Designing a Roadmap towards a low-carbon city in case of Kyoto

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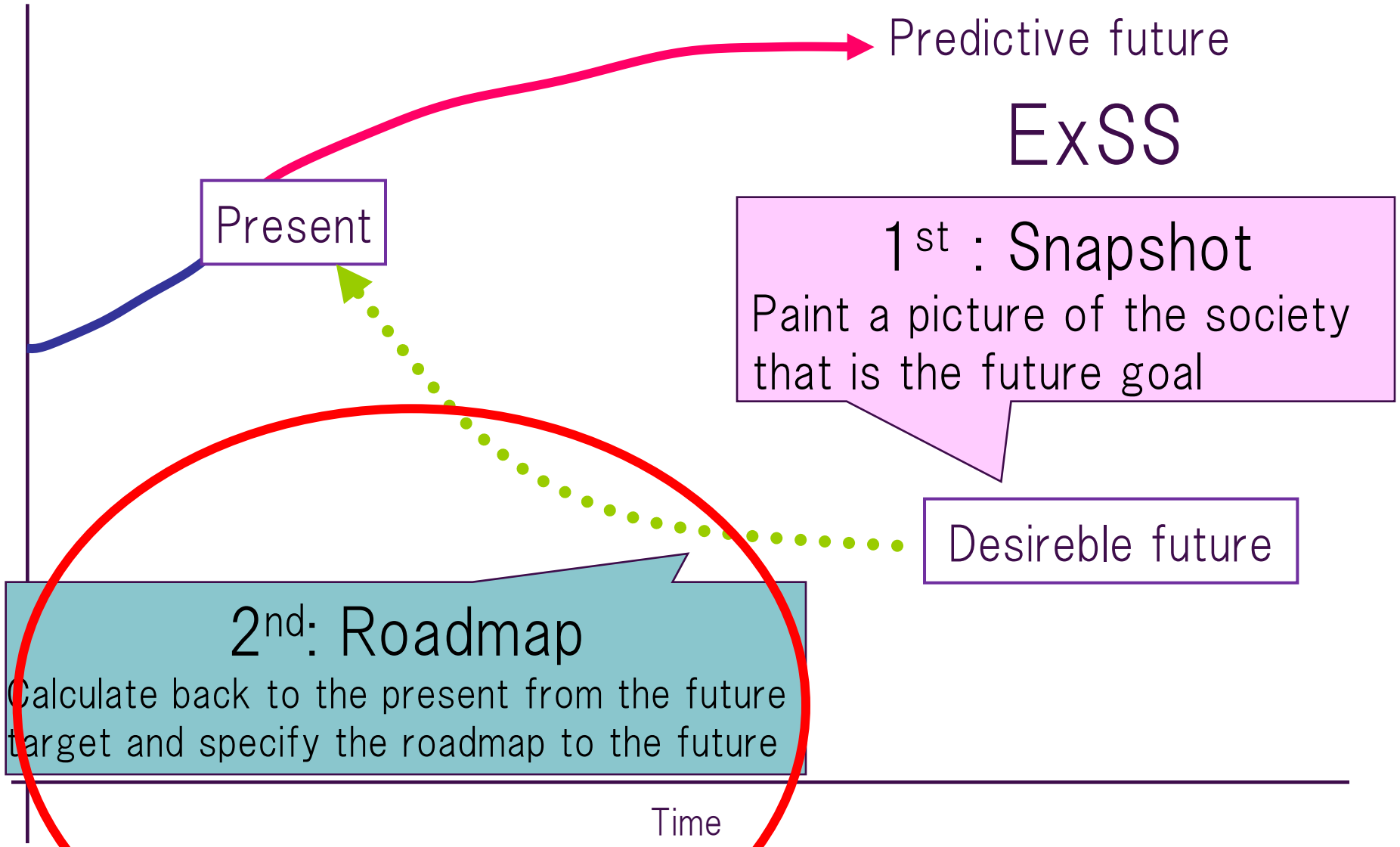
Two steps of backcastig



Development of Backcasting Tool (BCT)

- A dynamic model .
- Calculates the schedule of the measures in order to reach the target in the final year of the period.
- Considers not only diffusion of technologies but also measures like; R&D of technologies, planning of local and central governments, formulating a scheme, developing financial mechanism, social decision making, growing awareness of the public, etc.

Calculation mechanism of BCT

- Based on constraints and input information of measures, BCT estimates,
  - Schedule of measures
  - Emission reduction pass
  - Annual input resource.

- Integrated effect is also considered.

  (the effect of the measures other than GHG emission reductions, such as better transport, cleaner air, more green area, etc)

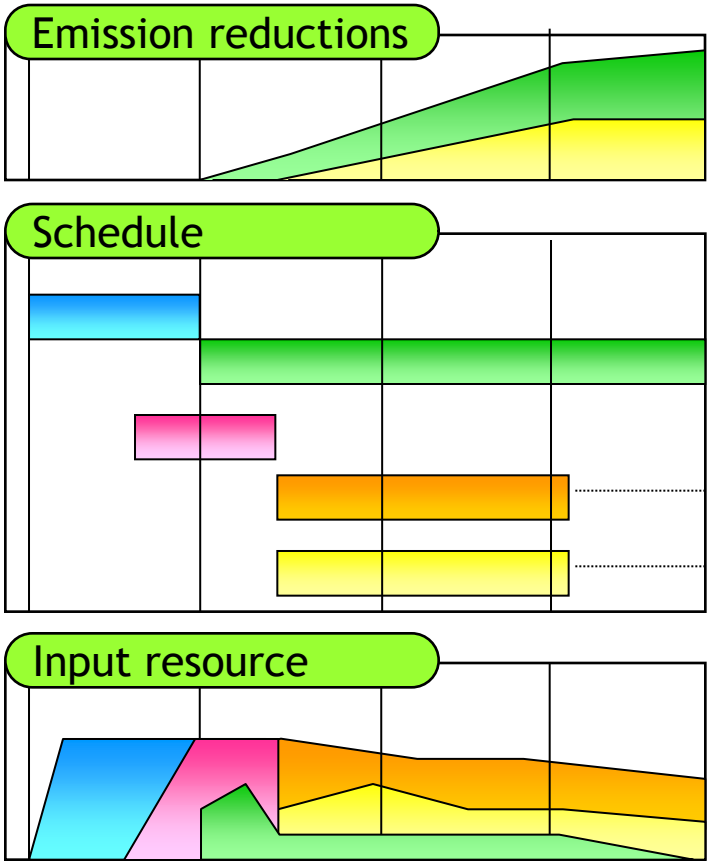
Constraints

Commercial year of technologies

Required resource input (human & financial)

Necessary years to implement

Direct GHG emission reductions



Upper bound of annual input resource

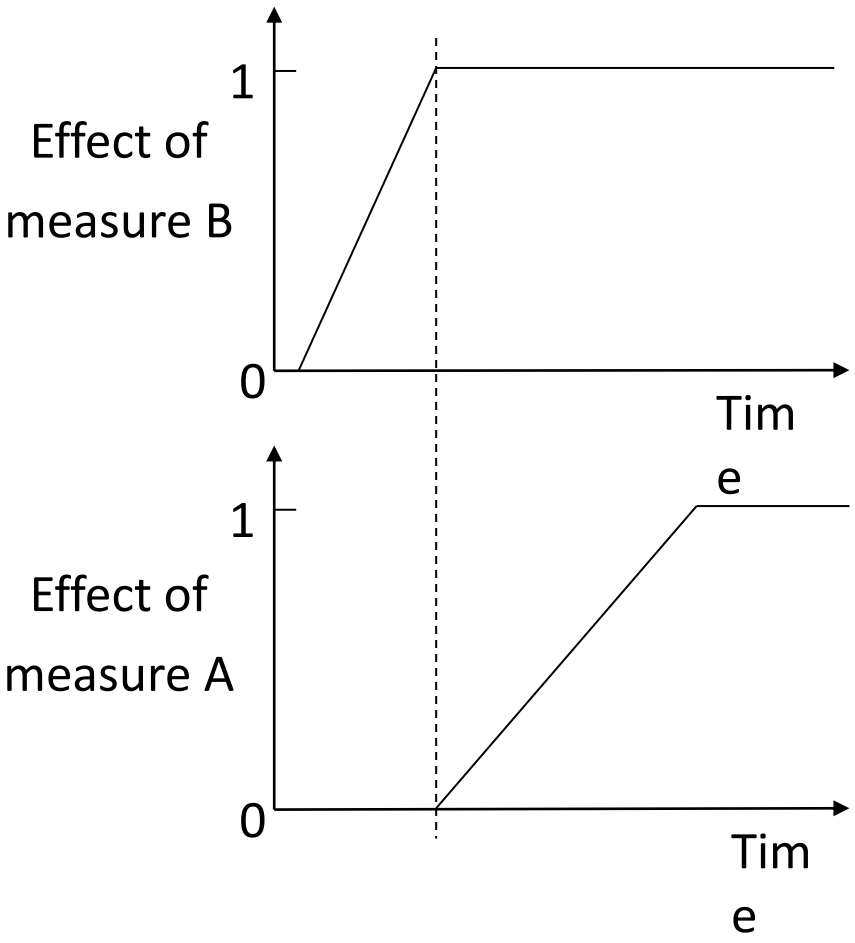
Relations between measures

State in the starting year

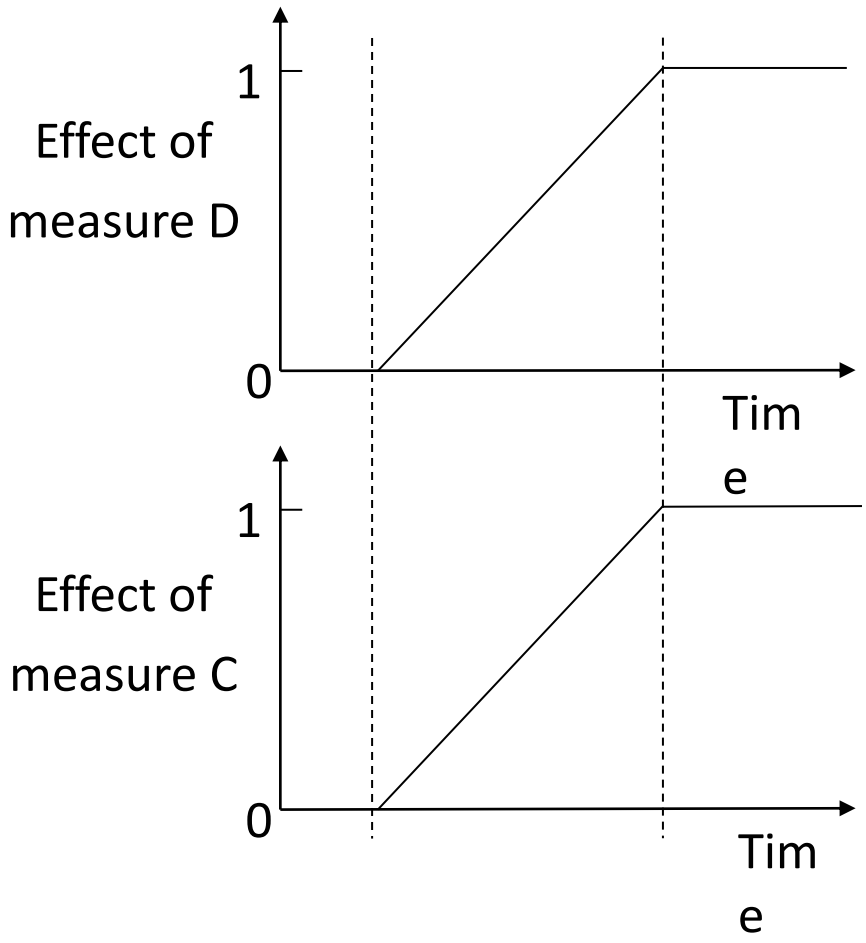
Integrated effect (ancillary and/or co-benefit)

Relations between measures

Pre-request option



Parallel option



Application to Kyoto city

- Base year: 2005
- Target year: 2030
- Target area: Kyoto City area
- Target activity:
  - Residential, commercial and industrial activity in Kyoto City area
  - Transport originated in Kyoto city area
- Target gas:
  - CO2 from fossil fuel combustion
  - CO2 from waste (plastic) incineration
- Low-carbon target: -40% compared to 1990 level
- Two cases:
  - Frozen at current levels case
  - Corrective measures case

Base year information

- Population 1.47million Household 0.65 million
- GDP 6.1 trillion yen
- Industrial structure f:s:t = 0.2 : 28 : 71
- Passenger transport demand 9251 Mp-km
- Freight transport demand 3484 Mt-km
- GHG emissions 8015 ktCO2 (5.5tCO_2/capita)

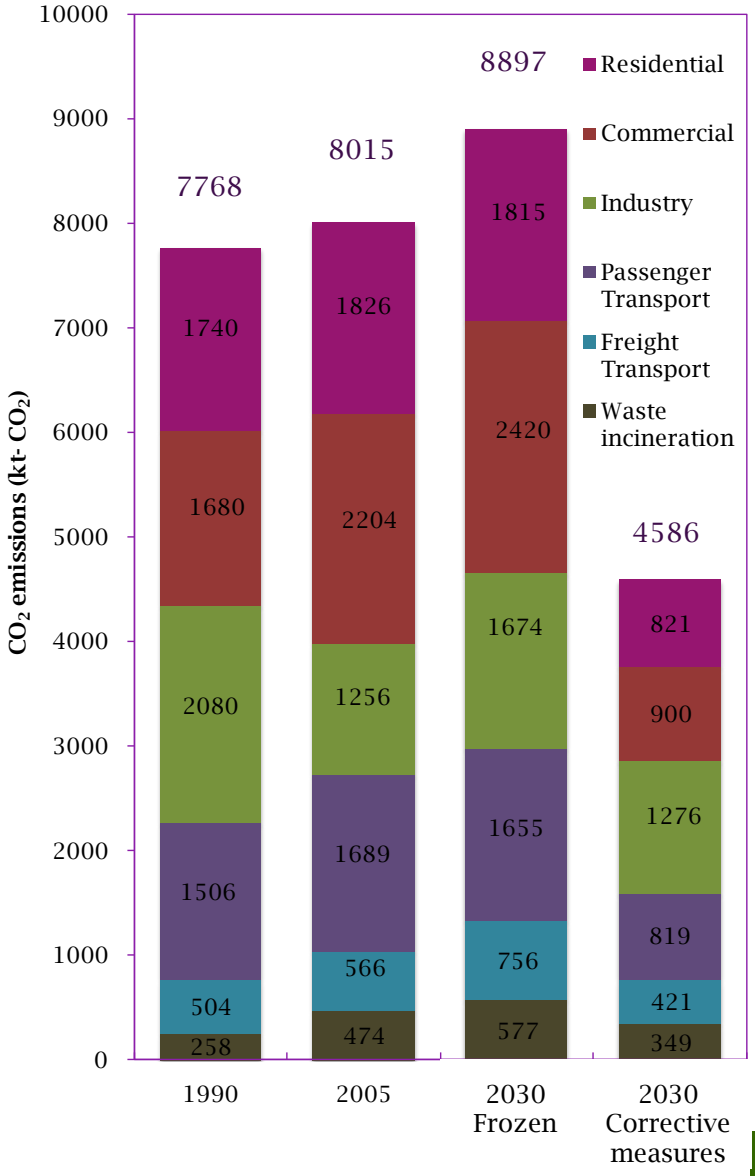
Data source:
京都市民経済計算,京都府民経済計算,工業統計,事業所・企業統計,国勢調査,京阪神都市圏旅客流動調査,京阪神物流基礎調査,学校基本調査,京都府産業連関表,京都市エネルギーバランス表,総合エネルギー統計エネルギーバランス表,京都市産業連関表,京都市産業連関表,平成12年産業連関表(日本),平成17年産業連関表(日本),自動車輸送統計年報,自動車保有台数月報,京都市統計書,鉄道統計年報,交通関係エネルギー要覧,陸運統計要覧,京都市地域新エネルギービジョン策定調査報告書 etc

Low carbon measures

- Around 100 measures
- Energy efficient technologies
- Fuel share: higher share of natural gas in end-use sectors
- Power supply: fuel shift and energy efficiency improvement
- Modal share: assumed higher share of bus and train than in “frozen at current levels” case
- Renewable energy: diffusion of PV and solar water heater among household and business buildings

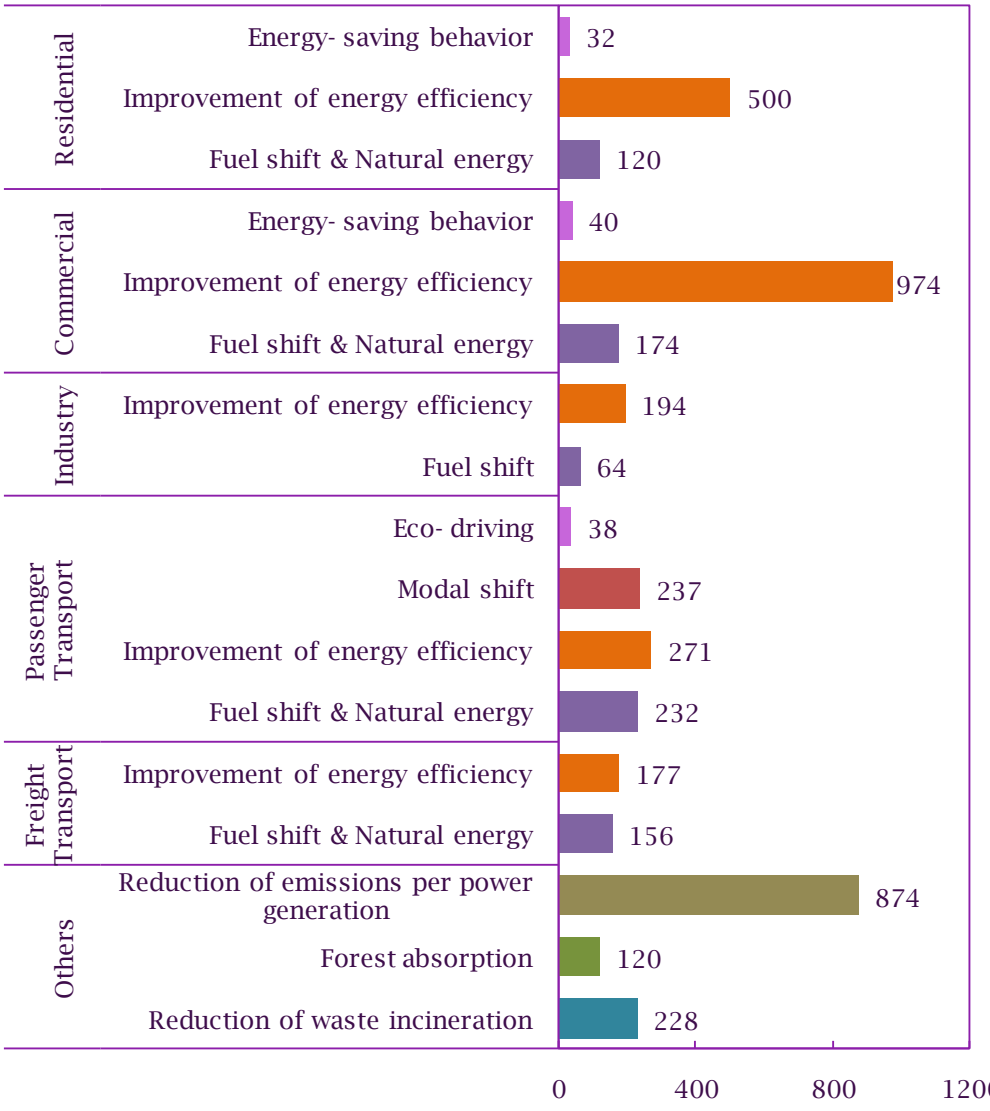
Snapshot of Kyoto City in 2030

	2005	2030	2030/ 2005
Population (10^4)	147	140	0.95
No. of households (10^4)	65	65	0.99
GDP (bill yen)	6124	8305	1.36
GDP per capita (mill yen/capita)	4.15	5.94	1.43
Gross output (bill yen)	9938	13400	1.35
Primary industry	17	19	1.13
Secondary industry	2735	3542	1.30
Tertiary industry	6947	9507	1.37
Passenger transport (mill p-km)	9251	8192	0.89
Freight transport (mill t-km)	3484	4571	1.31



Low-carbon direct measures

Contribution to CO2 emissions reduction (compared to Frozen)



Direct measures

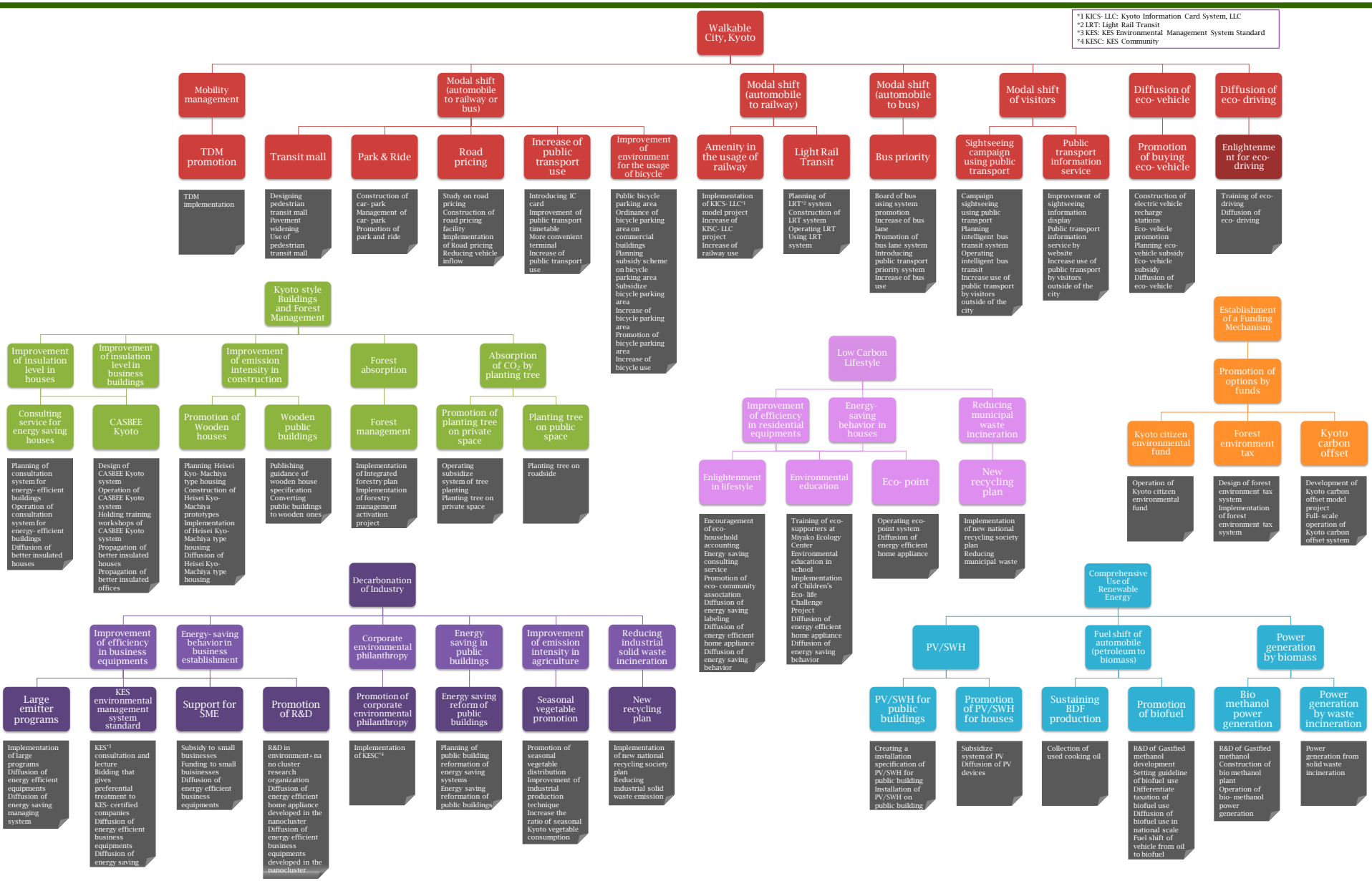
Sector	Low- carbon countermeasure	Data		Source	Category (*)	Identified implementation intencity		Emissions reduction (kt- CO_2)	Action (**)
Household sector	Air conditioner							50.1	3(***)
	Highest energy efficiency air conditioner	COP	6.60	2	E	Diffusion ratio (cooling and heating)	50%		
	High energy efficiency air conditioner	COP	2.54	1	E	Diffusion ratio (cooling and heating)	50%		
	High energy efficiency kerosene hearting	COP	0.88	1	E	Diffusion ratio (heating: kerosene)	80%	12.9	3
	High energy efficiency gas heating	COP	0.88	1	E	Diffusion ratio (heating: gas)	80%	25.8	3
	High energy efficiency oil water heater	COP	0.83	1	E	Diffusion ratio (hot water: oil)	70%	6.1	3
	Gas water heater							55.0	3
	Latent heat recovery- type water heater	COP	0.83	1	E	Diffusion ratio (hot water: gas)	50%		
	High energy efficiency gas water heater	COP	0.83	1	E	Diffusion ratio (hot water: gas)	50%		
	Heat pump water heater	COP	4.50	3	E	Diffusion ratio (hot water: electricity)	70%	48.9	3
	High energy efficiency gas cooker	Thermal efficiency (base year=1)	0.55	1	E	Diffusion ratio (cooking: gas)	70%	12.3	3
	High energy efficiency IH cooker	Thermal efficiency (base year=1)	0.86	1	E	Diffusion ratio (cooking: electricity)	70%	8.0	3
	Fluorescent light							51.5	3
	LED (substitute fluorescent light)	Electricity consumption (conventional type=1)	2.67	1	E	Diffusion ratio	50%	24.1	3
	Hf inverter fluorescent light	**Electricity consumption (conventional type=1)**	1.33	1	E	Diffusion ratio	50%		
	Incandescent light							72.1	3
	LED (substitute incandescent light)	Electricity consumption (conventional type=1)	8.70	1	E	Diffusion ratio	50%		
	Balls- type fluorescent light	Electricity consumption (conventional type=1)	4.35	1	E	Diffusion ratio	50%		
	Refrigerator							31.9	3
	Super high energy efficiency refrigerator	Electricity consumption (conventional type=1)	2.92	1	E	Diffusion ratio	50%		
	Highest energy efficiency refrigerator	Electricity consumption (conventional type=1)	2.33	1	E	Diffusion ratio	50%		
	TV							100.7	2
	LCD TV	Electricity consumption (conventional type=1)	2.27	1	E	Diffusion ratio	50%		
	Highest energy efficiency TV	Electricity consumption (conventional type=1)	1.54	1	E	Diffusion ratio	50%		
	House insulation							32.4	3
	Next generation level	Thermal loss (base year=1)	0.36	4	E	Diffusion ratio	40%		
	New standard	Thermal loss (base year=1)	0.43	4	E	Diffusion ratio	40%		
	Energy- saving behavior	Energy service demand reduction ratio	10%	5	B	Diffusion ratio	25%	26.9	5
	Photovoltaic generation	Potential(ktoe)	295	6	S	Diffusion ratio	10%	38.8	5
	Solar water heating	Potential(ktoe)	1037	6	S	Diffusion ratio (hot water: all)	10%	0.2	3
	Other energy efficiency improvement				E			27.3	3
	Other fuel shifting				S			**625.1**	
	Total							41.3	4
Commercial sector	Air conditioner (cooling only)							19.1	4
	Super high energy efficiency air conditioner (cooling only)	COP	5.00	2	E	Diffusion ratio (cooling: electricity)	50%		
	Highest energy efficiency air conditioner (cooling only)	COP	4.07	1	E	Diffusion ratio (cooling: electricity)	50%		
	Cooling (gas)							64.2	4
	High energy efficiency gas heat pump	COP	1.60	8	E	Diffusion ratio (cooling: gas)	40%		
	High energy efficiency absorption tiller (gas)	COP	1.35	7	E	Diffusion ratio (cooling: gas)	40%		
	High energy efficiency absorption tiller(oil)	COP	1.35	9	E	Diffusion ratio (cooling: oil)	70%	3.2	4
	High energy efficiency boiler (oil)	COP	0.88	1	E	Diffusion ratio (heating: oil)	70%	25.1	4
	High energy efficiency boiler (gas)	COP	0.88	1	E	Diffusion ratio (heating: gas)	70%	75.4	4
	Air conditioner (heating only)							67.0	4
	Super high energy efficiency air conditioner (heating only)	COP	7.40	2	E	Diffusion ratio (heating: electricity)	90%		
	Highest energy efficiency air conditioner (heating only)	COP	4.44	1	E	Diffusion ratio (heating: electricity)	10%		
	High energy efficiency oil water heater	COP	0.87	1	E	Diffusion ratio (hot water: oil)	70%	16.0	4
	Gas water heater							64.2	4
	High energy efficiency gas waterheater	COP	0.87	1	E	Diffusion ratio (hot water: gas)	50%		
	Latent heat recovery- type water heater	COP	0.85	1	E	Diffusion ratio (hot water: gas)	50%		
	CO_2 cooling medium water heater	COP	3.00	1	E	Diffusion ratio (hot water: electricity)	100%	64.2	4
	High energy efficiency gas cooker	Thermal efficiency (base year=1)	0.55	1	E	Diffusion ratio (cooking: gas)	70%	27.0	4
	IH cooking heater	Thermal efficiency (base year=1)	0.86	1	E	Diffusion ratio (cooking: electricity)	70%	11.6	4
	Incandescent light							131.6	4
	Timer controlled LED (substitute fluorescent light)	Electricity consumption (conventional type=1)	3.95	1	E	Diffusion ratio	50%		
	Illumination controlled LED (substitute fluorescent light)	Electricity consumption (conventional type=1)	3.36	1	E	Diffusion ratio	50%		
	Incandescent light							20.6	4
	LED (substitute incandescent light)	Electricity consumption (conventional type=1)	4.55	1	E	Diffusion ratio	50%		
	Balls- type fluorescent light	Electricity consumption (conventional type=1)	4.55	1	E	Diffusion ratio	50%		
	High- intensity evacuation light	Electricity consumption (conventional type=1)	4.18	1	E	Diffusion ratio	70%	0.5	4
	Large scale computer (energy- saving type)	Electricity consumption (conventional type=1)	1.18	1	E	Diffusion ratio	70%	3.1	4
	Personal computer (energy- saving type)	Electricity consumption (conventional type=1)	2.47	1	E	Diffusion ratio	70%	3.3	4
	Copier (energy- saving type)	Electricity consumption (conventional type=1)	1.45	1	E	Diffusion ratio	70%	0.9	4
	Fax machine (energy- saving type)	Electricity consumption (conventional type=1)	1.45	1	E	Diffusion ratio	70%	0.6	4
	Printer (energy- saving type)	Electricity consumption (conventional type=1)	1.45	1	E	Diffusion ratio	70%	1.2	4
	Elevator (energy- saving type)	Electricity consumption (conventional type=1)	4.01	1	E	Diffusion ratio	70%	5.4	4
	Ventilation							50.1	4
	with energy- saving fan	Electricity consumption (conventional type=1)	2.00	1	E	Diffusion ratio	50%		
	with low- pressure duct	Electricity consumption (conventional type=1)	1.82	1	E	Diffusion ratio	50%		
	Vending machine (energy- saving type)	Electricity consumption (conventional type=1)	2.17	1	E	Diffusion ratio	70%	11.5	4
	Traffic light (LED type)	Electricity consumption (conventional type=1)	3.75	1	E	Diffusion ratio	70%	1.4	4
	High energy efficiency transformer	Electricity consumption (conventional type=1)	2.53	1	E	Diffusion ratio	70%	13.3	4
	Other electric appliances							61.2	4
	30% energy- saving type	Electricity consumption (conventional type=1)	1.43	1	E	Diffusion ratio	50%		
	10% energy- saving type	Electricity consumption (conventional type=1)	1.11	1	E	Diffusion ratio	50%		
	Building insulation	Thermal loss (base year=1)	0.50	1	E	Diffusion ratio	100%	231.1	2
	BEMS	Energy demand reduction ratio	10%	10	E	Diffusion ratio	25%	24.4	4
	Energy- saving behavior	Energy service demand reduction ratio	10%	5	B	Diffusion ratio	25%	40.3	4
	Photovoltaic generation	Potential(ktoe)	295	6	S	Diffusion ratio	10%	26.9	5
	Solar water heating	Potential(ktoe)	1037	6	S	Diffusion ratio (hot water: all)	5%	49.6	5
	Other fuel shifting				S			70.8	4
	Total							**1161.8**	
Industrial sector	Energy efficient equipments				E			184.7	4
	High energy efficiency boiler	Thermal efficiency(base year=1)	1.09	11		Diffusion ratio	80%		
	High energy efficiency furnace	Thermal efficiency(base year=1)	1.67	12		Diffusion ratio	80%		
	High energy efficiency morter	Electricity consumption(base year=1)	1.25	11		Diffusion ratio	80%		
	Inverter control	Electricity consumption(base year=1)	1.05	11		Diffusion ratio	80%		
	Fuel shifting	From oil to gas			S	Shifting ratio	60%	63.9	4
	Increase in the ratio of seasonal vegetable production	Ratio of CO2 emissions against non- seasonal vegitable produc	0.7	17	E	Ratio of selling seasonal vegitables	36.2%	0.3	4
	Increase in the ratio of wooden buildings	Ratio of CO2 emissions against non- wooden buildings	0.6	17	E	Diffusion ratio	30%	9.0	4
	Total							**257.9**	
Passenger transport sector	Vehicle							270.7	1
	Hybrid vehicle	Fuel cost (conventional type=1)	0.6	1	E	Diffusion ratio	50%		
	High energy efficiency vehicle	Fuel cost (conventional type=1)	0.8	1	E	Diffusion ratio	50%		
	Modal shift	From vehicle to;			B			236.7	1
	Intra area trip	walking and bicycle				Shifting ratio	15%		
		train and bas				Shifting ratio	30%		
	Inter area trip	bicycle				Shifting ratio	10%		
		train and bas				Shifting ratio	30%		
	Trip to outside of the city	train				Shifting ratio	30%		
	Bio fuel	From oil to bio fuel			S	Diffusion ratio	20%	231.7	5
	Eco- driving	Fuel efficiency improvement ratio	24%	13	B	Diffusion ratio	20%	37.8	1
	Total							**776.9**	
Freight transport sector	Vehicle							176.9	1
	Hybrid vehicle	Fuel cost (conventional type=1)	0.6	1	E	Diffusion ratio	50%		
	High energy efficiency vehicle	Fuel cost (conventional type=1)	0.8	1	E	Diffusion ratio	50%		
	Bio fuel	From oil to bio fuel			S	Diffusion ratio	20%	156.2	5
	Total							**333.1**	
waste incineration & others	Bio- methanol power generation			17		production of electricity (ktoe)	18.8	53.8	5
	Reducing the amount of waste incineration			17		Rate of CO_2 emissions reduction	40%	228.1	3, 4
	Improvement of CO2 intensity of power generation					CO_2 emission per generation (tC/toe)	0.78	873.9	4(***)
	Fuel shifting			14					
	Generation efficiency improvement								
	Coal	Generation efficiency	48%	15					
	Gas	Generation efficiency	55%	16					
Total								**4310.7**	

Six actions

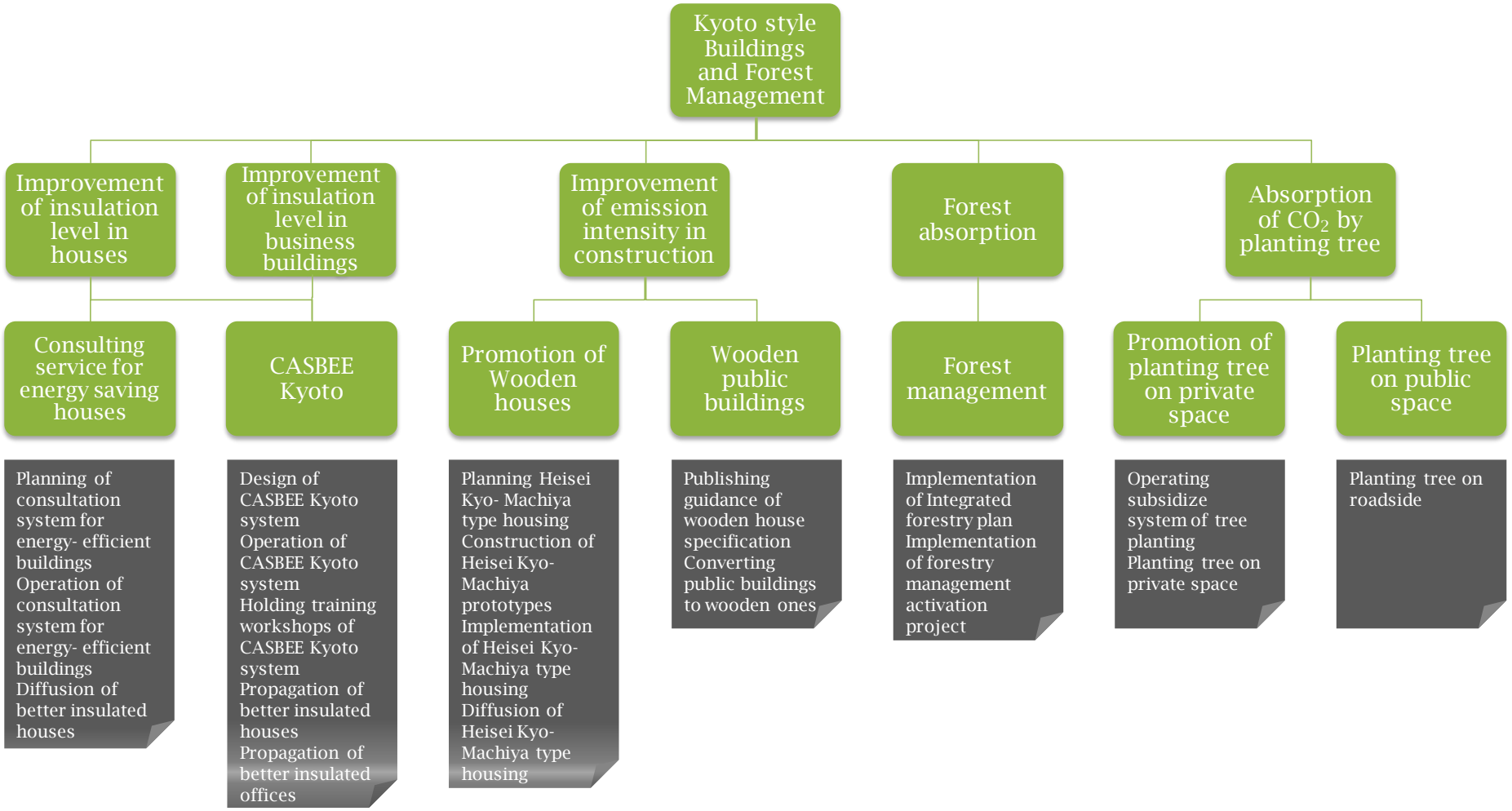
- Categorize measures into 6 groups according to fields of measures

Workable city, Kyoto	Kyoto style building and forest management	Low-carbon lifestyle
Decarbonation of Industry	Comprehensive use of renewable energy	Establishment of a funding mechanism

Low-carbon measures



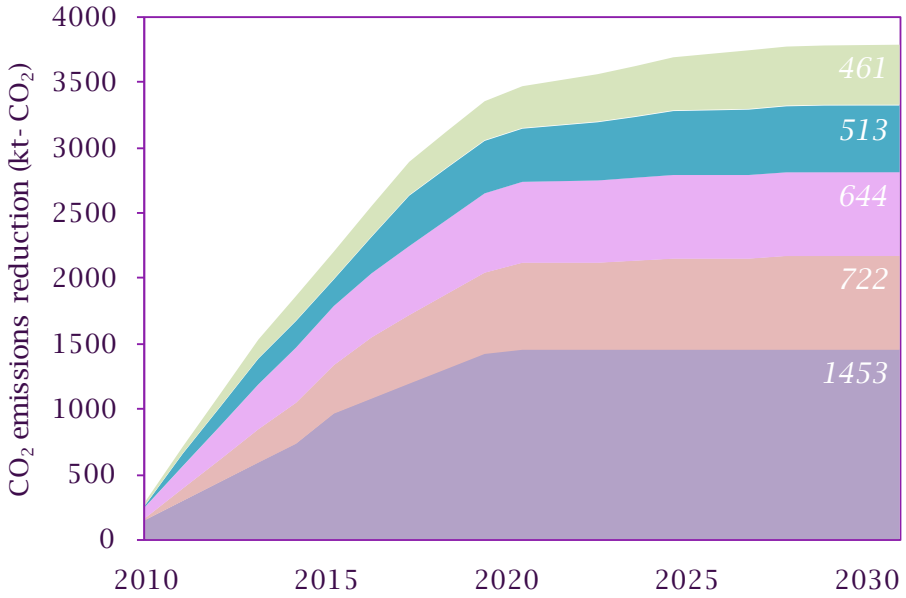
Ex. Buildings and forest



Information of measures

- Direct reductions in greenhouse gas emissions
- Resource needed to implement a measure
- Resource needed to continue a measure
- Integrated effect of measure implementation
- Shortest implementation period
- Earliest starting year
- Necessary prior measure
- Necessary parallel measure

A roadmap



Kyoto- style Buildings and Forest Development

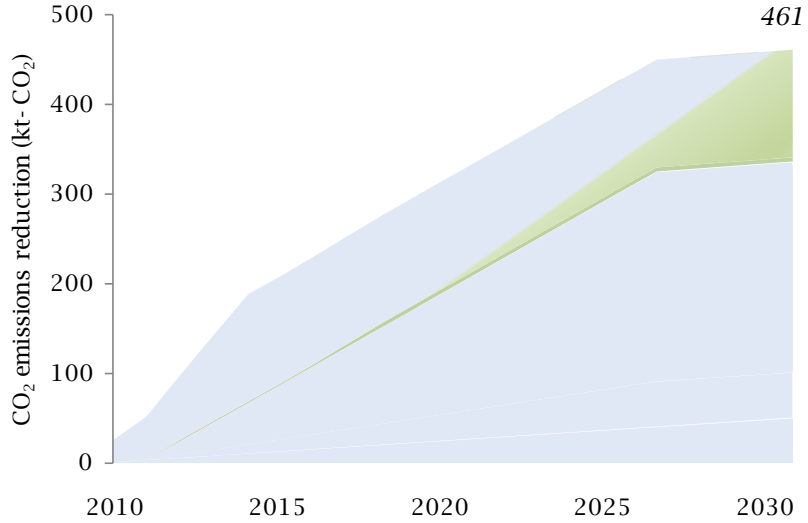
Comprehensive Use of Renewable Energy

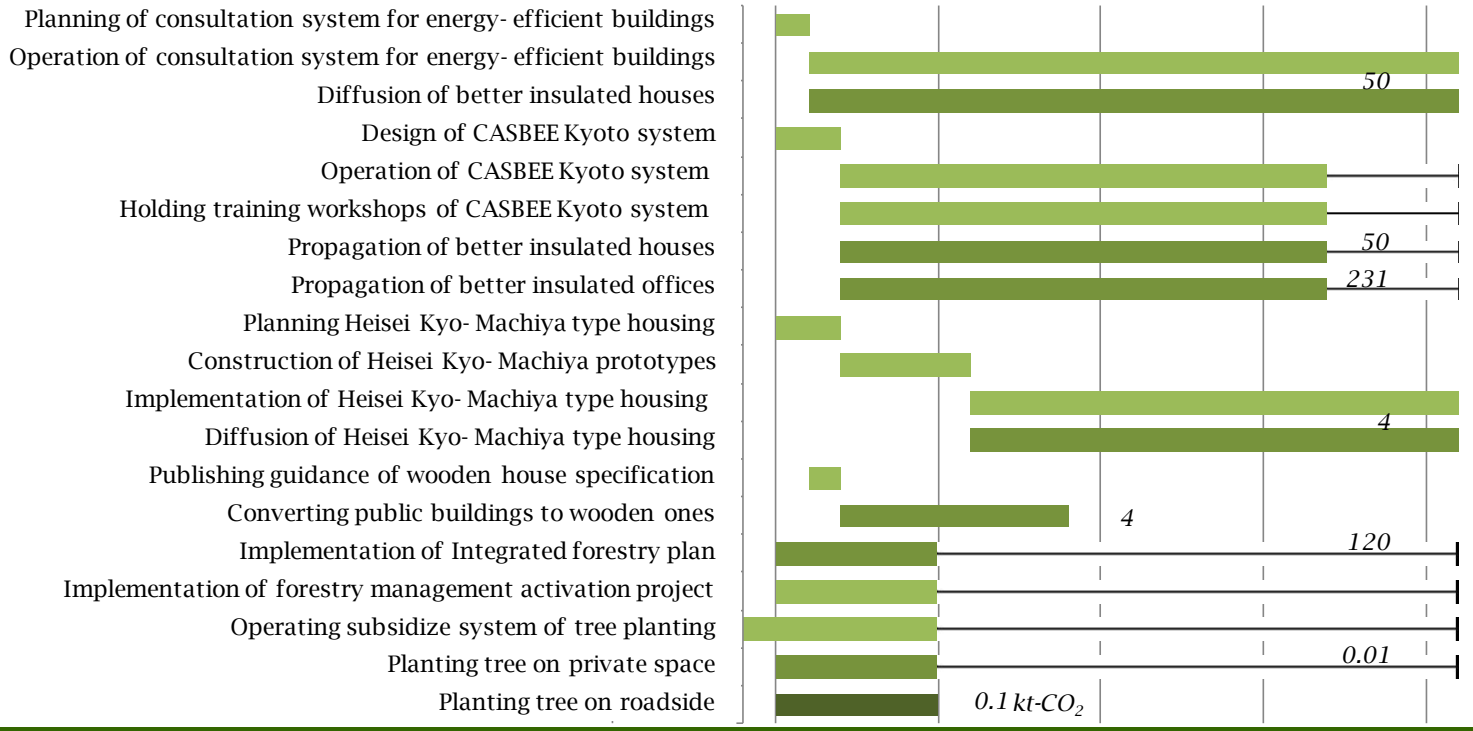
Low Carbon Lifestyle

Walkable City, Kyoto

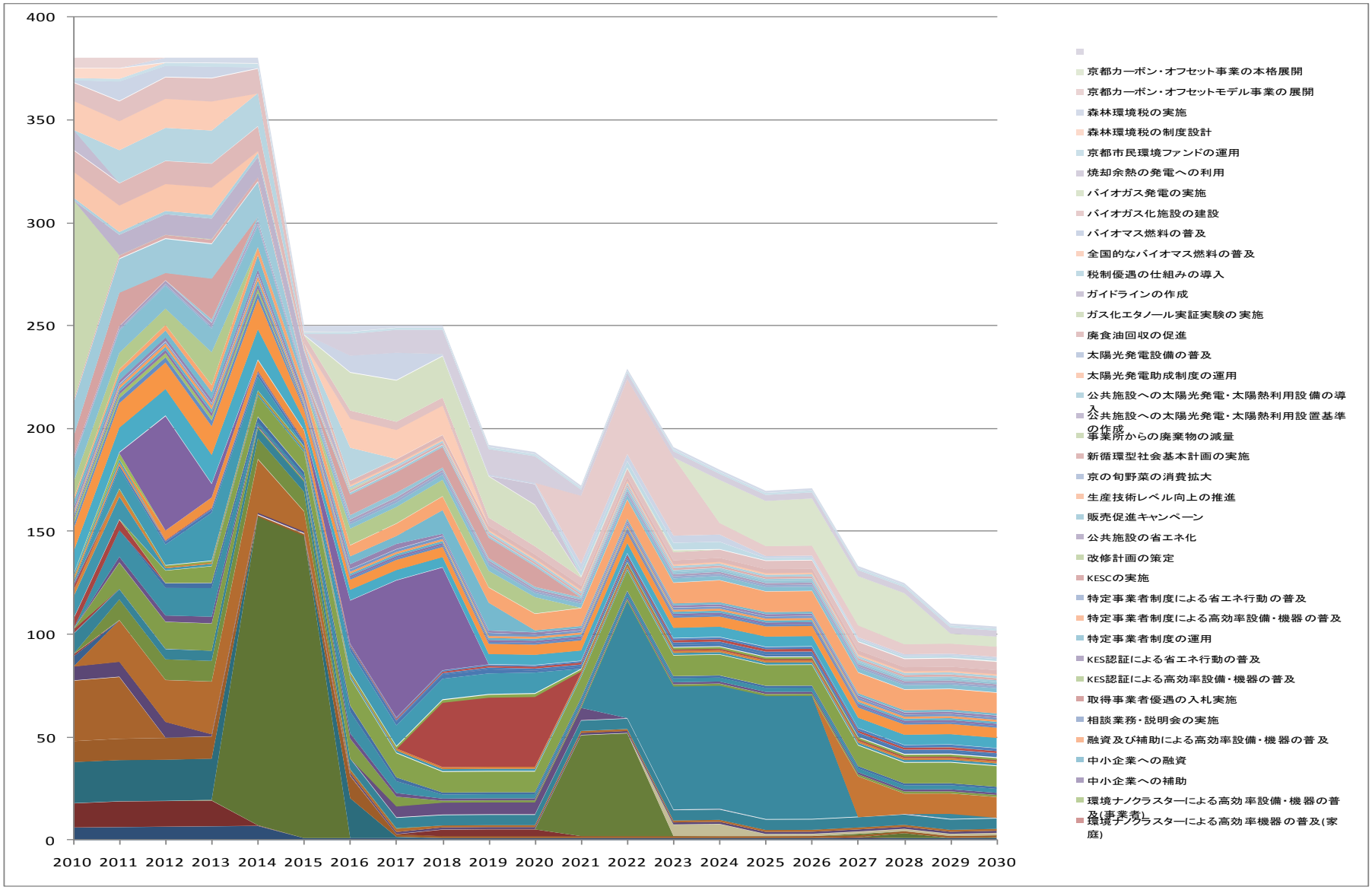
Decarbonation of Industry

Kyoto-style Buildings and Forest Management





(8) Resource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京都カーボン・オフセット事業の本格展開
京都カーボン・オフセットモデル事業の 展開
森林環境税の実施
森林環境税の制度設計
京都市民環境ファンドの運用
焼却余熱の発電への利用
バイオガス発電の実施
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バイオマス燃料の普及
全国的なバイオマス燃料の普及
税制優遇の仕組みの導入
ガイドラインの作成
ガス化エタノール実証実験の 実施
廃食油回収の促進
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改修計画の策定
KESCの実施
特定事業者制度による省エネ行動の普及
特定事業者制度による高効率設備・機器の普及
特定事業者制度の運用
KES認証による省エネ行動の普及
KES認証による高効率設備・機器の普及
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融資及び補助による高効率設備・機器の普 及
中小企業への融資
中小企業への補助
環境ナノクラスターによる高効 率設備・機器の普及(事業者)
環境ナノクラスターによる高効 率機器の普及(家庭)

Conclusion

- Developed Backcasting Tool for the second stage of backcasting for local LCS scenarios.
- BCT considers all related measures, resource constraints, and integrated effect.
- Applied to Kyoto city and developed a roadmap towards 2030 with support of Kyoto city environmental policy bureau.
- Consideration of cost of the other sectors and its overall effect to the economy.