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**Strategies and Technological Challenges  
For Realizing Lightweight Mass Production  
Automobile by using CFRTP**

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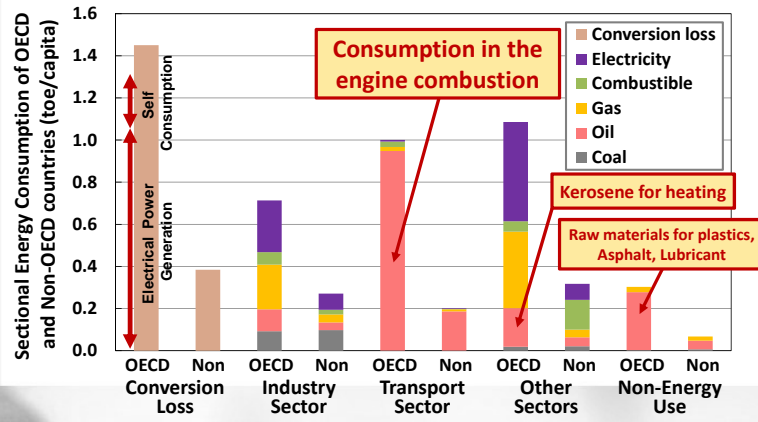


**What is the decisive factor to use CFRP in automobile ?**

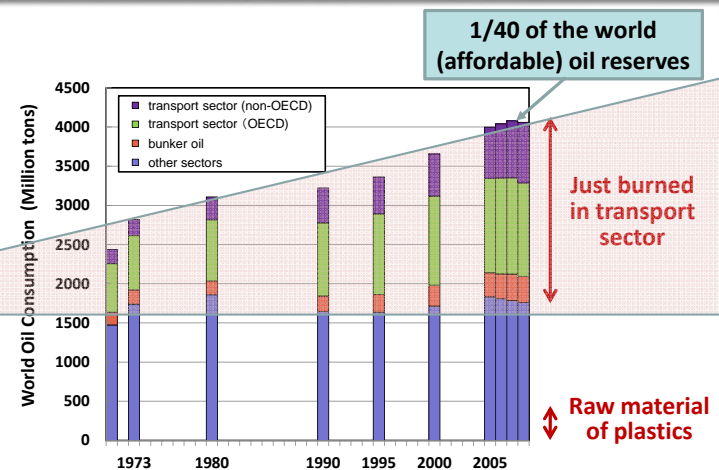
- Driving performance ?      Yes, but...
- Fuel efficiency ?              Of course yes, but...
- Not rust property ?            Maybe yes, but...
- Multifunction property ?      .... (yawn)
- Aesthetics ?                    .... (zzz)
- Recyclability ?                 You must be joking !
- Cost ?                             **Yes, cost is the first and absolute condition !  
Others are later.**

**Sectional Energy Consumption of OECD and Non-OECD countries**

2008	Population	Total Primary Energy Supply	Total Final Energy Consumption
OECD	1190 million	4.56 toe/capita	3.11 toe/capita
Non-OECD	5498 million	1.24 toe/capita	0.86 toe/capita

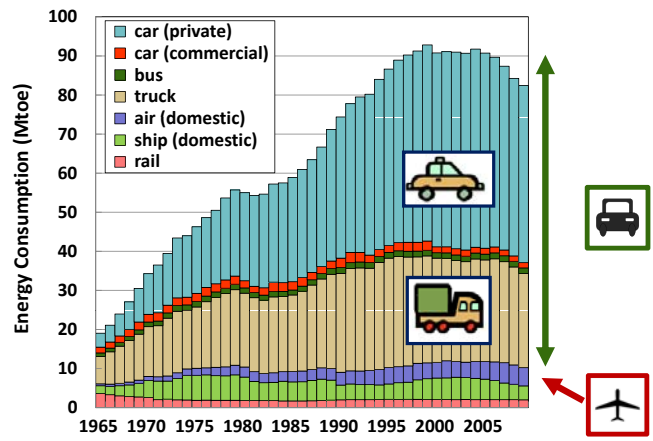


**Oil consumption of the world and transport sector**



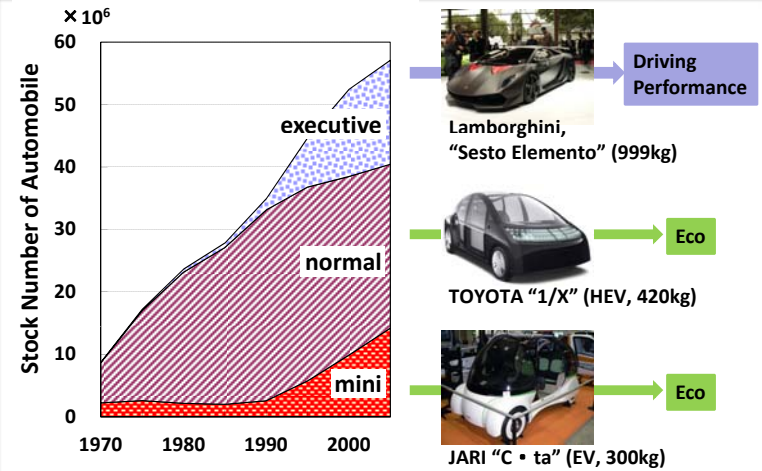
Source: EDMC, Energy & Economic Statistics 2011

### Energy Consumption Structure of Japanese Transport Sector



Source: EDMC, Energy & Economic Statistics 2011

### Transition of Passenger Automobile Type in Japan



Problem is not only cost but also production cycle time and recyclability.

### Cost reduction of CFRP products by using thermoplastics

#### < Thermosetting CFRP >

##### Material cost

- Hi CF volume fraction
- Expensive resin
- Inefficient prepreg system
- Ineffective utilization ratio of CF

##### Manufacturing cost

- Machine → mass production
- Operation → out of autoclave
- Employees → automation
- Tools

#### < Thermoplastic CFRP >

##### Material cost

- Lower CF volume fraction
- Inexpensive resin
- Efficient prepreg system
- Effective utilization ratio of CF

##### Manufacturing cost

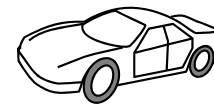
- will be reduced by automated high cycle molding technology

#### Effective measures for cost reduction

- Develop higher cycle manufacturing method
- Achieve required properties by lower  $V_f$
- Establish advanced 3R system of CF

### Concept of automobile lightening for mass production

Current ( ave.1380kg, 200,000cars/y<sup>-1</sup> )  
<sup>\*)</sup> 800/day = 50/hour = cycle time is 1minute



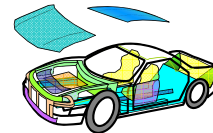
Global energy saving ?  
For EV ?

Concept car (weight is 1/3)  
integration structure by thermoset CFRP



Lightweight ⊙  
Parts number ×  
Cycle time ×  
Cost ×  
Recycle ×  
Safety ?

Project target (weight ▲30%, 200,000cars/y)  
Parts substitution by thermoplastic CFRP



By using CFRTP sheet and tape

- high cycle press molding
- expansion into non-automotive field

Then,

- Lightweight ⊙
- Cycle time ○ ← project theme
- Cost ○ ← project theme
- Recycle ○ ← project theme
- Safety ○ ← project theme

- Immediate effect for not only energy saving but also waste management laws
- It contributes cost reduction, early spread, saving rear metals of electric vehicles
- It will extend to 60% weight reduction for mass production automobile

## Development of Sustainable Hyper Composite Materials Technology (2008-12)

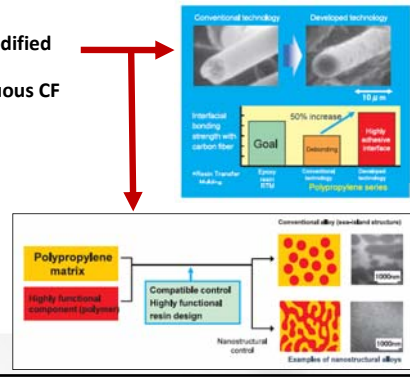


## Japanese National Program to Develop CFRTP for Mass Production Automobile

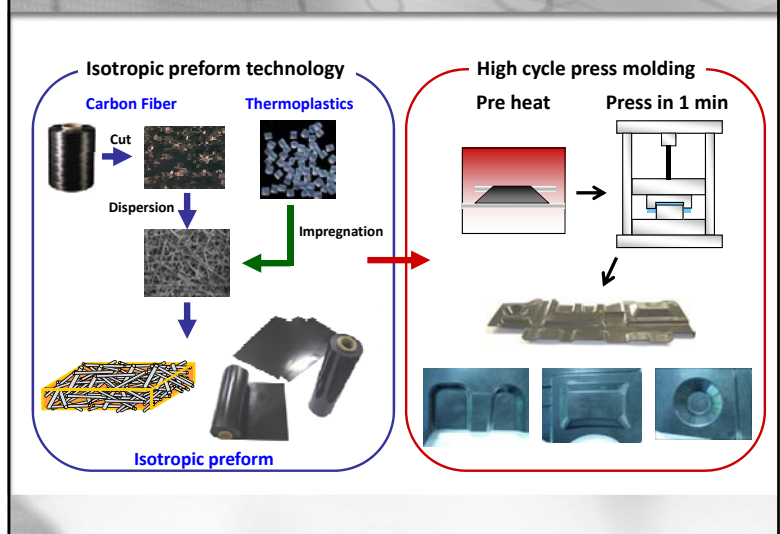
2008 – 2012fy

Total budget: 4 billion JPY (≒50 million US\$)

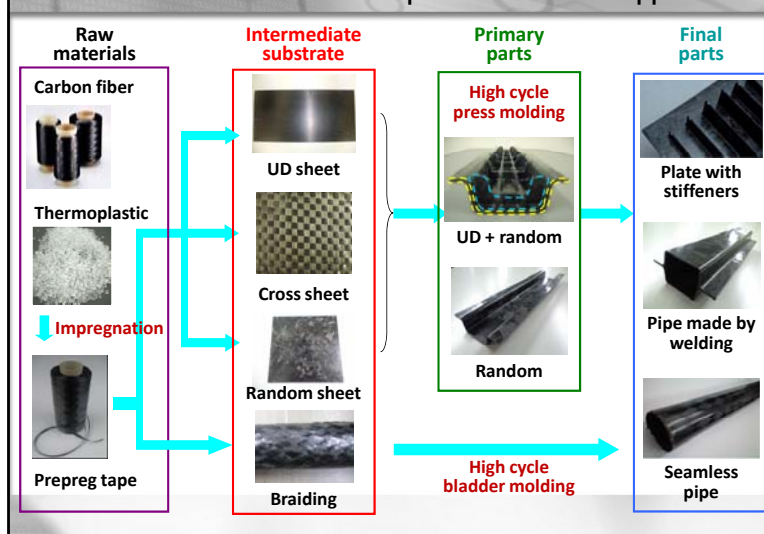
- CF/PP and CF/PA sheets
  - surface treated CF and modified thermoplastics
  - continuous and discontinuous CF reinforced sheets
- High cycle molding technology
  - press molding
  - bladder molding
- Joining technology
  - between CFRTP
  - with metal
- Repair and recycling

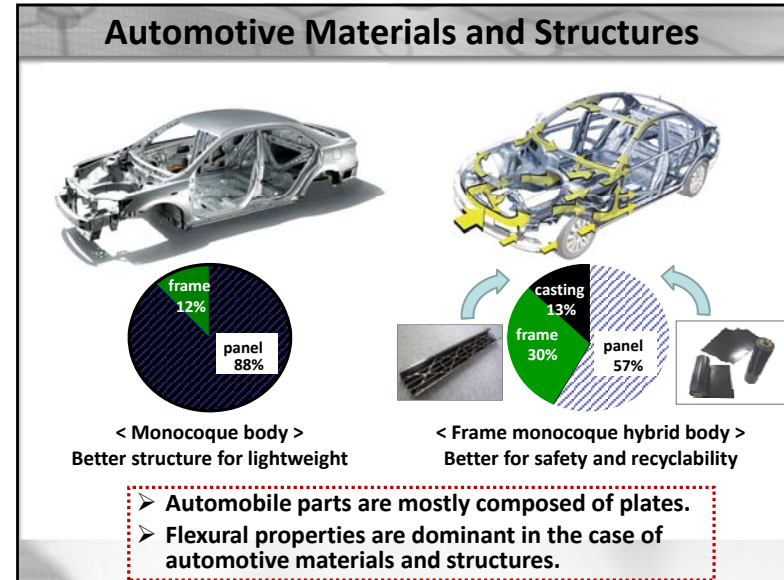
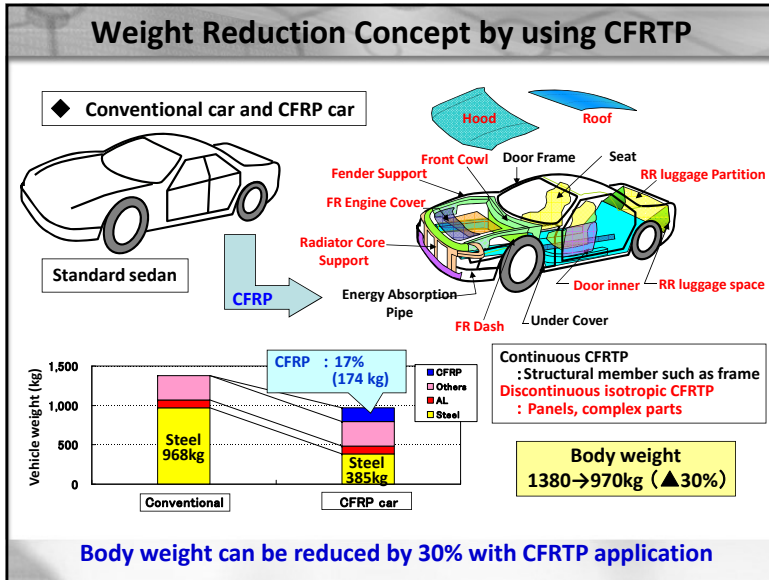


## Discontinuous fiber reinforced sheet



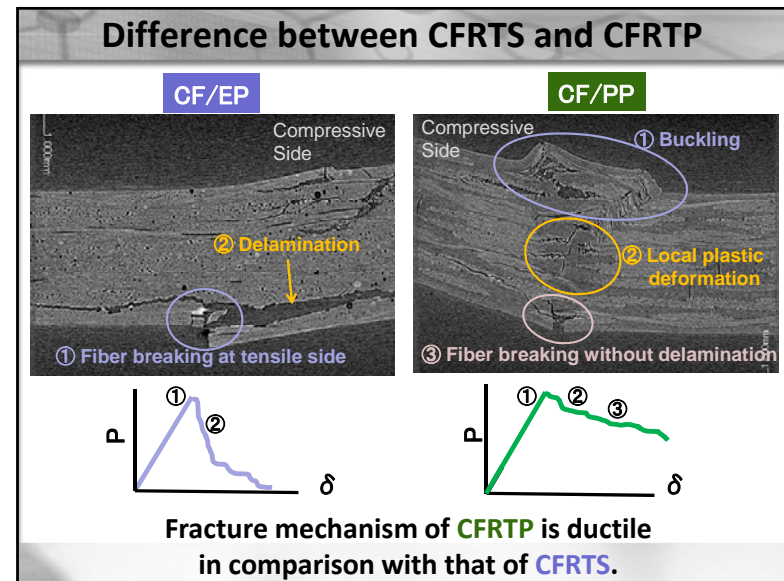
## Continuous CF reinforced UD-tape and its various application



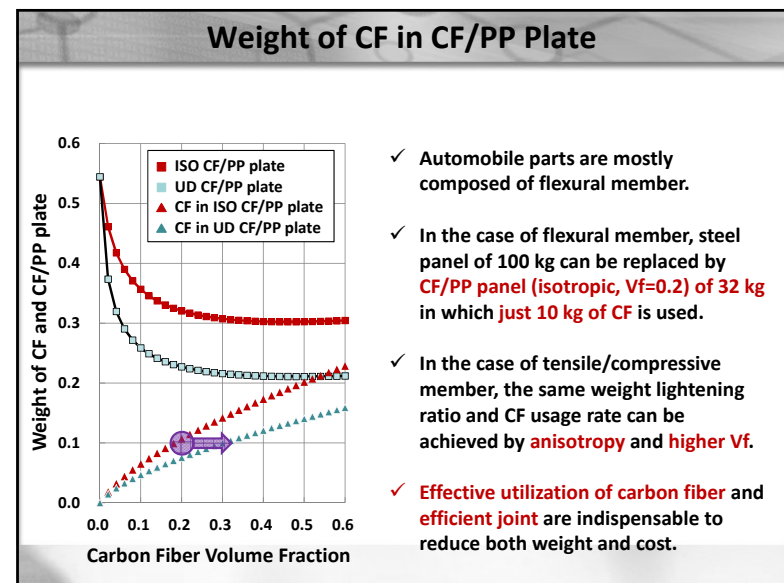
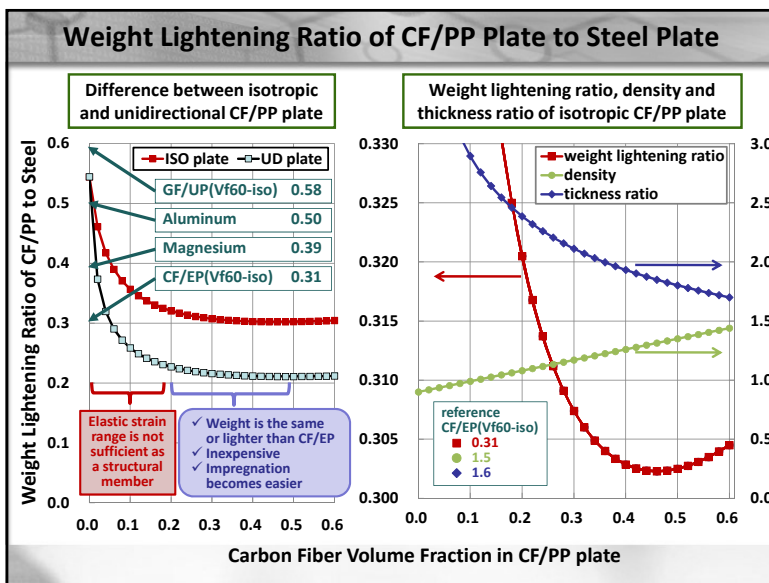
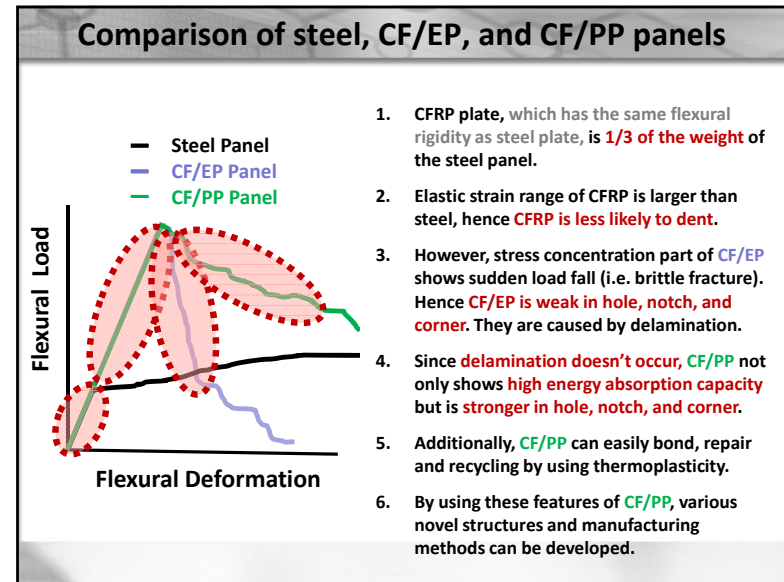
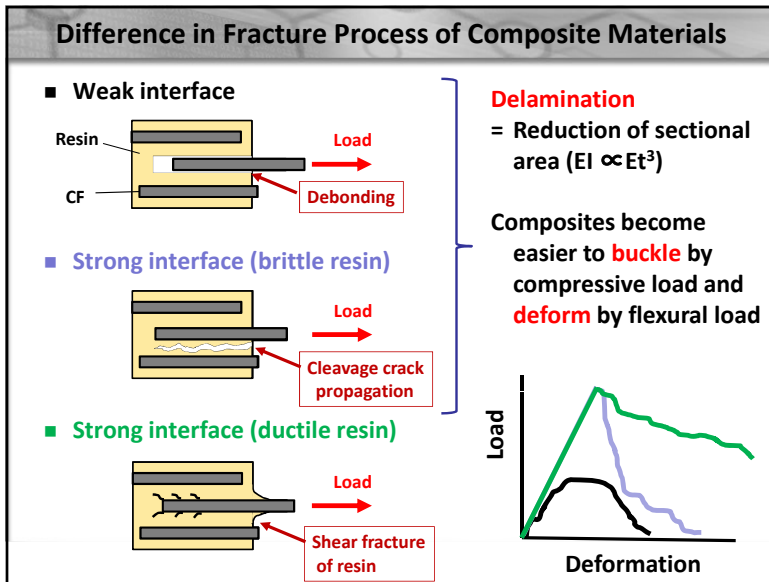


### Mechanism of one-third weight reduction

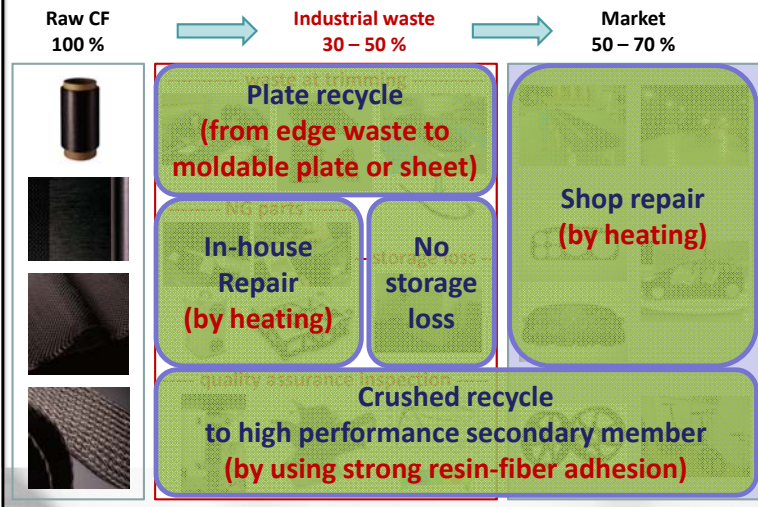
	Steel plate	CF/PP plate	Ratio to Steel
Elastic Modulus (E)	$E_s = 200\text{GPa}$	$E_c = 25\text{GPa}$ ( $\nu_f=0.3$ , ISO)	1/8
Thickness (t)	t	2t	2
Volume ( $V \propto t$ )	V	2V	2
Flexural stiffness ( $EI \propto Et^3$ )	$E_s t^3$	$E_c (2t)^3$	1
Deformation ( $\delta \propto P/EI$ )			1 same flexural performance
Surface strain ( $\epsilon$ )	$\epsilon$	2 $\epsilon$	2
Surface stress ( $\sigma$ )	$\sigma_s = E_s * \epsilon$	$\sigma_c = E_c * 2\epsilon$	1/4
Buckling strength	$P_s = \pi^2 E_s I_s / L^2$	$P_c = \pi^2 E_c I_c / L^2$	1
Density ( $\rho$ )	7.8	1.3	1/6
Weight (W)	7.8V	1.3*2V	1/3



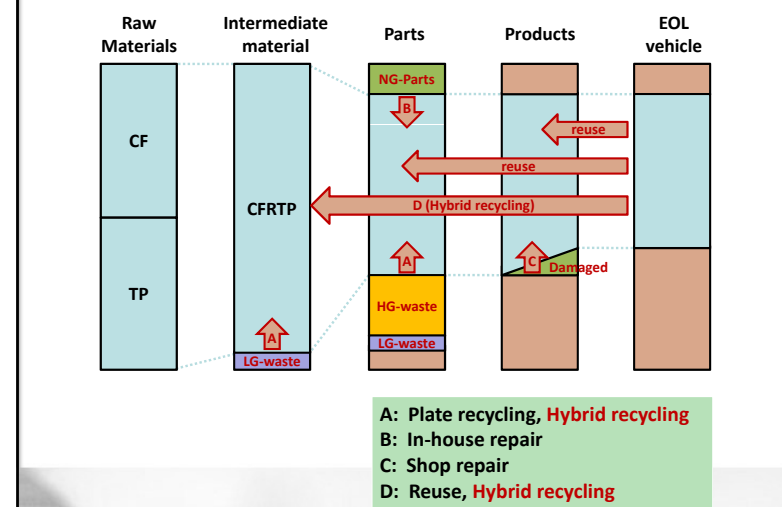




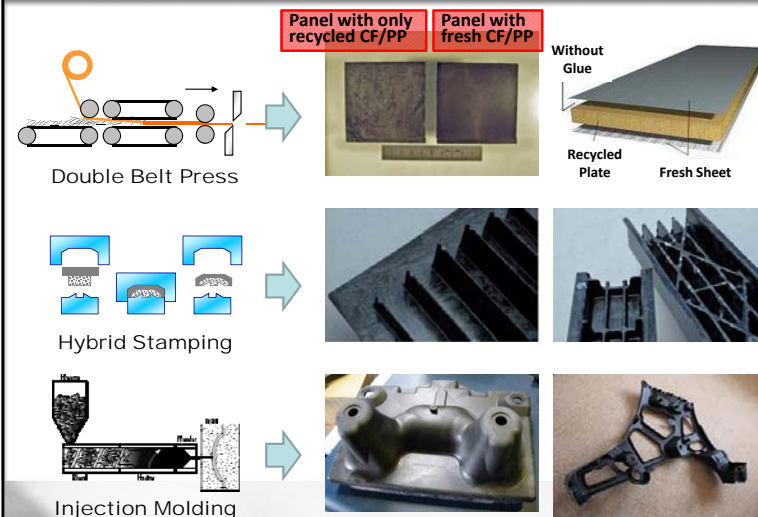
## How to reduce or reuse the industrial waste of CFRP ?



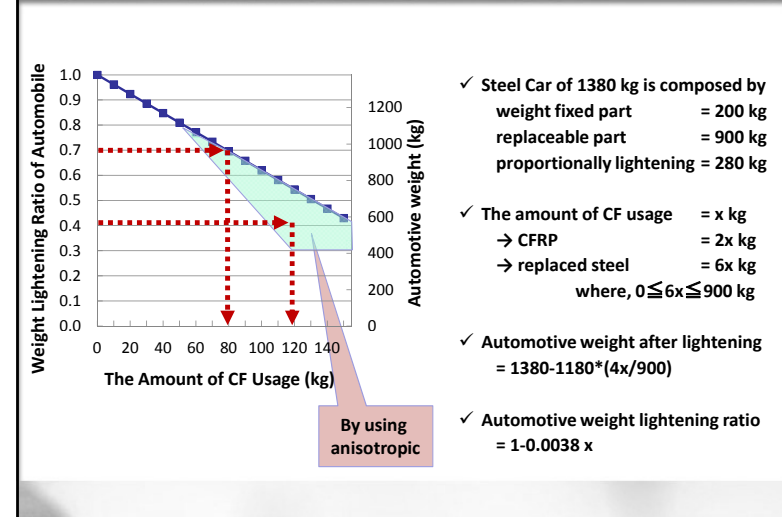
## Life Cycle of CFRTTP in Automobile and Possibility of 3R



## Schematics of CFRTTP recycling

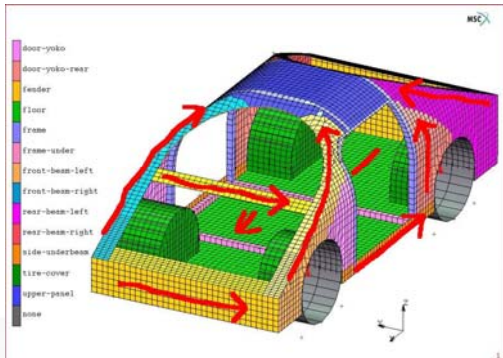


## The Amount of CF Usage and Automotive Lightening Ratio



### Trade-off between cycle time and weight lightening ratio

	Flexural stiffness	Torsional stiffness	Weight
Isotropic	152	210	151kg
Anisotropic	200	286	151kg



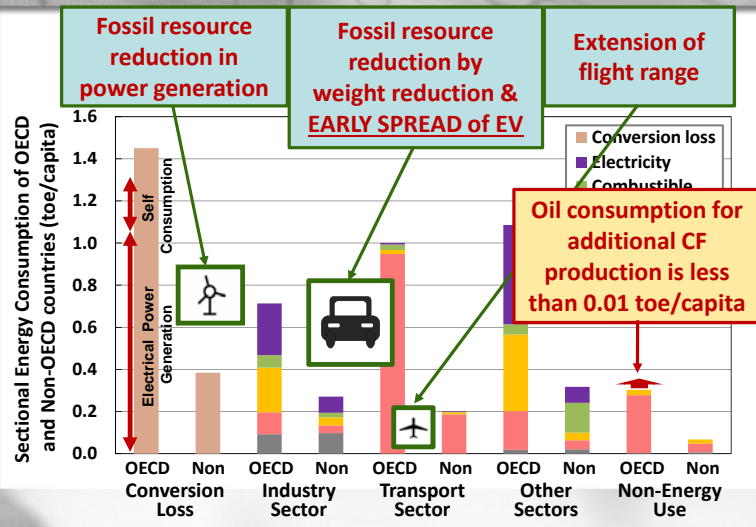
### World carbon fiber Potential demand by application

	unit	passenger automobile	truck	wind turbine blade	commercial airplane (L)
world stock	10 <sup>3</sup>	700,000@2010 1,000,000@2030 1,300,000@2050	260,000@2010 380,000@2030 500,000@2050	120@2010 1,000@2030 1,500@2050	15@2010 30@2030 45@2050
world annual production		<div style="border: 2px solid red; padding: 5px; display: inline-block;">Drastic increase of carbon fiber production capacity is necessary</div>			
CF demand per product	ton	0.1	0.4	4	25
world annual CF demand	10 <sup>3</sup> tons per year	5,300@2010 7,500@2030 10,000@2050	8,000@2010 12,000@2030 16,000@2050	100@2010 200@2030 240@2050	15@2010 30@2030 45@2050
production volume per plant	per year	200,000	50,000	5,000	300
	per day	800	200	20	1.2
	per hour	50	13	1.25	0.075
number of plants (Assuming an ideal production plant)		65@2010 75@2030	400@2010 600@2030	5@2010 10@2030	2@2010 4@2030
CF demand per plant		<div style="border: 2px solid red; padding: 5px; display: inline-block;">Drastic high cycle manufacturing technology of CFRP is necessary</div>			

Japanese National Project 2011-2015

Japanese National Project 2008-2012

### Promising target for massive application of CFRP



Thank you for your kind attention.

