. **
Ube Industries, Ltd. **
The University of Tokyo

* Joined FY2017 ** Joined FY2018

Strategy

Social implementation

Value and benefits of CNFs → Light weighting of vehicles Reduction of CO_2 emissions → Promote dissemination of CNF-based products

From polymer to CNF composite
Door trim, intake manifold, air conditioning case, etc.

From iron to CNF composite
Trunk lid
Engine hood

FY2017

Nano Cellulose Vehicle (Concept car)

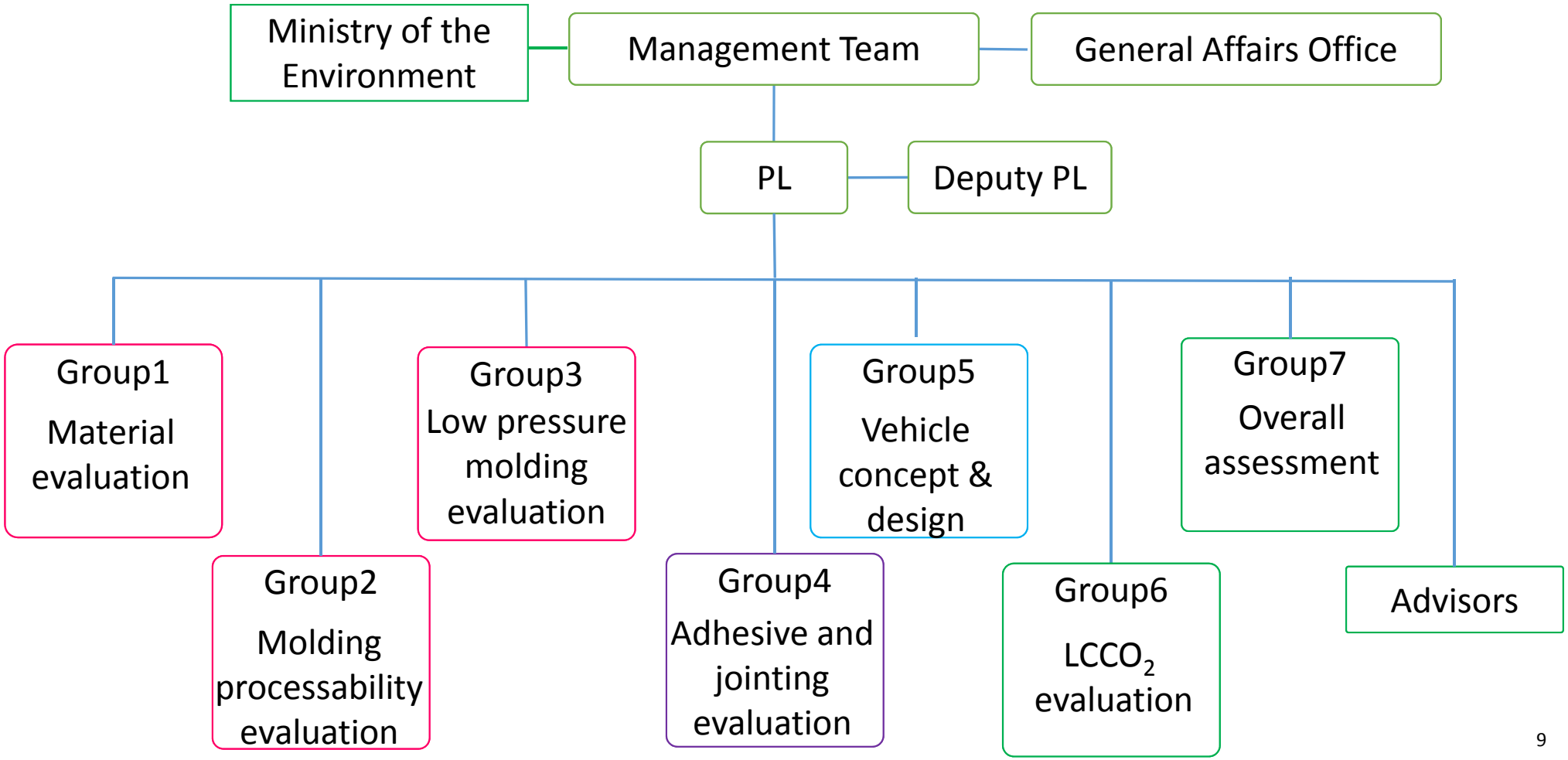
FY2019

Product development in automotive industry

- Evaluation of CNF materials
- Injection, blow, RTM, 3D printing, etc.
- Pipes, sheet, honeycomb, etc.
- $LCCO_2$ (Life cycle CO_2)
- Simulation

Oct. 2016 | 2017 | 2018 | 2019 | Year

NCV Project Organization



Materials and Molding

CNF

- Chemically modified(esterified) and unmodified, including “Kyoto Process®” composites
- Filler (in polymer) or other forms such as sheet

Polymer

- Nylon 6 (PA6), Polypropylene (PP), Polyethylene (PE), Polycarbonate (PC), Epoxy, Ethylene-propylene-diene rubber (EPDM)

Molding/Process

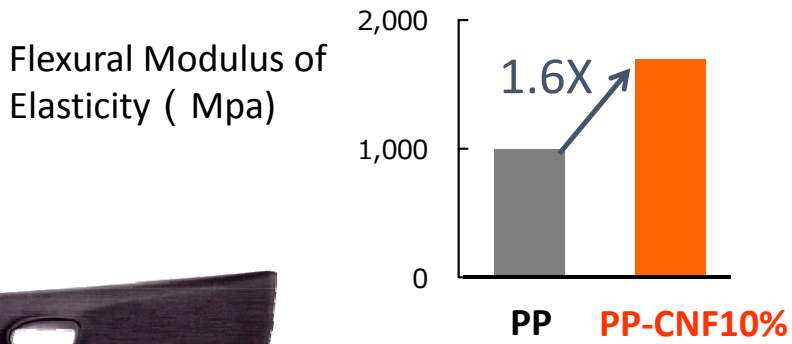
- Injection molding, blow molding, press molding, resin transfer molding (RTM), sheet winding
- 3D printing (additive manufacturing)

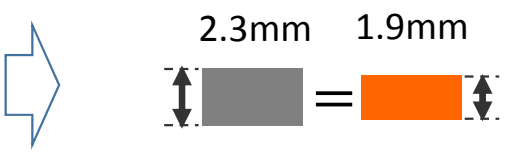
Samples and prototypes

- Test pieces, sheet, pipes, honeycomb
- Door trim, intake manifold, engine hood, trunk lid, ・・・・

Door trim

- Interior parts of automobiles
- CNF reinforced polypropylene (PP-CNF)
- Typical requirement: rigidity (hard to deform) and impact strength (hard to break)





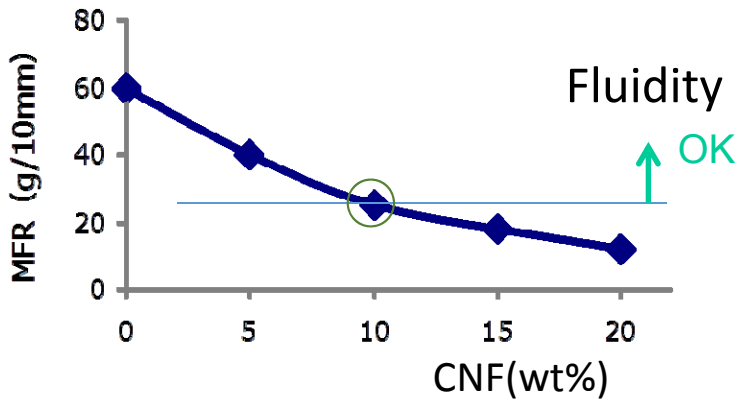
Thickness reduced & weight reduced

Weight reduction of 780g/car *

* Calculated value using elastic modulus of composites (not considered impact strength)

(TOYOTA BOSHOKU CORPORATION)

Door trim



The same moldability as conventional material

Future work

- Increase of impact strength
- Smell, VOC

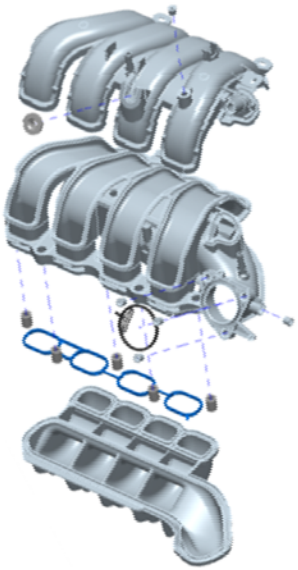
(TOYOTA BOSHOKU CORPORATION)

Intake manifold

- Distribute and supply air to each cylinder of the engine
- CNF-reinforced polyamide 6 (PA6)
- Typical requirements: pressure resistance, heat resistance and long-term reliability

	PA6-GF30	PA6-CNF15
Weight	2.2kg	1.9kg
Weight difference	—	**- 0.3kg**
	—	**- 13%**

PA6-GF30 : PA6-30wt%GF (Glass fiber)
PA6-CNF15 : PA6-15wt%CNF

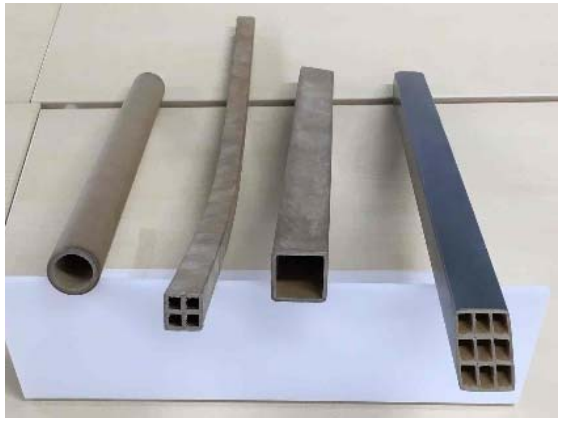


Appearance of intake manifold molded using PA6-CNF15

(Aisin Seiki Co., Ltd.)

Sheet Winding

Material: CNF sheet
Potential application: reinforcing beams, etc.



(SHOWA MARUTSUTSU Co., Ltd.)

Blow Molding

Material: Polypropylene (PP)-CNF10%

Model for deck board

(KYORAKU Co., Ltd.)

Plating

Material: Nylon 6 (PA6)-CNF
Plating of engine cover after injection molding

Engine cover

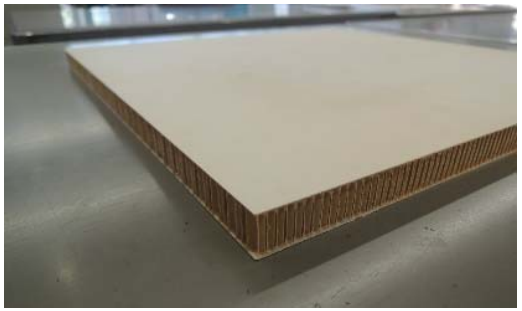
(Maxell, Ltd.)

(Engine cover: supplied by NEDO)

Press Molding

Material: 100 % CNF

100% CNF board



Honeycomb

Trunk lid (upper)

(RISHO KOGYO Co., Ltd.)

Injection Foam Molding

Material: Nylon 6 (PA6)-CNF5%

Trunk lid
(lower)

(DaikyoNishikawa Corporation)
(Material: supplied by NEDO)

RTM (resin transfer molding)

Material: CNF, epoxy resin

Engine hood (bonnet)

(Kanazawa Institute of Technology)
(Toyota Customizing & Development Co.,Ltd.)

Resin Glass

Material: Polycarbonate (PC), CNF

Sample image

(Toyota Motor East Japan, Inc.)

3D Printing

Material: Nylon 6 (PA6)-CNF

Outer panel (in part)

(Kyoto University)
(Nagoya Institute of Technology)

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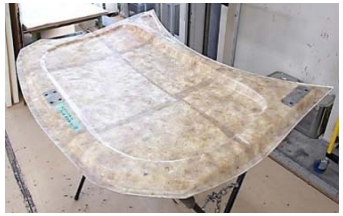
Oct. 2016 | 2017 | 2018 | 2019 | Year

Parts Replacement with CNF（TOYOTA 86）

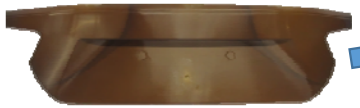
① Engine hood



Engine hood
(CNF, epoxy resin)

② Trunk lid

Trunk lid (upper)
（100%CNF）

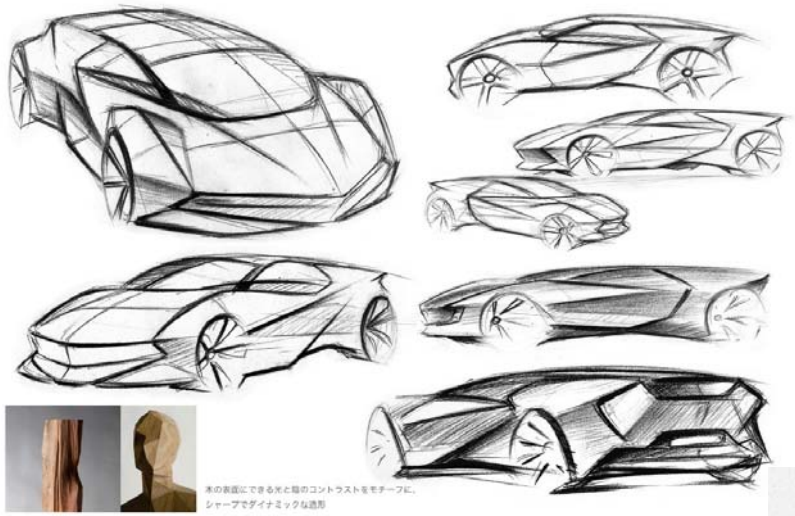


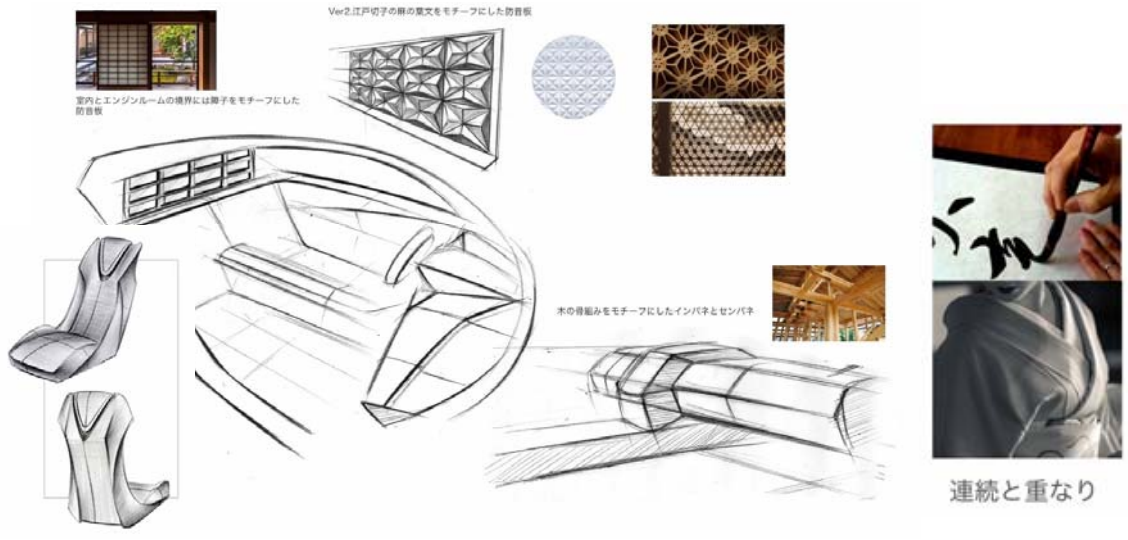
Trunk lid (lower)
（Foamed PA6-CNF5%）

(TOYOTA CUSTOMIZING & DEVELOPMENT Co.,Ltd.)

NCV (Nano Cellulose Vehicle)

Concept car using CNF parts





Sample image

Will be shown at Tokyo Motor Show (October, 2019)

Life Cycle Assessment (LCA)

- Focus on Global Warming Impact
- Focus on Life Cycle CO_2 ($LCCO_2$)
- Evaluate on a lifecycle basis in several levels of boundaries

Raw materials
(CNFs, polymers)

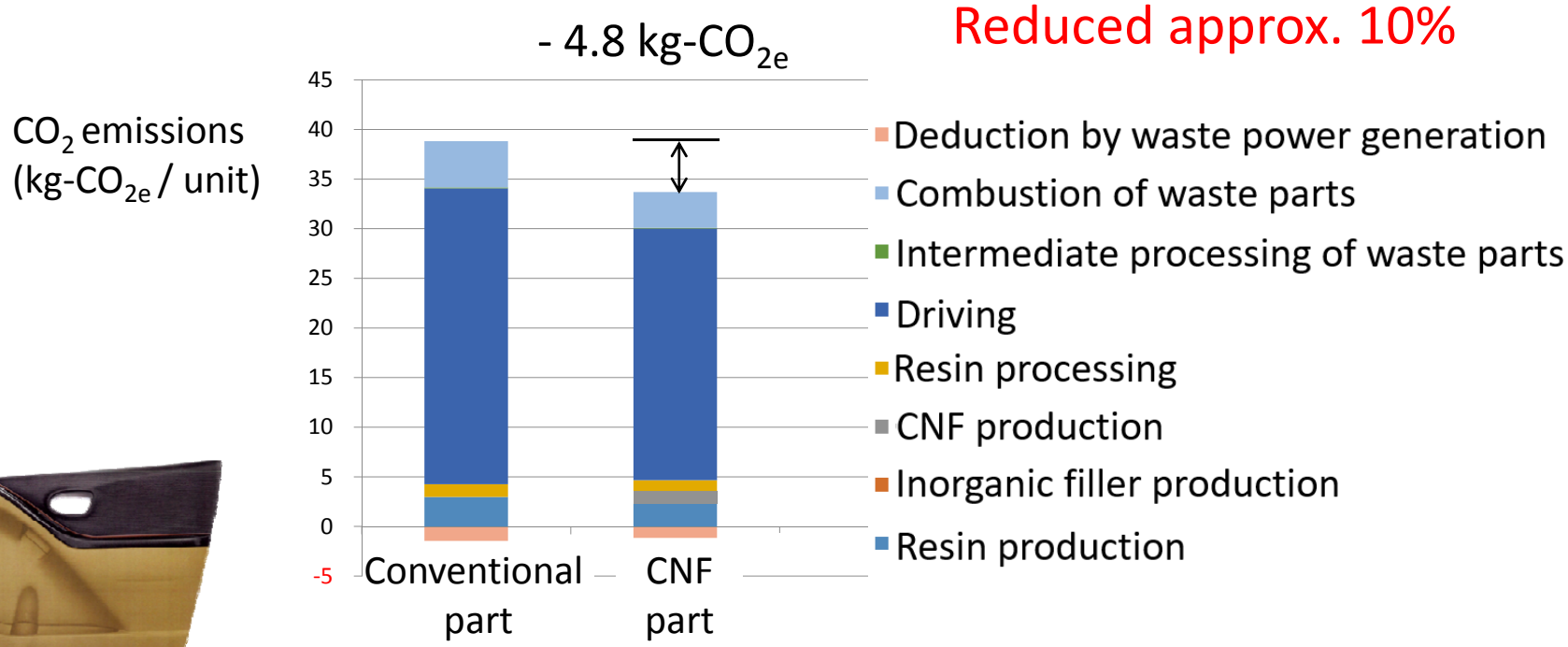
Automobile parts

Vehicles

Society

Example : $LCCO_2$ (Life cycle CO_2)

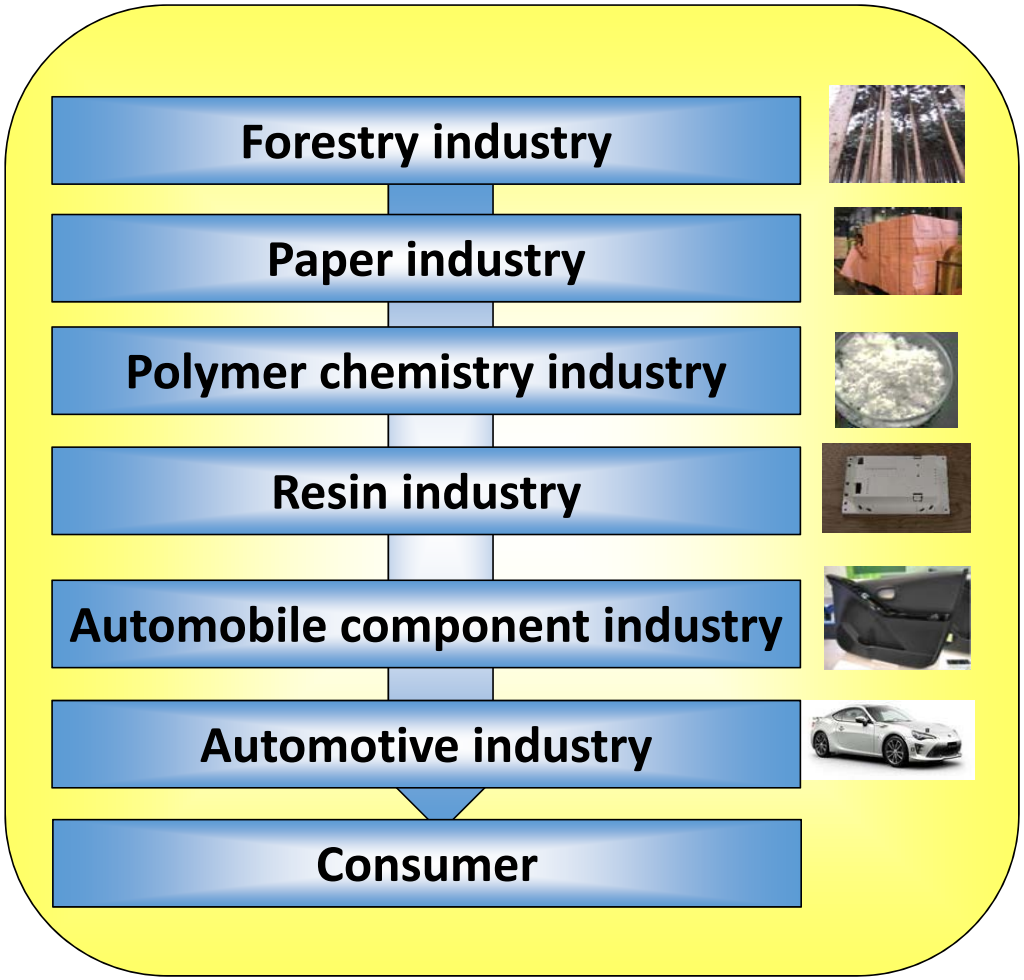
Preliminary results for a door trim



CO_2 emission from life cycle of a door trim

(NCV report 2018)

Building a Low-carbon Sustainable Society



- Value of CNF based materials
- Performance and cost
- How do we deliver the value ?
- Partnerships ?
- How do we circulate?

Acknowledgements

This project was conducted under Cellulose Nanofiber Performance Evaluation Work Project of the Ministry of the Environment.

We thank the institutions who are participating in the NCV Project for their cooperation.

NCV PJ leaflet

Thank you

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