Path toward Low-Carbon Society: Japan and Asia
1st session: "The results of 'Japan Low-Carbon Society Scenarios toward 2050' Project" (Feb. 12th 2009)

低炭素社会の交通
Transportation in Low Carbon Society

(Updated, Feb.11th)

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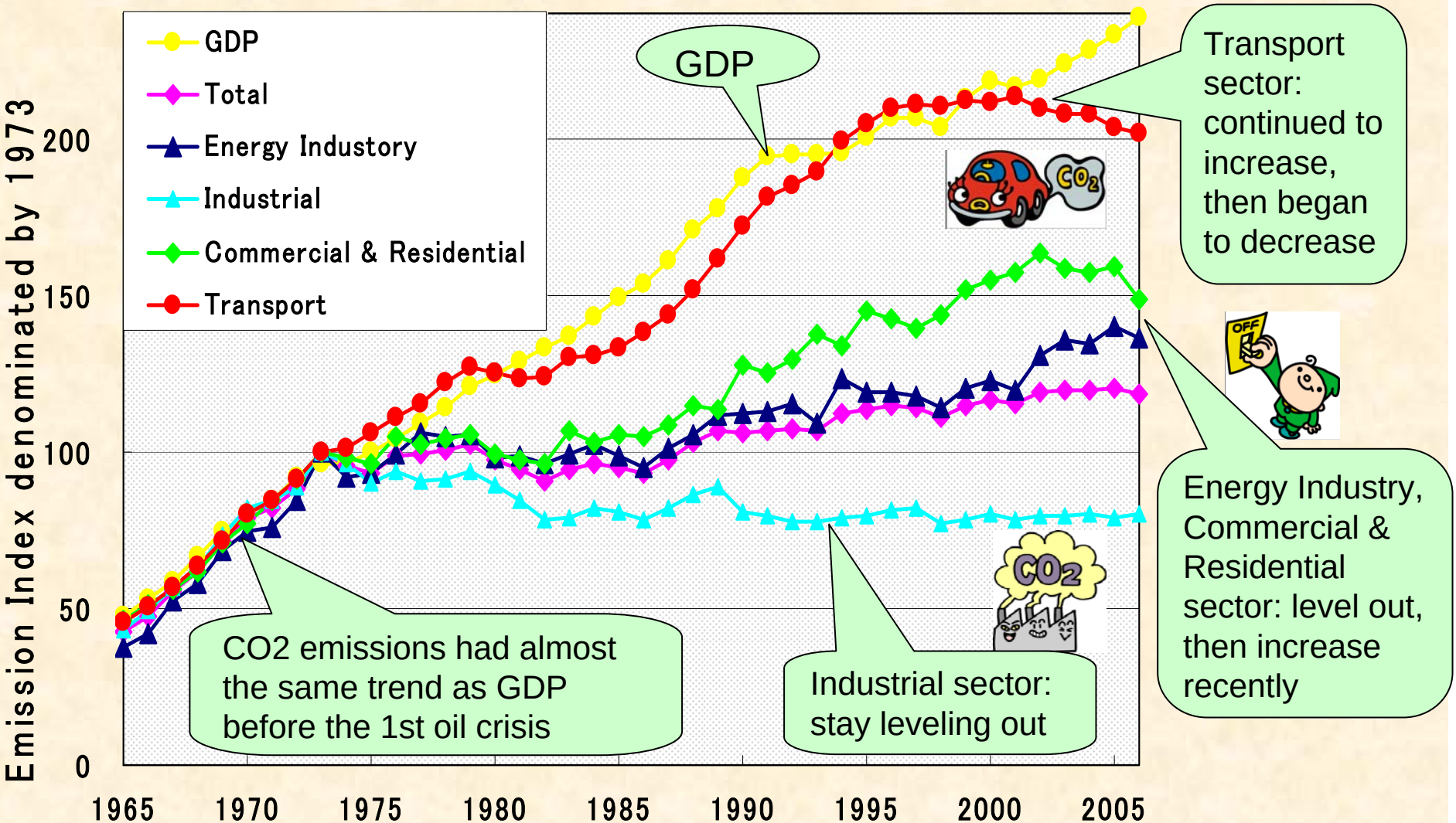
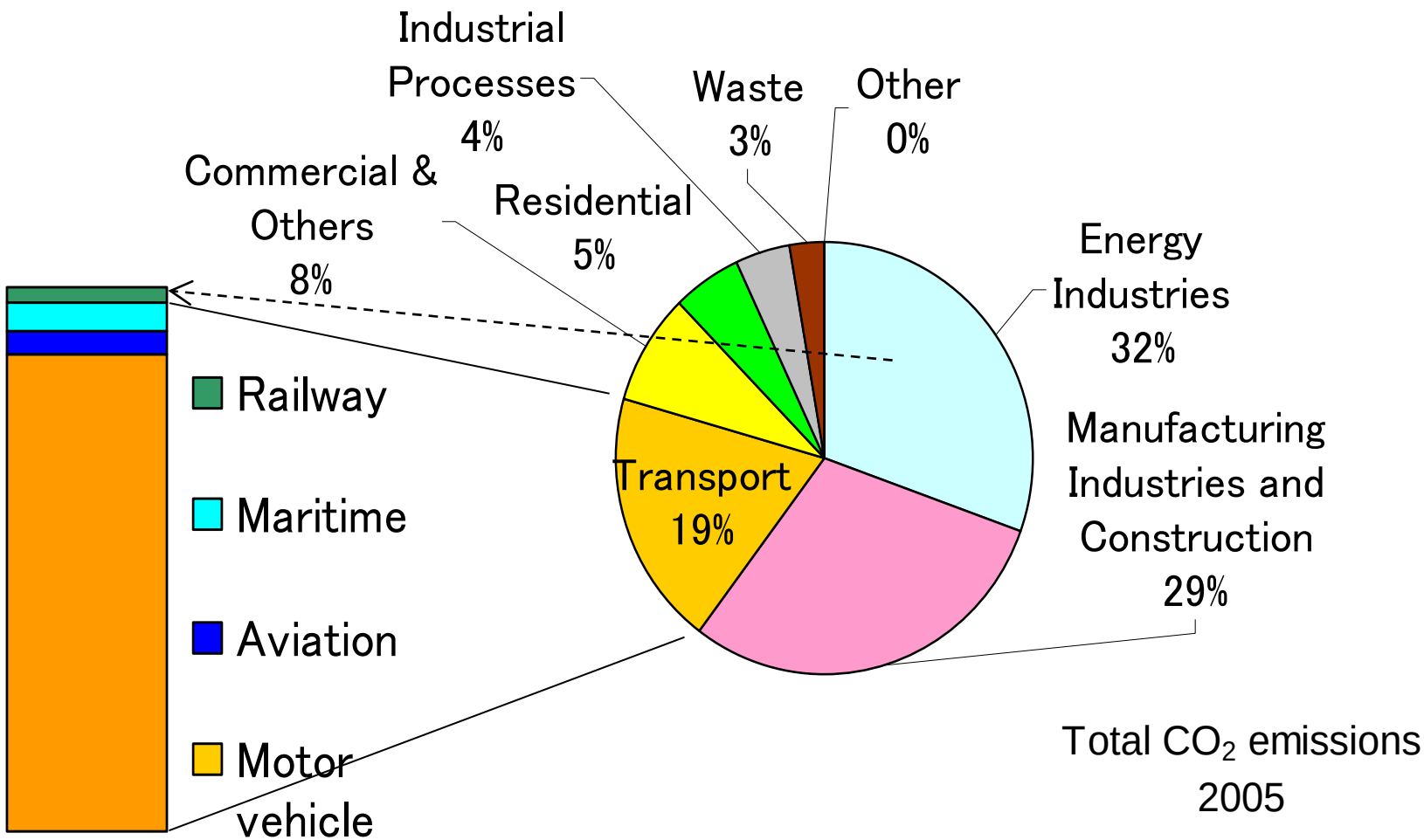
Contents

Trend of GDP and CO_2 emissions by sector in Japan



運輸部門排出量は1997年ごろまで伸び続けた

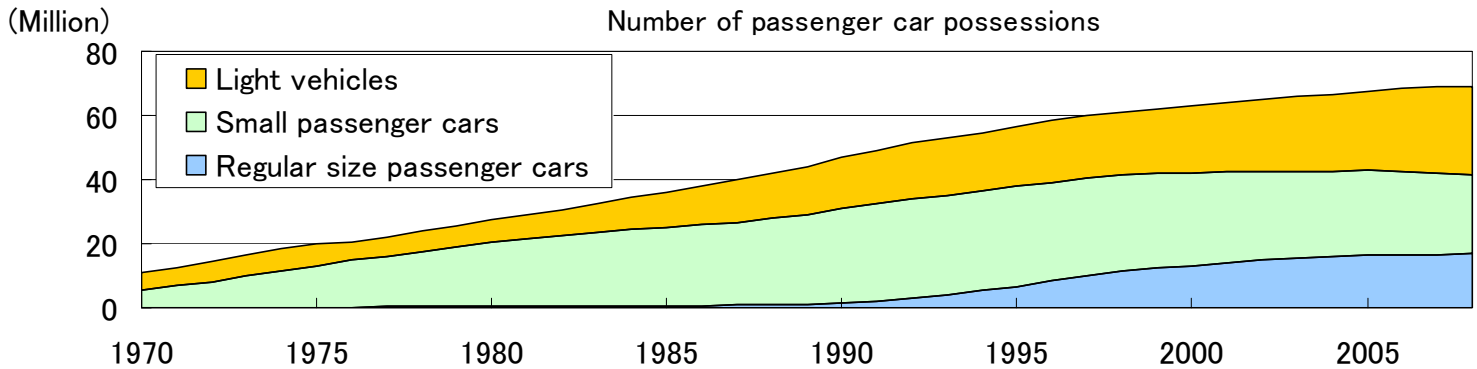
Share CO_2 emissions of transport sector



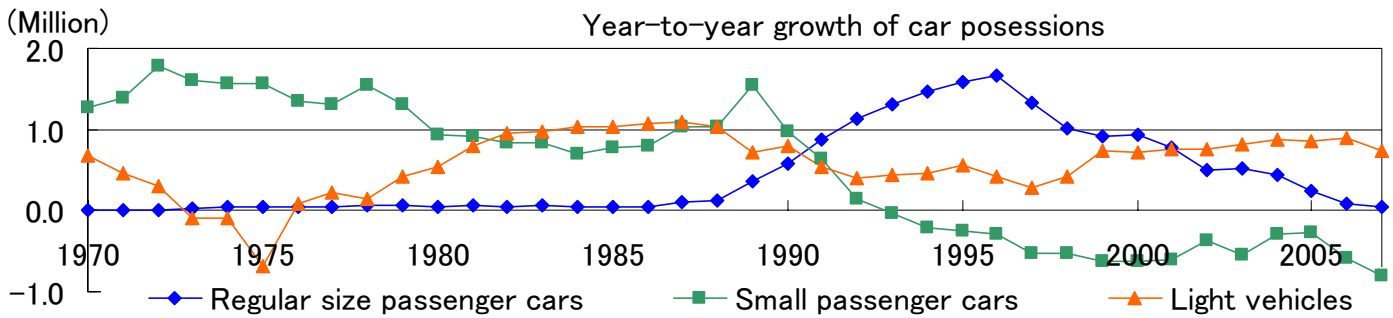
運輸部門は日本の排出量の約2割を占める。その大半が自動車からの排出

Trend of car possessions

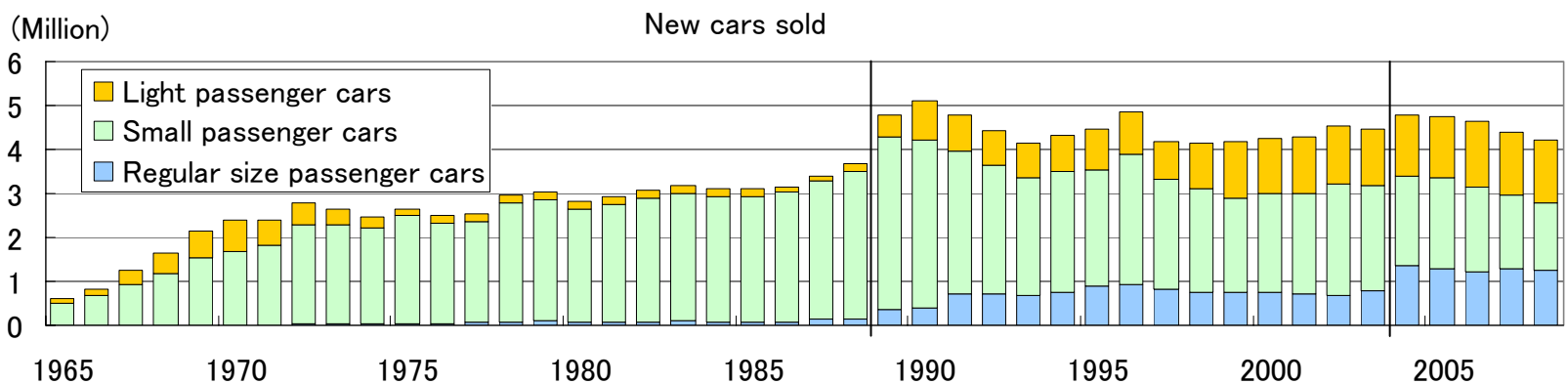
保有



増減

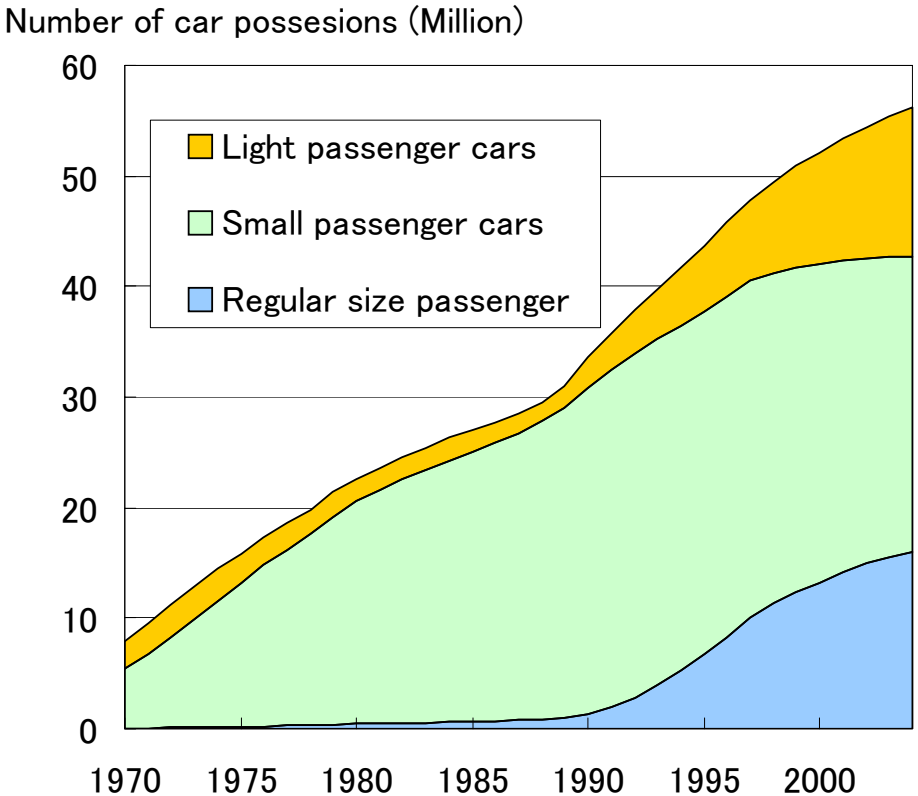


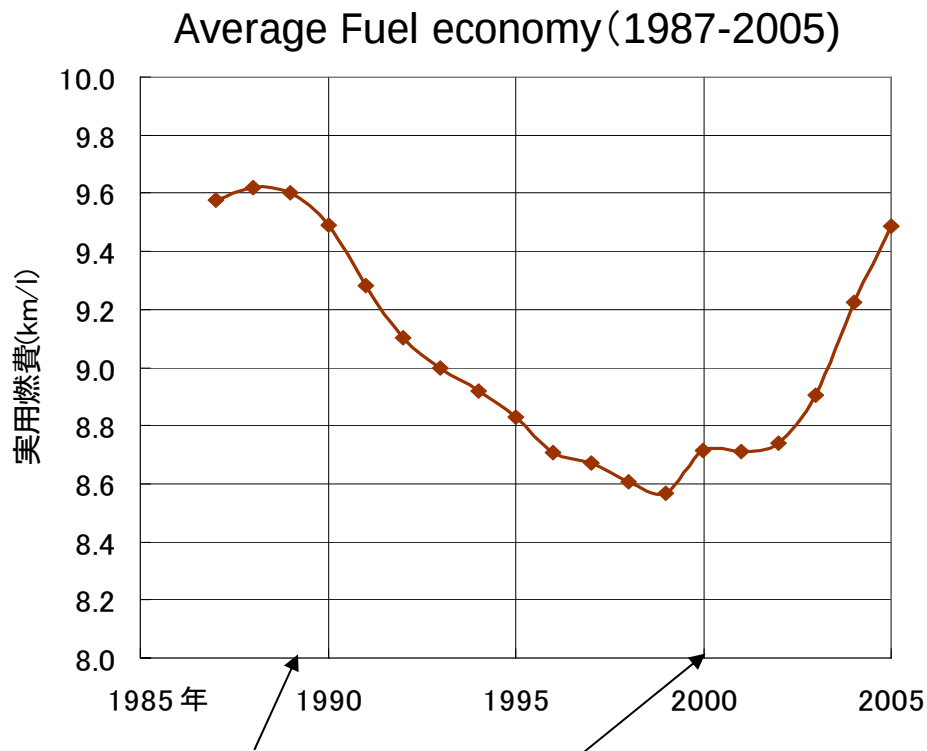
販売



乗用車の保有台数はピークを迎えた

Size of passenger cars has been getting larger and causes larger CO_2 emissions





Tax system change 税制改正：
1989　普通車優遇　物品税廃止
自動車税低減
2000　低燃費車優遇　自動車税低減

Average fuel economy had been getting worse in 90's

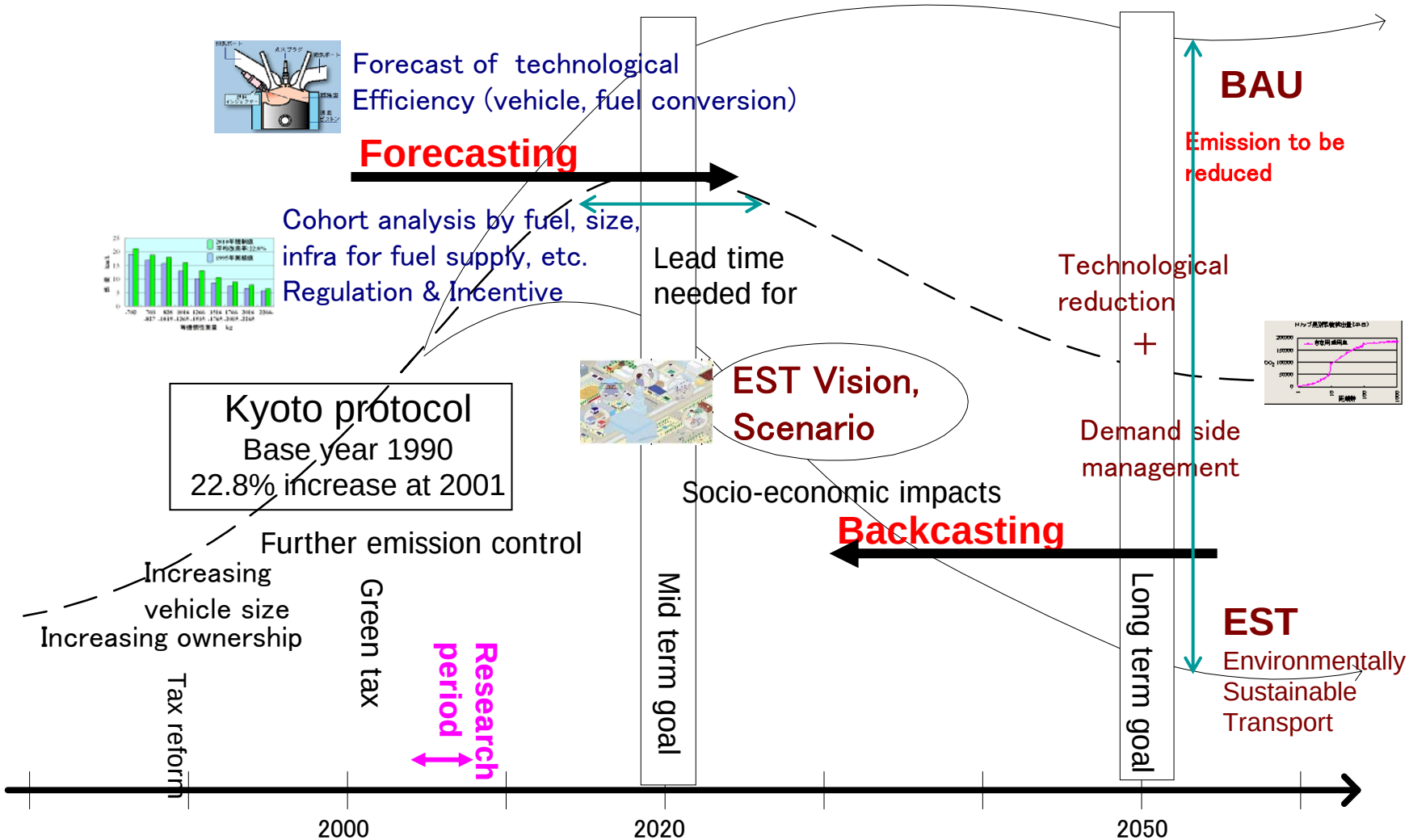
税制の影響が明らか

Contents

Overview of the project across time horizon

(1)Assessment of effectiveness of new technologies and their policy measures taking lead time into account

(2)Proposal of long-term emission reduction scenarios by back-casting



技術を中心とした2020年シナリオと需要変化を組合せた2050年シナリオ

Survey and assessment of automotive technology

$$\frac{Fuel}{Vkm}$$

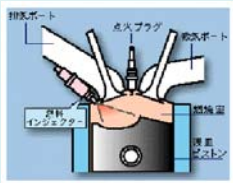
Drive Wheel — Fuel tank (Charge) Tank — Primary energy Well

(Charge) Tank to Wheel — Well to (Charge) Tank

Well to Wheel

$$\frac{CO_2EF}{Fuel}$$

The Well to Wheel approach to assess total efficiency

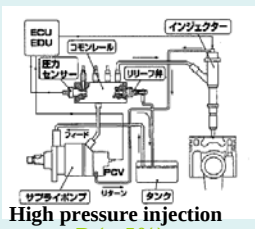


●筒内直接噴射方式構造図

G (10～30%)

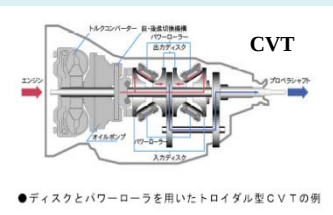
variable valve

G (～5%)



High pressure injection

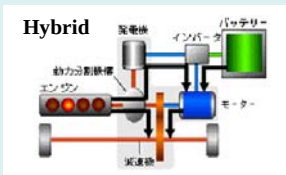
D (～5%)



CVT

●ディスクとパワーローラを用いたトロイダル型ＣＶＴの例

G (5～10%)



Hybrid

G, D (30～100%)

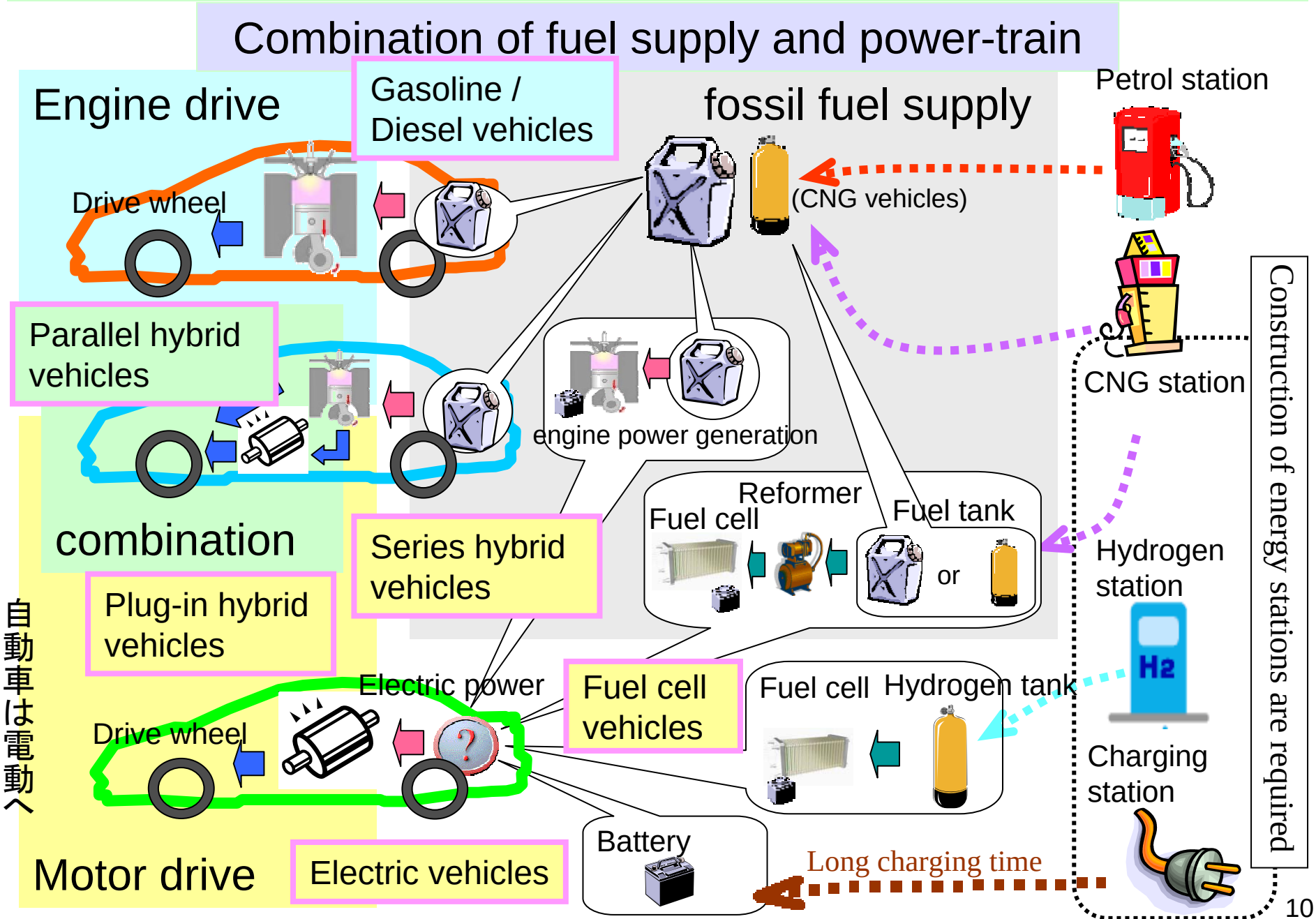
Survey of technical information

名称		NM	TRGSHB	ガソリンハイブリッド乗用自動車	
概要		AB	同一車体の中に2つの動力機関(モーター、エンジン)を持つことにより、双方の利点を活かして省エネルギーや排ガスの低減する。特別なエネルギー供給インフラが不要。		
	技術的課題				
	制度的課題				
	社会的課題				
	副次的効果				
代替技術	1	T1	TRGSCV	レシプロエンジンガソリン乗用車	
	2	T2			
基本ユニット		UN	台数	1	台
供給サービス量	1	S1	自動車旅客輸送量	15,000	人km/年
	2	S2			
エネルギー消費量	1	E1	ガソリン	500	kgoe/年
	2	E2			
温室効果ガス排出量	1	G1	CO2	642	kgCO2/年
	2	G2			
稼働量		OR	100 100	%	
固定費用		FC	2200000[2010]; 2000000[2020]	円	
年間維持管理費用		MC	50,000	円	
耐用年数		LT	10	年	
市場導入可能年		IY	1997	年	
市場撤退年		WY	9999	年	
普及量		ST	2000年 50,000	台	
普及見通し(上限)		MX	%S1 10%[2010]; 100%[2020]		

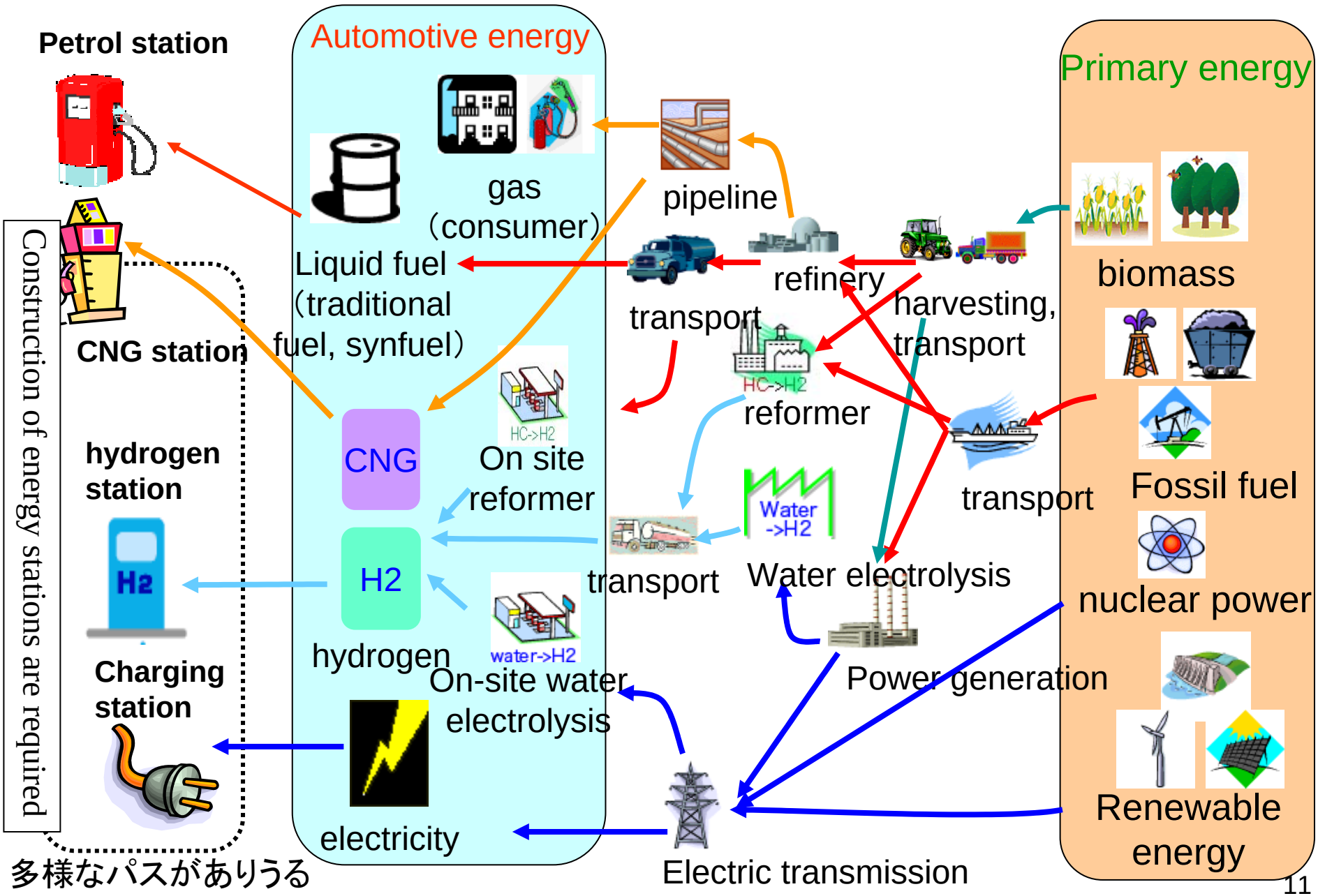
Environment Option Database

車両要素技術と燃料調達経路を考慮した自動車技術の評価

Automotive technologies altering engine-drive vehicles

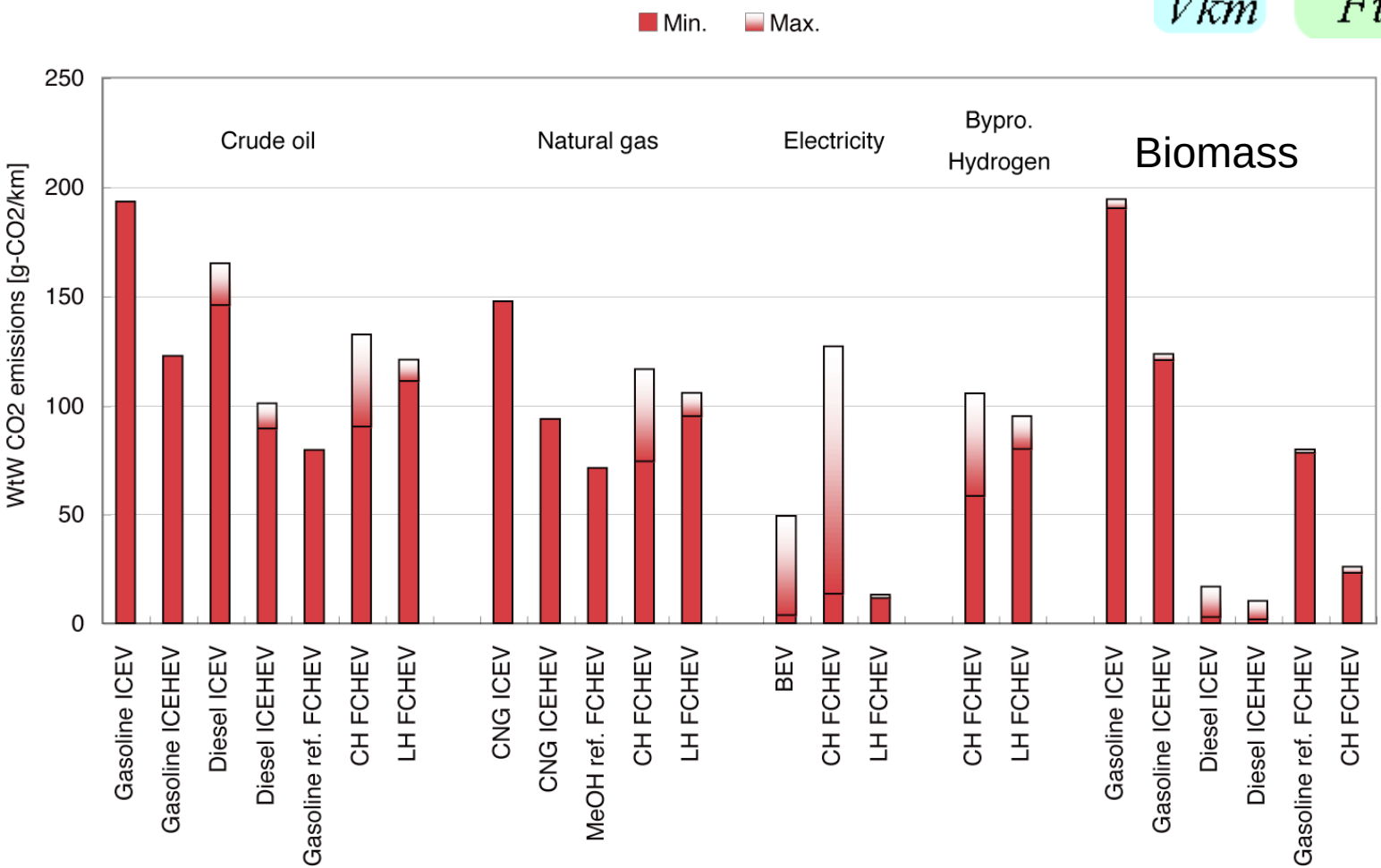


Paths from primary energy to automotive energy



Well to wheel CO_2 emissions

$$\frac{Fuel}{Vkm} \quad \frac{CO_2EF}{Fuel}$$

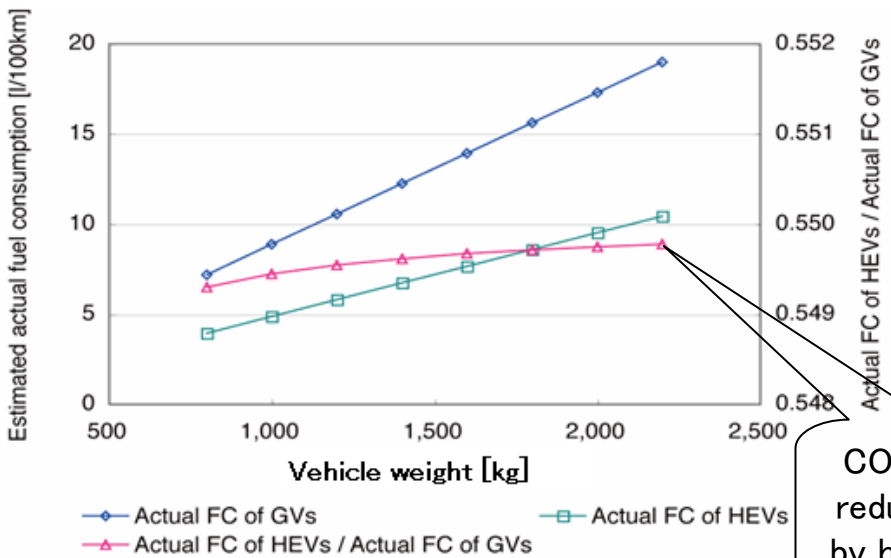


- Although CO_2 emissions from FCEV are less than HV, FCEV has got problems to be solved such as FC durability, FCEV cost and the way to produce and supply hydrogen. Therefore, wide spread of HVs is thought to be one of the feasible and effective measures in 2020.

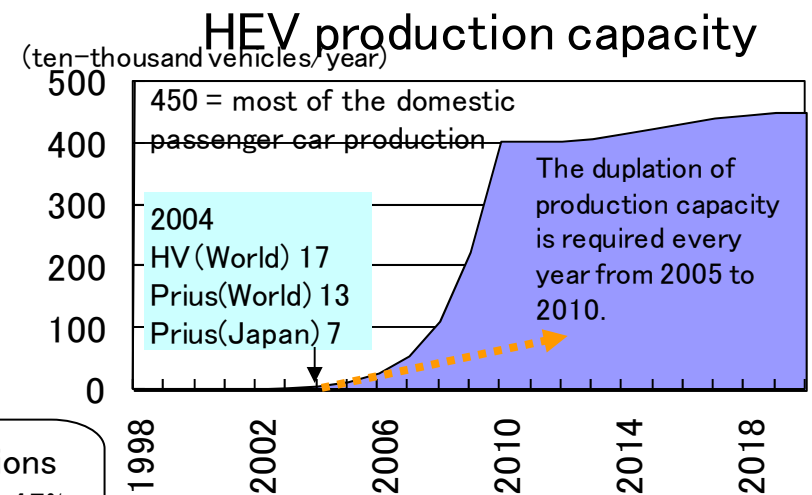
排出係数が少ない燃料電池車やバイオ燃料車は、費用と量の確保等に課題

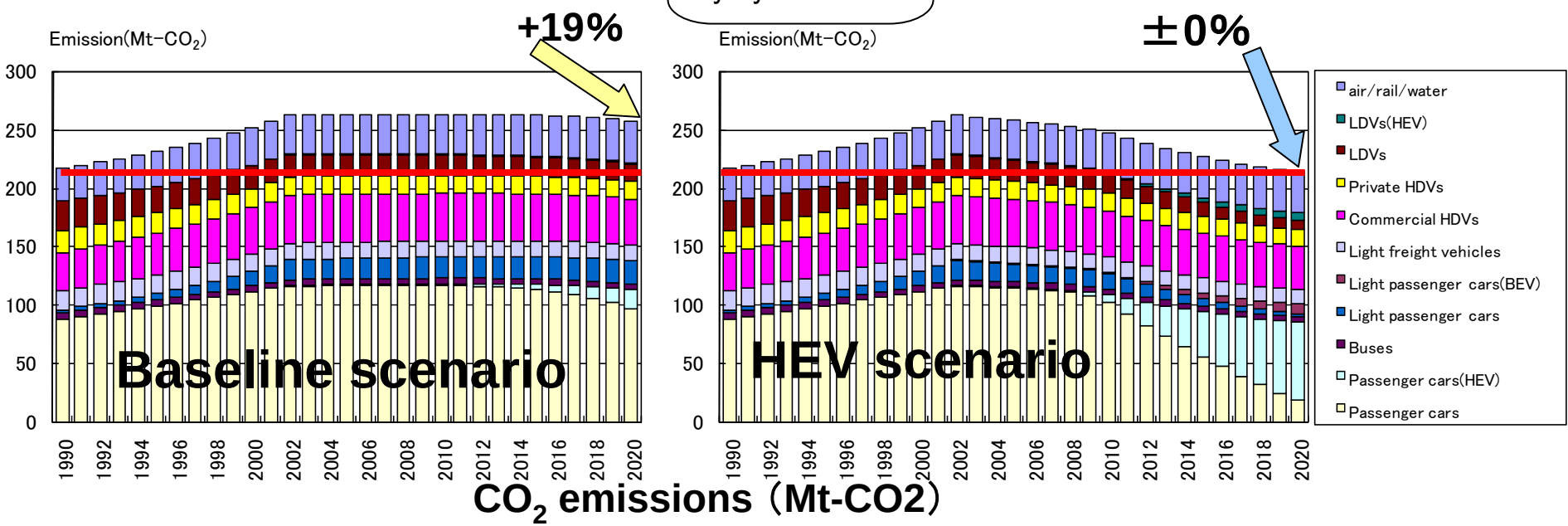
JHFC(2007)

Scenario: Penetration of Hybrid Electric Vehicles（HEV）



CO_2 emissions reduced by 45% by hybridization.

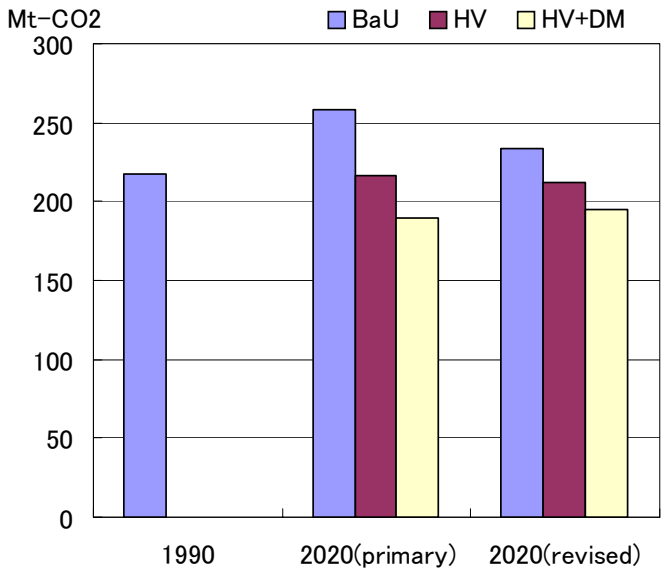




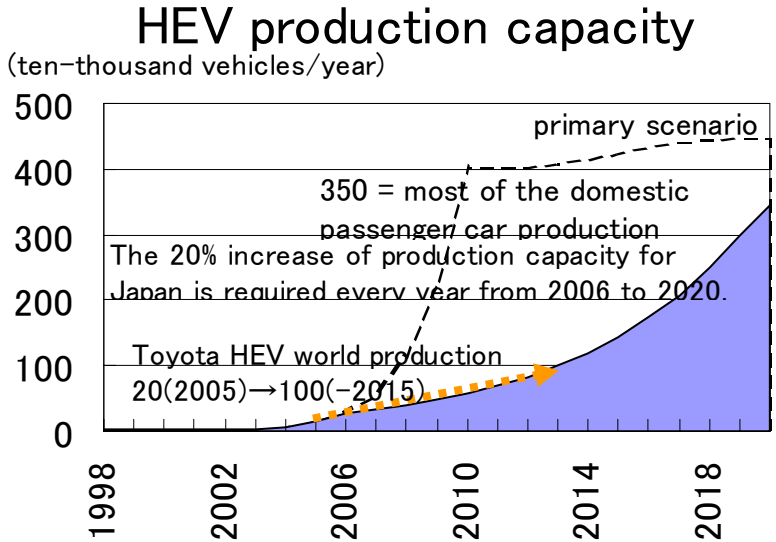
CO_2 emissions（Mt-CO2）

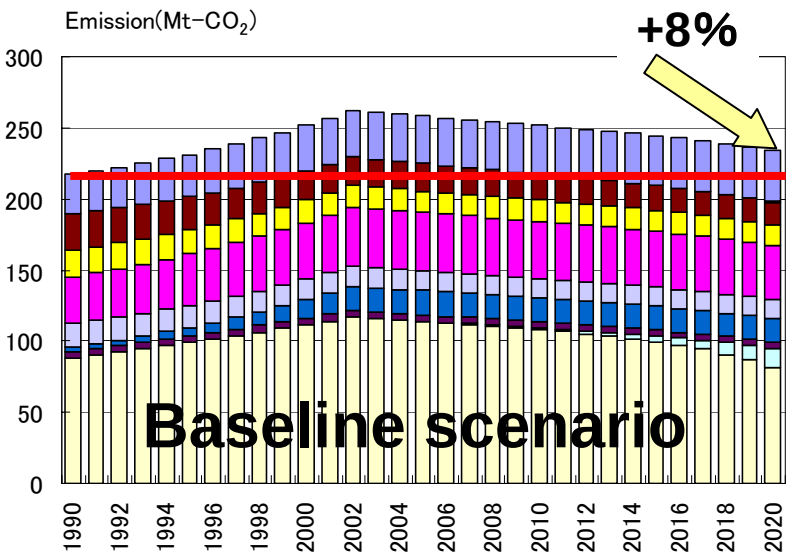
（初期版）ハイブリッド車の大量普及で2020年+19%を±0%に

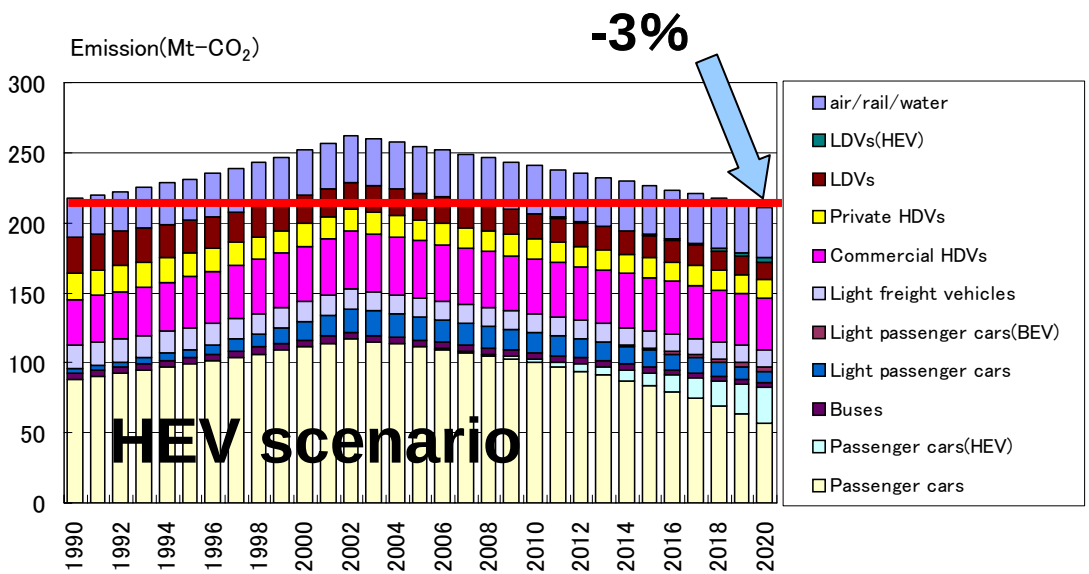
Revised Scenario: Penetration of Hybrid Electric Vehicles（HEV）



研究期間中に2020年シナリオを更新した。BAUの将来交通量は約1割減となり、対策のハイブリッド車普及率を約80→40%にした。時計が進む一方で達成可能性は向上した。







CO_2 emissions（Mt-CO2）

（改訂版）ハイブリッド車の大量普及で2020年+8%を-3%に

Outline of 2020 scenarios

Scenario	**Baseline**	**HEV**	**+Demand Management**
Penetration of HEVs and BEVs	Pass. Car (PC) HEVs 20% Low duty vehicle (LDV) HEVs 10%	PC- HEVs 37% LDV-HEVs 20% Light PC-BEVs 37%	
Fuel consumption of HEVs	40% reduction compared with the current fuel consumption of gasoline / diesel vehicles. LDV-HEV reduce 20% of fuel consumption of current LDV's）		
Improvement of fuel consumption （to 2002）	PCs, buses, LDVs reduce 10% of fuel.	PCs 20%, Buses 10%, Mini car 10%, Heavy duty vehicles 5%, LDVs15%	
Traffic volume （to 2002）	3% decrease of PCs 7% decrease of freight vehicles (FVs)		PCs -13% FVs -16%
Air, rail, marine transport	5% reduction of fuel consumption of air, rail and marine transport. Air transportation increase by 20% compared with current volume.		
CO_2 emissions (compared to 1990)	+8%	-3%	-10%

さらに交通需要管理により-10%へ

Contents

Combination of countermeasures which reduce 20% each could cause over 70% reduction as total

Demand management
e.g. by information-communication technology
[transport-service per capita]

(1-0.2)x(1-0.2)x(1-0.2)x(1-0.2)x(1-0.2)x(1-0.2)=0.26

Modal shift to reduce CO_2 EF per passenger-km or ton-km

Improve fuel economy
[Fuel consumption per vehicle-km]

$$\frac{CO_2}{capita} = \frac{TransServ}{capita} \times \frac{Pkm(Tkm)}{TransServ} \times \sum_{Mode}\left(\frac{Vkm}{Pkm(Tkm)} \times \frac{Fuel}{Vkm} \times \frac{CO_2EF}{Fuel}\right)$$

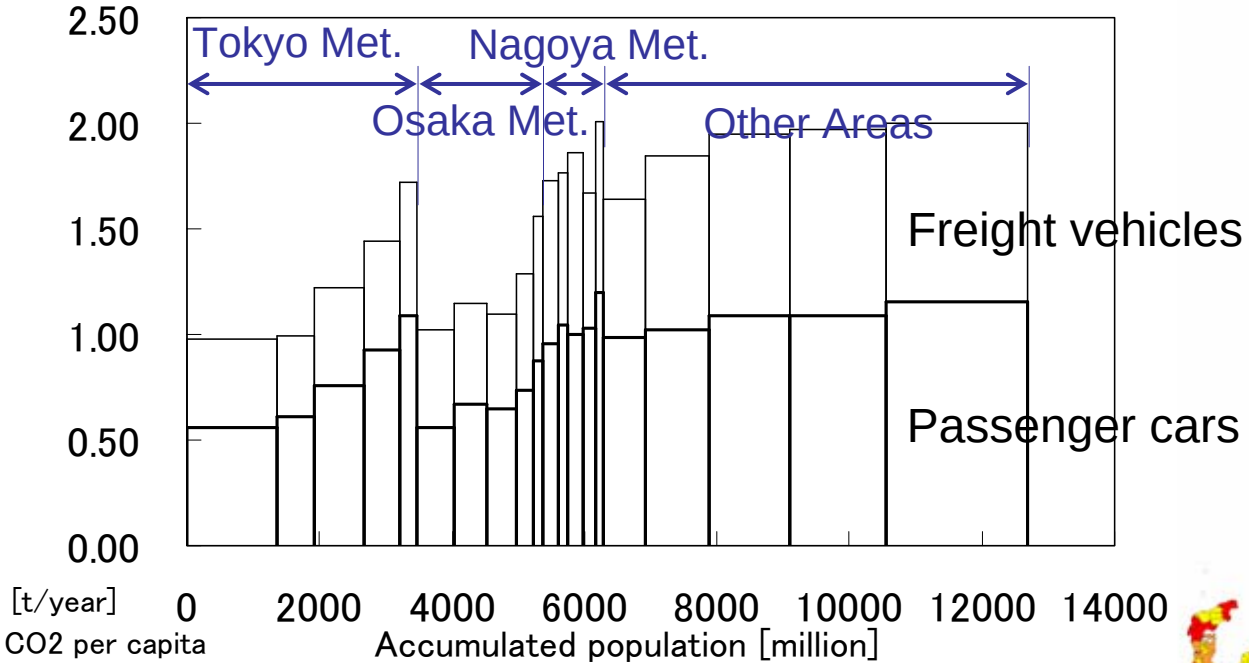
Improve load factor
[vehicle-km per Pkm(Tkm)]

Improve accessibility
[passenger-km or ton-km per transport-service]

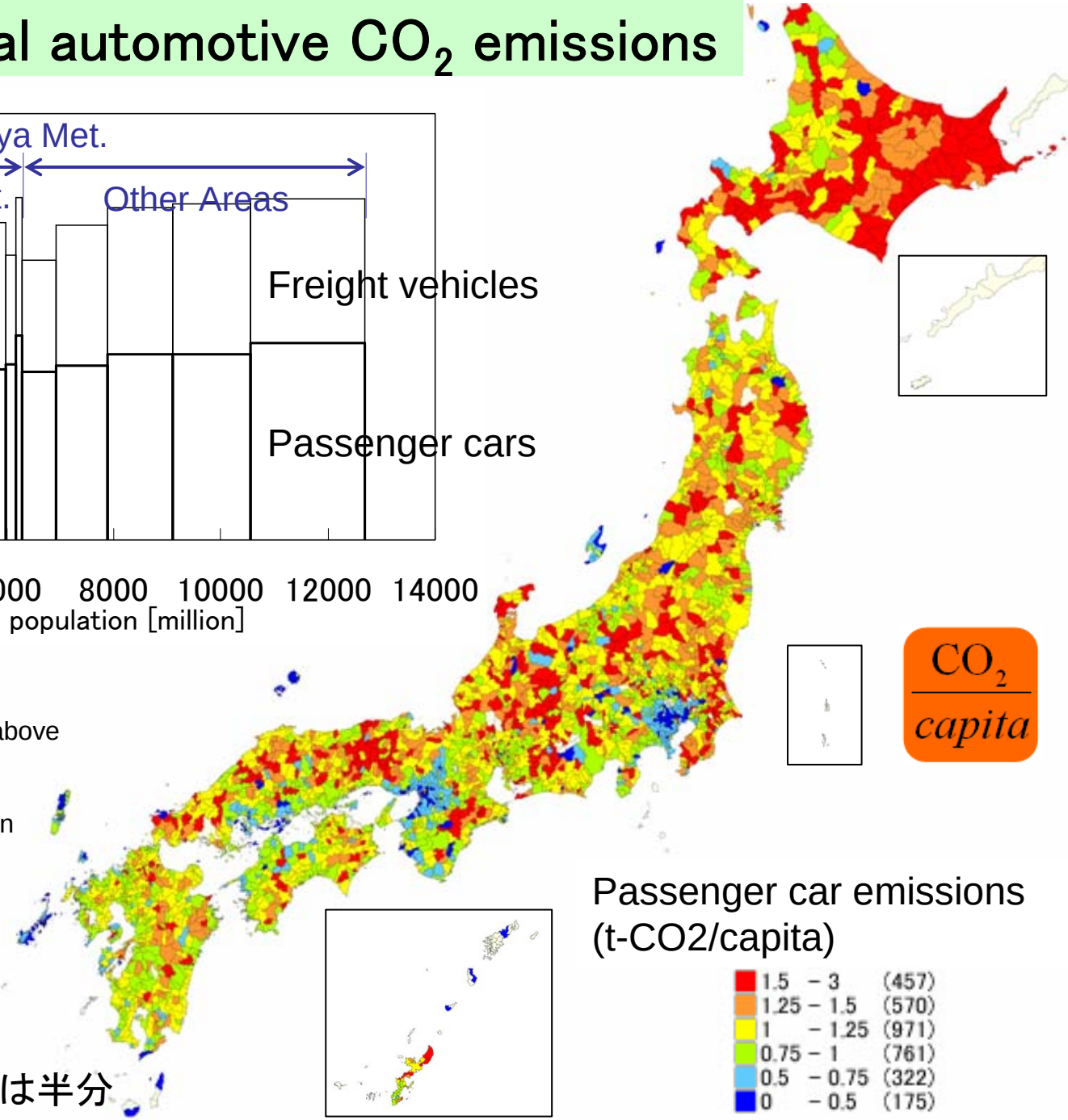
Introduce low carbon energy
[CO_2 emission factor per fuel consumption]

対策を組み合わせることで大きな削減が可能

Estimated regional automotive CO_2 emissions

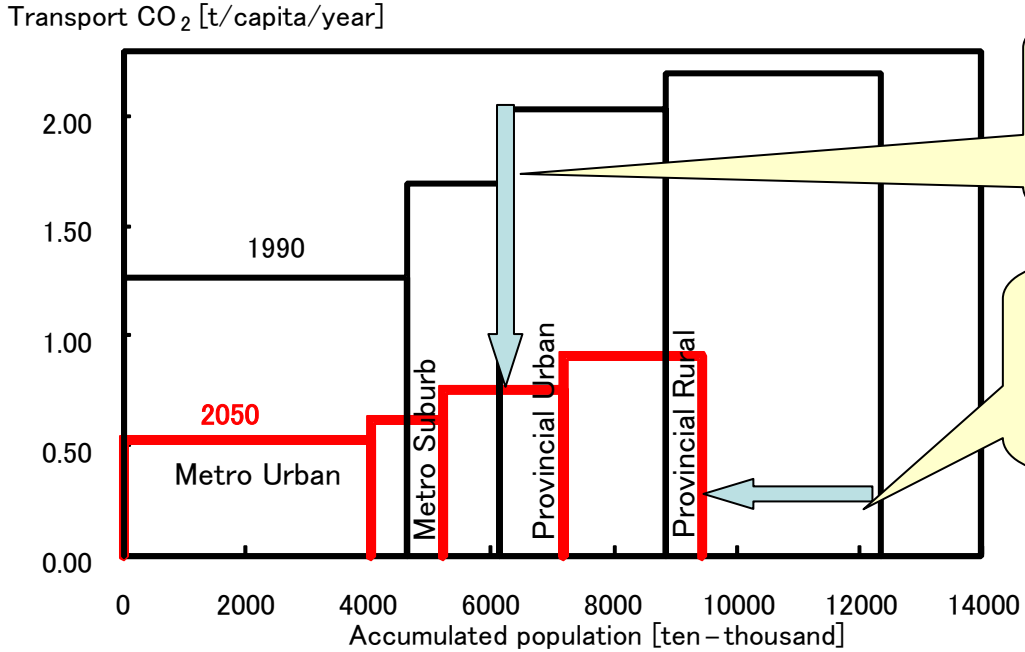


Each Area is categorized in
1. Major cities
2. Cities with a pop of 0.5 million and above
3. Cities with a pop of 0.3 and above
4. Cities with a pop of 0.1 and above
5. Cities with a pop less than 0.1 million
6. Counties



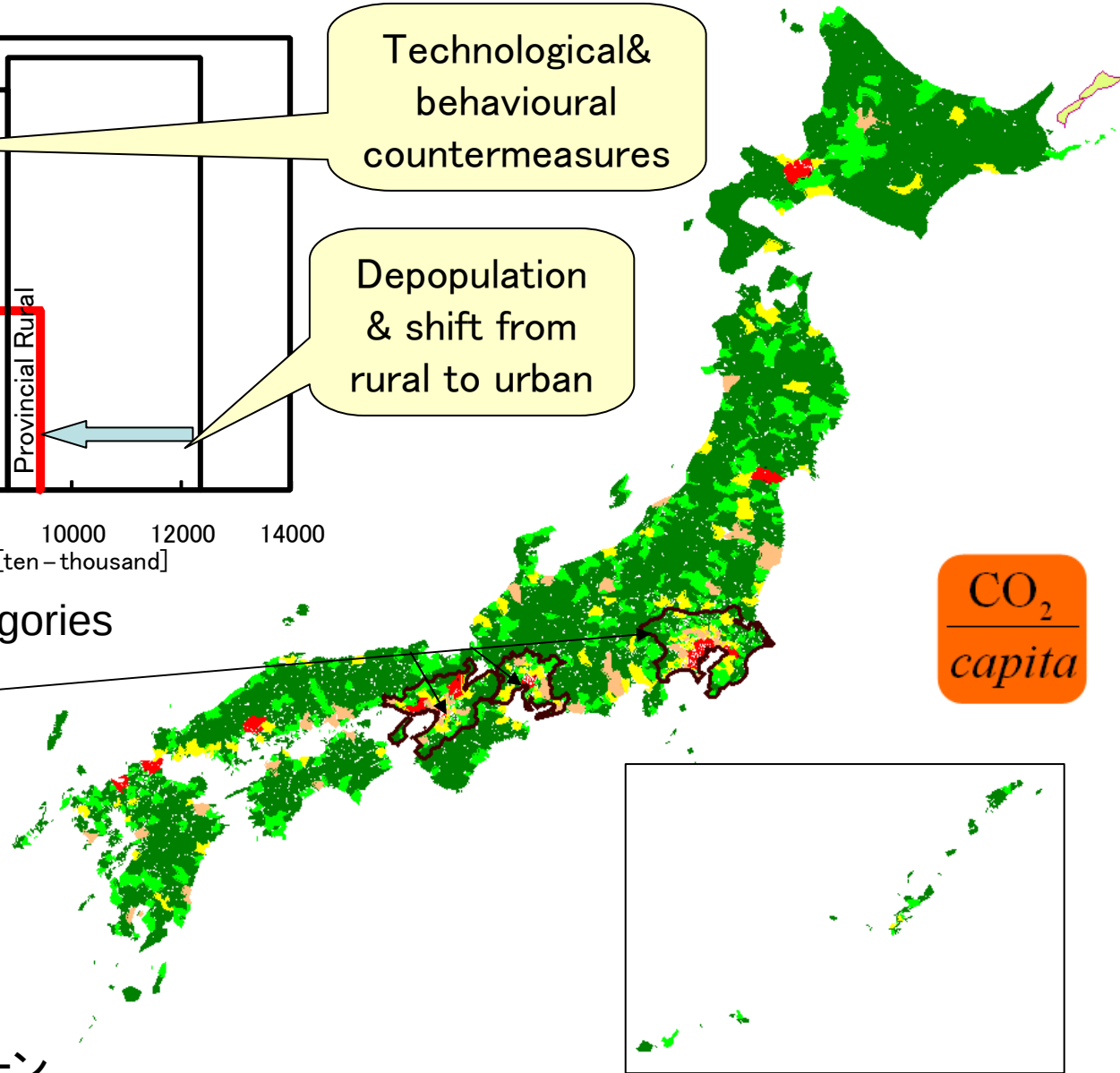
都市部の一人当たり排出量は半分

Regional categories



Technological& behavioural countermeasures

Depopulation & shift from rural to urban



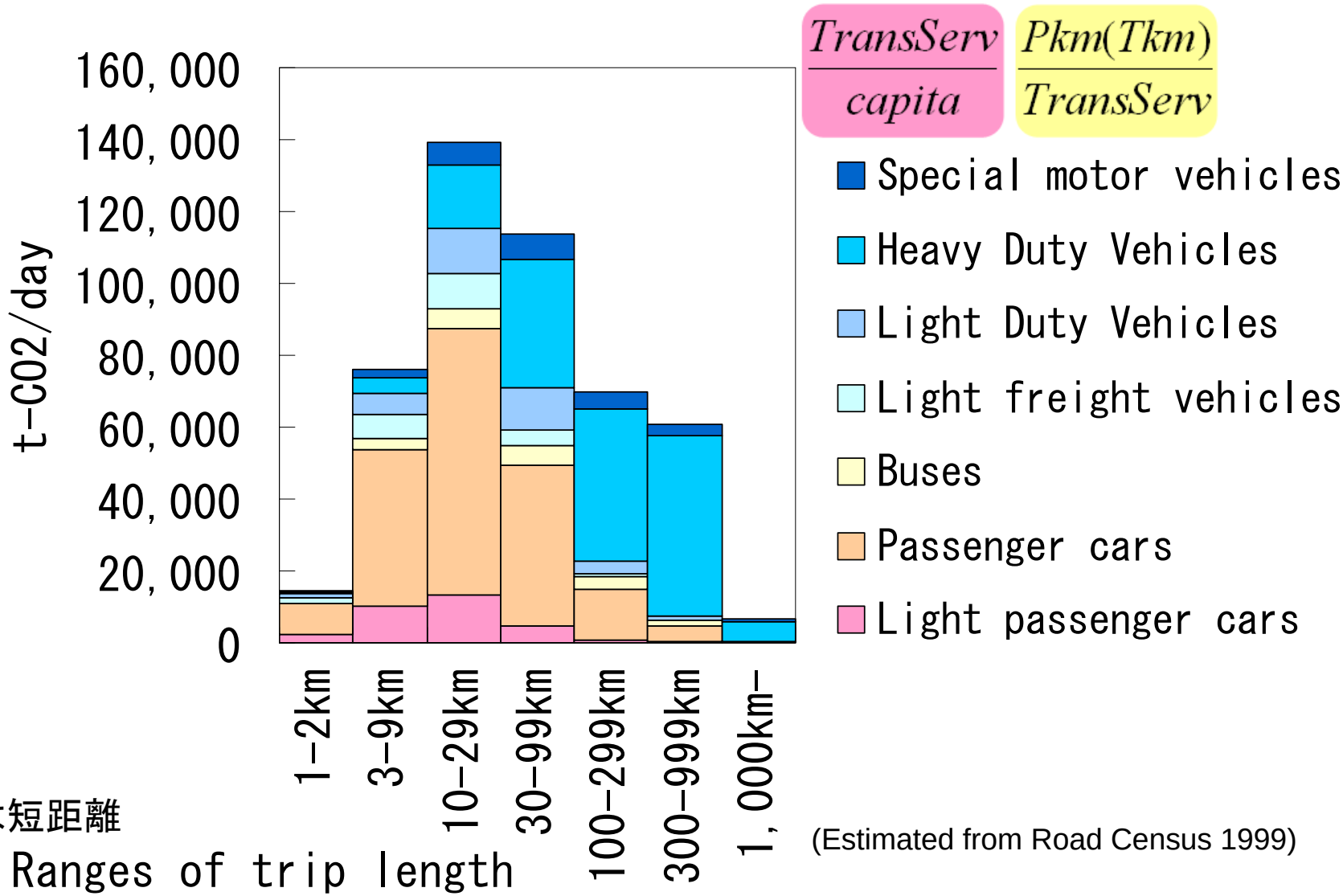
Index of the regional categories

Rural: Metro, Provincial

Urban

地域別の対策と人口減少パターン

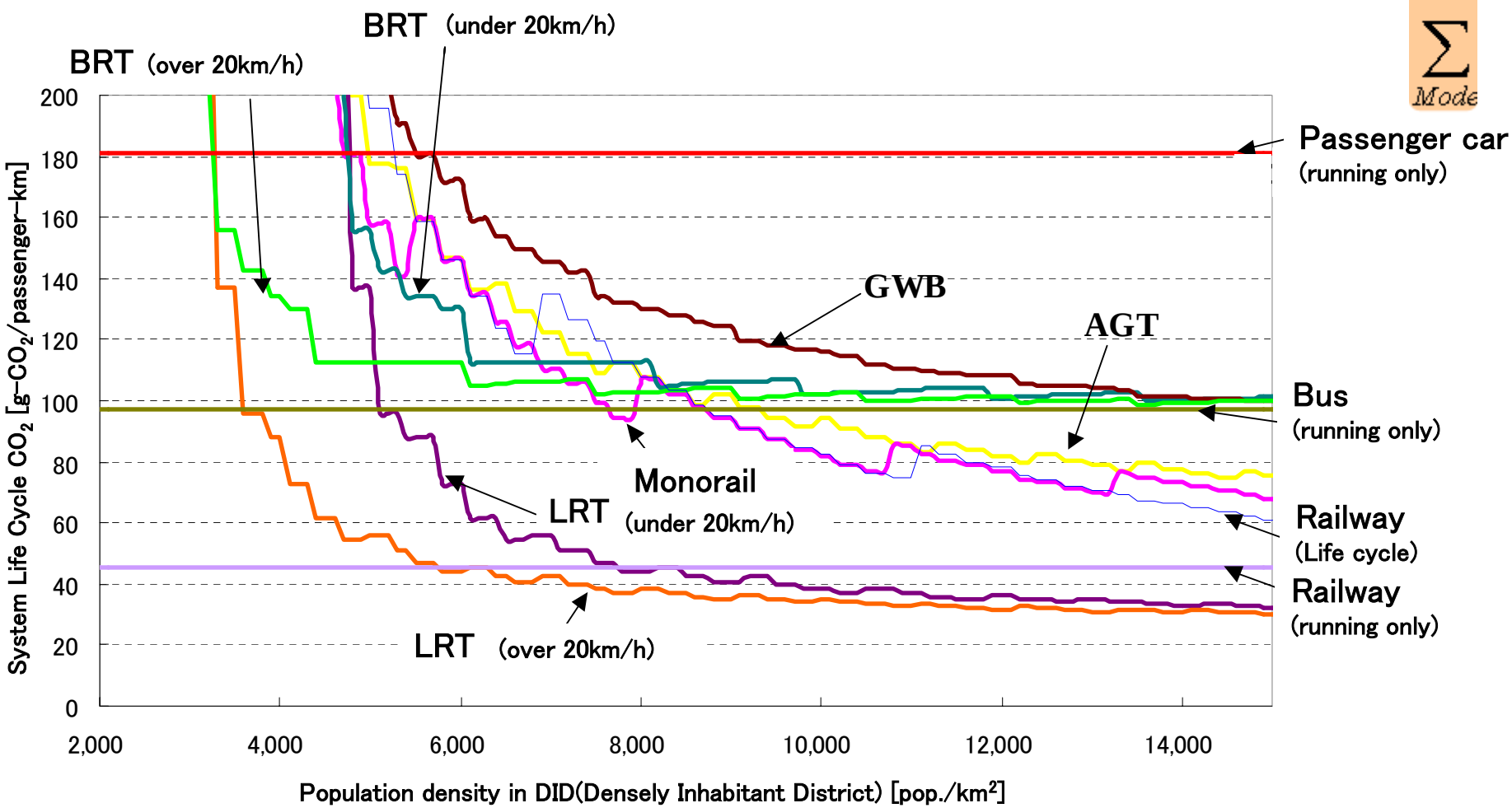
CO_2 emissions of each vehicle category by trip length ranges



乗用車は短距離

(Estimated from Road Census 1999)

Effects of population density on life cycle CO_2 of various transit system



LRT (Light Rail Transit)・BRT (Bus Rapid Transit)・
AGT (Automated Guideway Transit)・GWB (Guideway Bus)

DIDではLRTが有効

S-3-5(2007)Summary Report of Research Results under the GERF

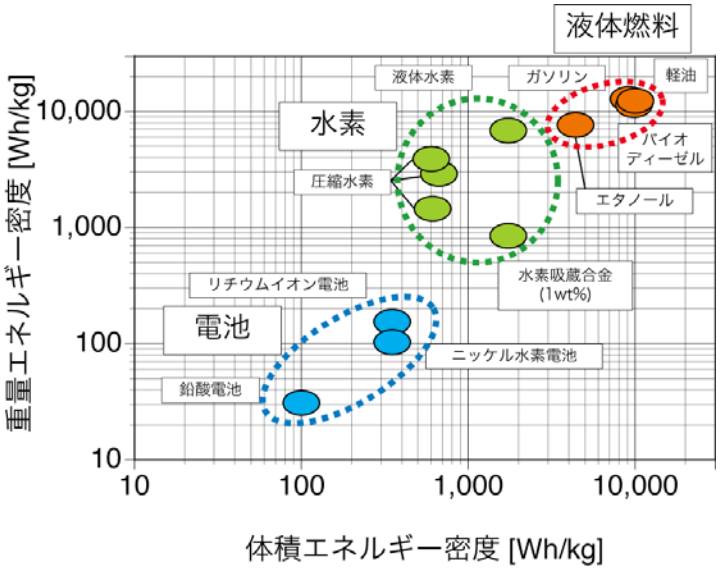
TOD (Transit Oriented Development) in local city

Toyama Light Rail(2006.4.26-)

- Lack of public transport for cities of less population than one millions.
- It has been difficult to manage LRT because “self-supporting accounting system” was required.
- Upgrading from traditional tram has started.

地方中核都市等の都市計画と公共インフラ整備が重要

New concepts for personal mobility



電池搭載は小型近距離に適性

Toyota i-REAL

$$\frac{Vkm}{Pkm(Tkm)} \quad \frac{Fuel}{Vkm} \quad \frac{CO_2EF}{Fuel}$$

Kawamura cycle KE

Yamato transport/ Electric bicycle with a cart

the Segway Human Transporter

個人利用の軽量電動車両にも大きな可能性がある

(catalog information)

Image of low carbon transport area

Intensive land use

Networking of proper modes on each areas

Enhance public transport and walking

$$\frac{TransServ}{capita}$$

$$\frac{Pkm(Tkm)}{TransServ}$$

$$\sum_{Mode}$$

$$\frac{Vkm}{Pkm(Tkm)}$$

$$\frac{Fuel}{Vkm}$$

土地利用と交通の計画が重要

Roadmap to reduce regional CO2 of passenger transport（Nagoya Univ.）

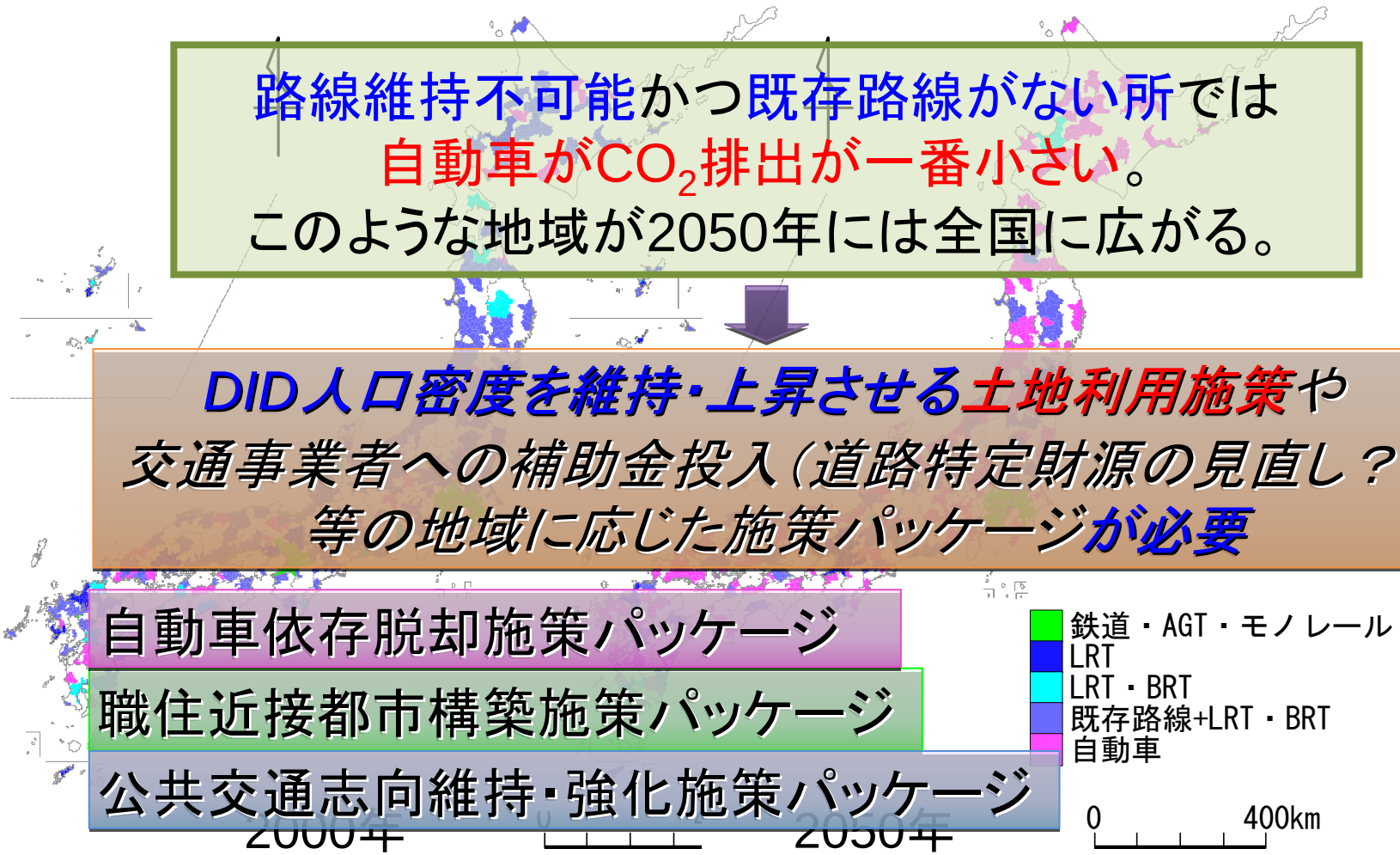
導入可能でCO_2排出が最小となる幹線輸送機関の分布

2050年は、2000年に対する人口減少率がDID地区と非DID人口地区で同じとした場合

路線維持不可能かつ既存路線がない所では
自動車がCO_2排出が一番小さい。
このような地域が2050年には全国に広がる。

DID人口密度を維持・上昇させる土地利用施策や
交通事業者への補助金投入（道路特定財源の見直し？）
等の地域に応じた施策パッケージが必要

自動車依存脱却施策パッケージ
職住近接都市構築施策パッケージ
公共交通志向維持・強化施策パッケージ



地域に応じた施策パッケージでCO_2削減

2050Vision: Passenger transport

	Metro Urban	Metro Suburb	Provincial Urban	Provincial Rural	Total
Compact neighborhood	△ Rehabilitation	○ Rehabilitation	△ Rehabilitation	○Compact Settlement	112->33Mt To 1990 − 70% Including (Inter-city Passenger: 30km-) Index: ◎: − 30% ○: − 20% △: − 10% ×: no room
Compact city	△City center renewal	△Withdrawal	△City center renewal	×	
Enhance public transit	△Pricing	△Park & Ride etc.	○LRT	△van pool, shared taxi	
Improve load efficiency	△Utilize small vehicles		△Enhance sharing	×	
Improve fuel consumption	◎Urban mode	○local mode			
Low carbon energy	△less room for improve	○biofuel, Low Carbon Electricity for EV and PHEV etc.			
pop(million)	46→40	15→12	27→20	35→23	124→94
t-CO_2/capita	0.66→0.27	0.94→0.35	1.03→0.38	1.11→0.51	0.90→0.35

$\frac{TransServ}{capita}$

$\frac{Pkm(Tkm)}{TransServ}$

$\sum_{Mode}$

$\frac{Vkm}{Pkm(Tkm)}$

$\frac{Fuel}{Vkm}$

$\frac{CO_2EF}{Fuel}$

$\frac{CO_2}{capita}$

2050年の70%削減に向けたビジョンの例

2050Vision: Freight and inter-city passenger transport

	Inter-local Freight: 300km-	Inter-city Freight: 30-300km	Inner-city Freight: -30km	(Inter-city Passenger: 30km-)	Total
Supply Chain Management	○SCM		△SCM		106->32Mt To 1990 - 70% Excluding (Inter-city Passenger: 30km-) Index: ◎: - 30% ○: - 20% △: - 10% ×: no room
Compact city			○Short route	△～× Enhance modal shift	
Enhance public transit	○Marine transport, Rail	△Rail	△Hand cart	◎Rail, Expressway bus	
Improve load efficiency	△Low delivery frequency	△Cooperative delivery	○Cooperative delivery	○Car pooling	
Improve fuel consumption	○ITS, Fuel-efficient truck	◎ITS, Fuel-efficient truck	○ITS, Fuel-efficient truck	◎ITS, Fuel-efficient car	
Low carbon energy	△biofuel			○biofuel, PHEV etc.	
Mt-CO_2	33→10	49→15	24→7	(35→10)	

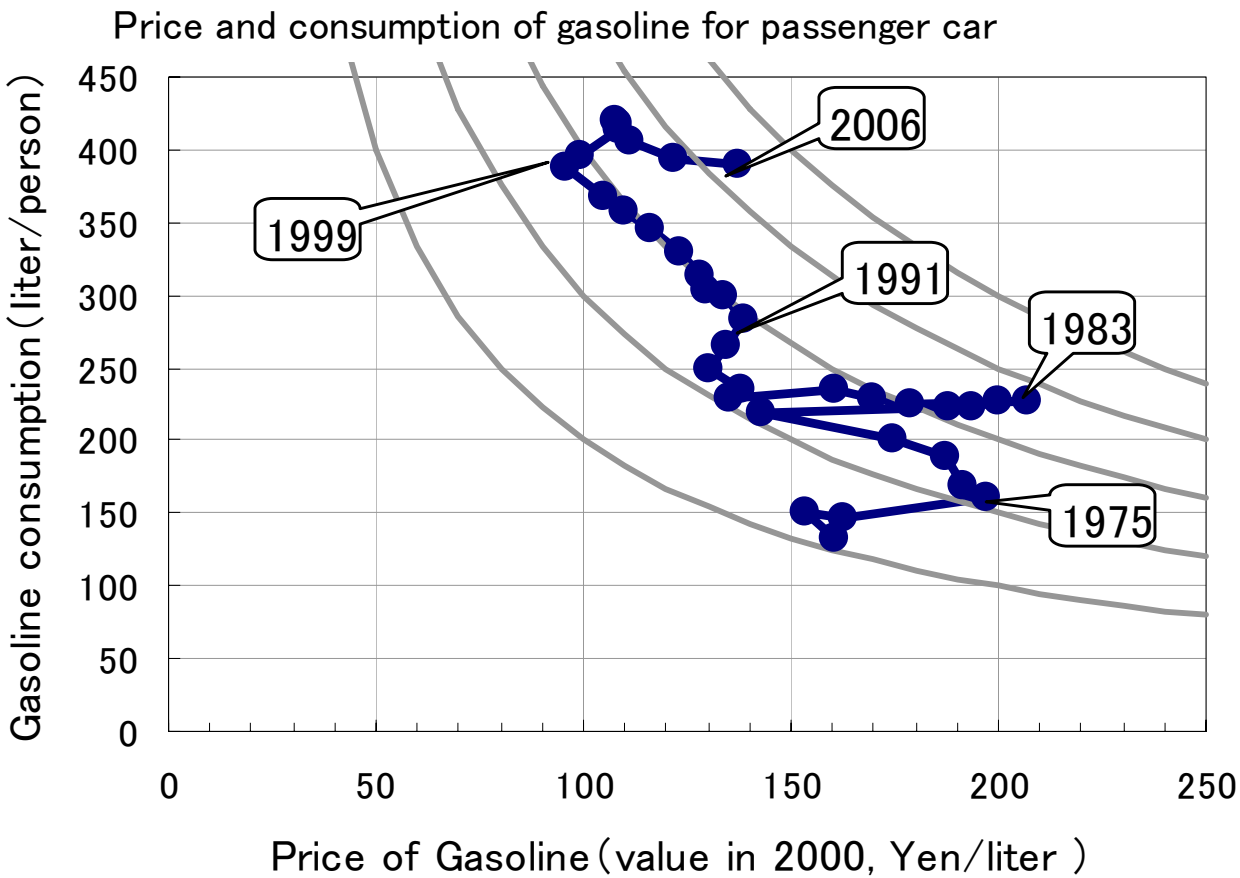
2050年の70%削減に向けたビジョンの例

Uncertain issues for 2050 Vision

- Globalization / Regionalism
- Demography : aging society
- Immigration / Emigration
- Spatial distribution of population
- Leading industries
- Busier life driven by IT vs. slow life
- Demand for high speed travel
- Trip frequency and length for leisure
- Price of fossil fuels (especially oil)
- The way to produce and supply hydrogen
- Public perceptions for nuclear technology
- Price of FCEVs
- Preferences on vehicle-size
- Investment balance between road and public transport

さまざまな不確実性がある

Gasoline price and consumption



Total expenses for gasoline per person was stable at 30-40 thousand yen from 1975 to 1999. Cheap price have cause large increase of car-usage in 90's. Higher gasoline price may cause large decrease of gasoline consumption in next decade.

中長期的にはガソリン価格の変化に対する反応が大きく出る可能性がある

Contents

2050Vision: Policy recommendations

		Metro Urban	Metro Suburb	Provincial Urban	Provincial Rural	Total
$\frac{TransServ}{capita}$	Compact neighborhood	△ Rehabilitation	○ Rehabilitation	△ Rehabilitation	○ Compact Settlement	112−>33Mt To 1990 − 70% Including (Inter−city Passenger: 30km−)
$\frac{Pkm(Tkm)}{TransServ}$	Compact city	△ City center renewal	△ Withdrawal	△ City center renewal	×	
$\sum_{Mode}$	Enhance public transit	△ Pricing	△ Park & Ride etc.	○ LRT	△ Control, shared taxi	
$\frac{Vkm}{Pkm(Tkm)}$	Improve load efficiency	△ Utilize small vehicles		△ Enhance sharing	×	
$\frac{Fuel}{Vkm}$	Improve fuel consumption	◎ Urban mode	◎ local mode			Index: ◎: − 30% ○: − 20% △: − 10% ×: no room
$\frac{CO_2EF}{Fuel}$	Low carbon energy	△ Renewal for improve	○ Biofuel, Overnight Charging Facilities for EV and PHEV etc.			
$\frac{CO_2}{capita}$	pop(million)	46→40	15→12	27→20	35→23	124→94
	t−CO_2/capita	0.66→0.27	0.94→0.35	1.03→0.38	1.11→0.51	0.90→0.35

Redevelopment

Renewal

Preferential tax treatments

Infrastructure, Subsidy

Approve shared taxi

Regulation of fuel consumption

Prefential tax treatments

Setting goals for Engineering developments

Provision of infrastructures

2050年70%削減ビジョン達成に向けた政策の例

Conclusion

- Opportunities for low-carbon transport:
  - Penetrating HEV for 2020
  - Combination of various countermeasures for 2050
- Best practice examples
  - More hybrid on the market
  - Increasing support for public transit (e.g. LRT)
- Linkages with other policy goals
  - Sound public finance in depopulating society
  - Accessibility for transportation poor in rural areas
- Policy recommendations
  - Preferential tax treatments
  - Regional plan of land-use and transport

ハイブリッド自動車を生かしつつ公共交通と軽量なパーソナルモビリティの組合せへ
人口減少等への対応とあわせて、低炭素化に向けた計画と税制誘導による推進が重要