International Symposium on how to make sustainable low carbon society
Synergy of social and engineering system

Development and Transfer of ESTs: A Pillar of the International Climate Regime post 2012

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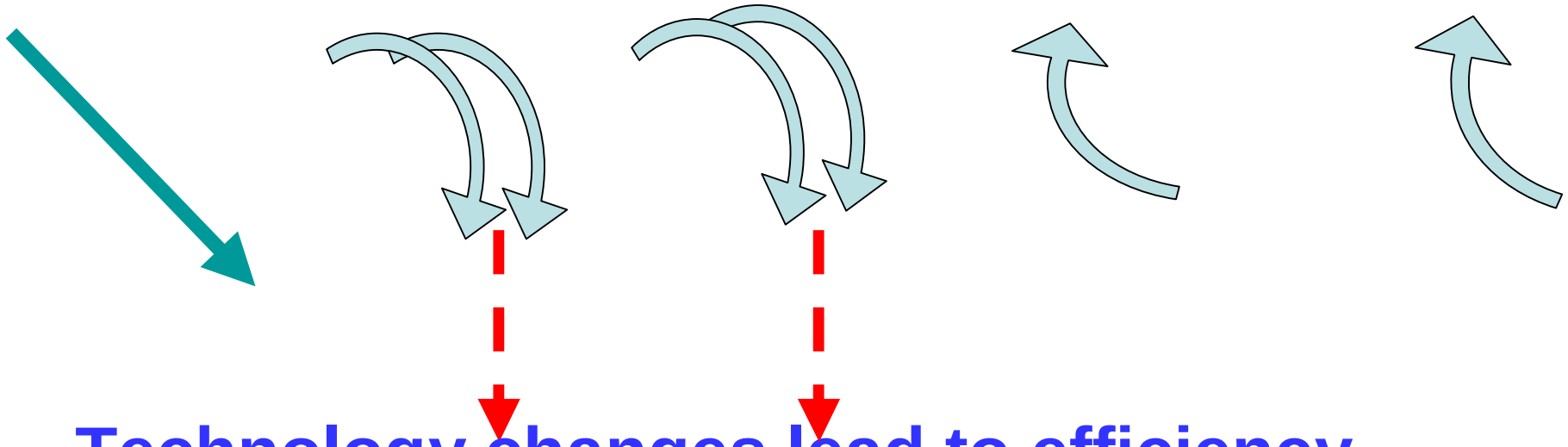
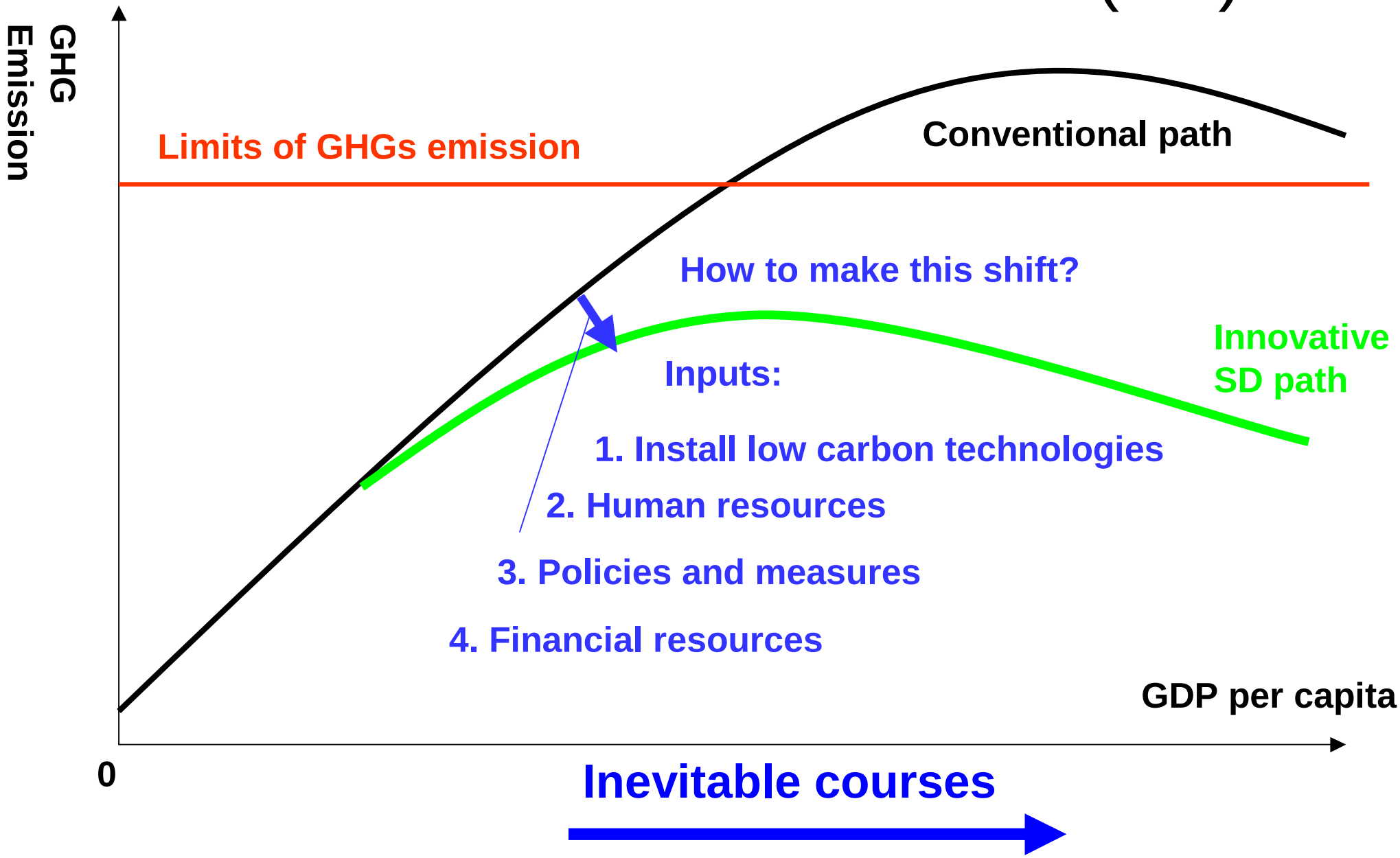
Technology change is the only way-out for developing countries

$$Emission = \frac{Emission}{Energy} * \frac{Energy}{GDP} * \frac{GDP}{Population} * Population$$



Technology changes lead to efficiency improvement

It's a matter of development paths: Conventional *v.s.* Innovative (SD)

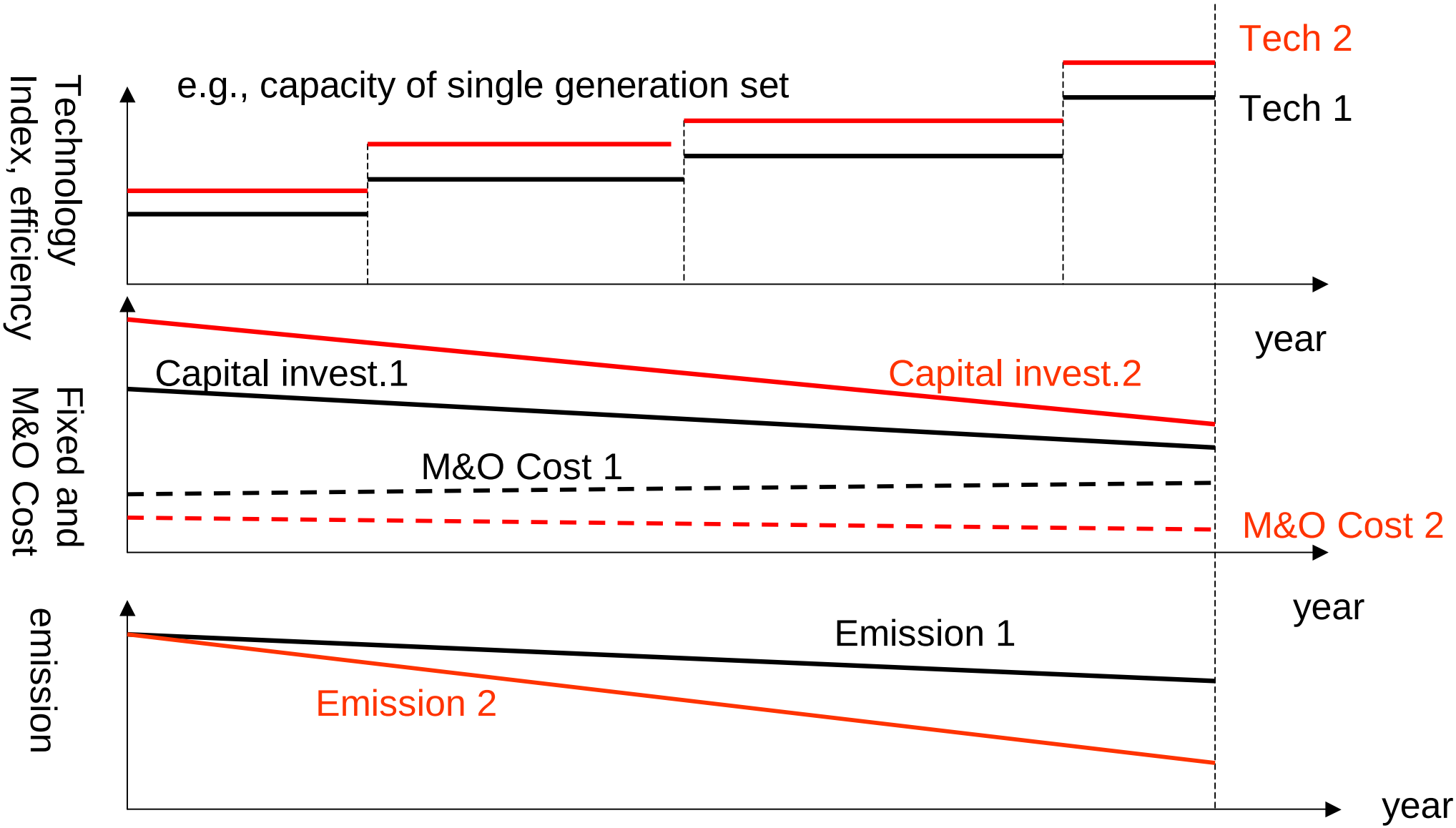


Urgency: Avoiding Lock-in effects

- **Energy-intensive infrastructure sectors are easy to be locked-in**: power, heating, air-conditioning, transport system, buildings……;
- **The lifespan for infrastructure operation is very long**: over several decades;
- Not easy to change the emission feature of existing infrastructure with **very high replace costs**
- **Rapid and massive construction of infrastructure** in developing countries, e.g., in China, **cannot wait for a slow and modest CST flow into their economies**, given the keen anticipation to improve living standards and alleviate poverty.

Concept of lock-in effects in Power Sector

relationship between capital investment, M&O cost, and efficiency/emission level



1. High carbon tech scenario; 2. Low carbon tech scenario.

CO2 Emission Reduction and Corresponding Technological Change and Capital Investment in Thermal Power Sector in china, 2020 and 2030

Technological options and changes in capacity (MW)		Small sets	Normal sets	Sub critical	Super critical	USC	IGCC
2005		105943	103640	156768	17500	0	0
BAU Scenario	2020	-72930	-20000	749000	0	0	0
	2030	0	-50000	520000	0	0	0
Tech Improving Scenario	2020	-72930	-70000	189000	200000	380000	30000
	2030	0	-60000	0	0	430000	100000
Capital Investment (bln USD)		2006—2020, **57** 2006—2030, **135**					
Accumulative CO2 reduction（Mt-CO2）		2006—2020, **998；** 2006—2030, **2, 875**					

Source: Ji Zou and S. Fu, 2008

Potential of Technology Change

- The gap of general energy efficiency between **China (35%)** and **the OECD average (45%)** is up to 10%.
- This shows a current potential for China to control its GHG emission **by improving its energy efficiency with more efficient technologies available from developed countries**.
- With large share of energy use and GHG emission, only several percentage points of improvement in energy efficiency may lead to significant GHG reduction.

Energy efficiency for major products in China, 1990 - 2004

energy consumption	China			Int'l standard	Gaps in 2004	
	1990	2000	2004		absolute	%
Thermal power generation Coal consumption（gce／kwh）	392	363	349	299.4	49.6	16.57
Power plant electric supply Coal consumption（gce／kwh）	427	392	376	312	64	20.51
alternating current consumption for Electrolytic Aluminum （kwh／t）	16233	15480	15080	14100	980	7.00
Steel （large firm） （kgce／ton)	997	784	705	610	95	15.57
cement（kgce／ton）	201.1	181	157	127.3	29.7	23.33
Crude oil process（kgce／ton）	102.5	118.4	112	73	39	53.42
Ethene （kgce／ton）	1580	1125	1004	629	375	59.62
synthetic ammonia （kgce／ton） （large scale）	1343	1327	1314	970	344	35.46
Paper and cardboard（ kgce／ton）	1550	1540	1500	640	860	134.38

Source: Qinyi Wang, *International Petroleum Economics*, 2006, NO.2

Understanding
Climate Sound Technology:
A Whole Package for Effectiveness

CSTs' Nature: providing for climate benefit as global public goods

- Climate benefits are core returns of CSTs;
- More rapid and effective development, transfer, diffusion, and deployment of CSTs in developing countries are of great importance to protect global climate as global public goods;
- These global public goods are shared and enjoyed by both developed and developing countries; and
- It may be regarded as an efficient global allocation of technology resources to curb global warming.
- We need to find out an innovative mechanism to realize the above global allocation of technologies efficiently and effectively.

CSTs work as a whole package

CST may include:

- Hardware: devices, equipment, process, etc.;
- Software: IPRs, designs, know-how,;
- Enabling environment: mechanism, policies, appropriate institutional arrangement; and infrastructure
- Human resources: awareness, well trained and qualified; and
- Financial resources to make D&T&T happen.

Category of Technologies

- **By stage of technologies**
  - Invention: earlier/pioneer/basic R&D,
  - Innovation: R&D for pre-competitive, demonstration
  - Diffusion: marketing, deployment,
  - Application: in place to produce environmental and commercial benefits
- **By sectors**: differences in scale of capital, intensity of knowledge, intelligence, and corresponding market structure (perfect, imperfect and monopoly market)
- **By owners**: public sectors vs private sectors
- **By mechanism for transfer and development**:
  - trade,
  - FDI,
  - innovative pattern (PPP)

Different types of technologies may apply to different stakeholders and policy instruments

Stage of tech / dimensions	Invention R&D	Innovation R&D (demo)	Diffusion and Deployment
Stakeholder	Research institutes and Universities	Large company, Research inst., Universities, joint venture	Companies, Brokers,
Financial resources	Public finance for R&D	Public finance Company invest. Venture capital	Company investment, Bank, stock, bonds
Policy instruments	Subsidies, Planning, awareness	Subsidies, planning, norms, permit, standard, directorate,	Taxation, pricing, competition promotion, permit, norms, …

Leverage points of int'l technology cooperation

They may be in all the stages of technology lifecycle:

- Basic scientific researches;
- Joint R&D for demonstration;
- Joint design of manufacture and urban planning
- Dissemination: market tapping, increasing penetration by transfer, diffusion, and deployment of CSTs; and
- Full application (or even commercialization).

Some leverage points in China 1

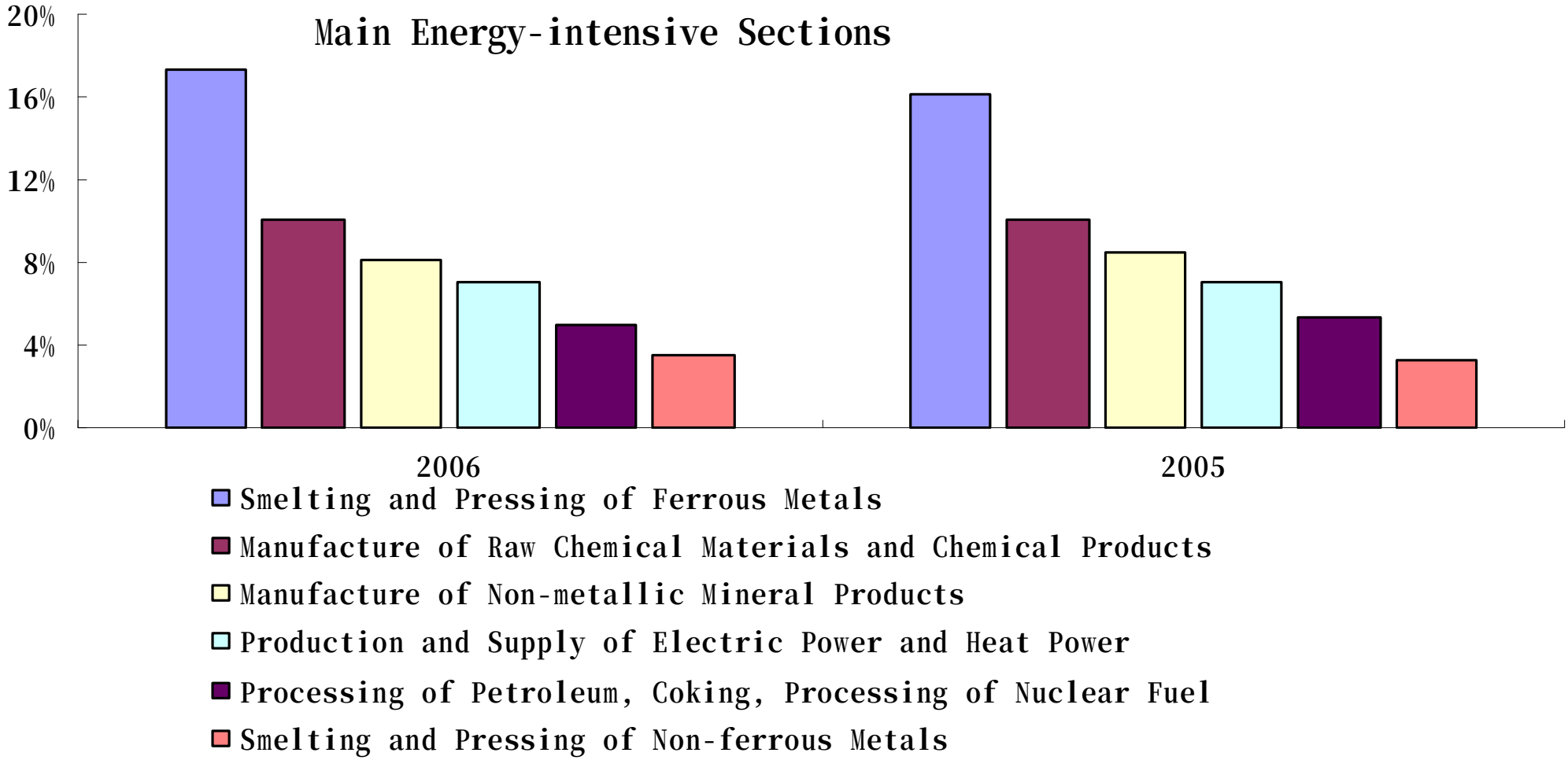
- Joint R&D to provide for strategic technology backup for medium and long-term development, e.g., CCS, PV, Fusion, etc.
- Joint smart manufacture design and urban planning for more efficient technology application
- Enlarge penetration of current available low-carbon technologies in markets by
  - Overcoming market obstacles related to int'l transfer and cooperation of CSTs
  - Innovative international regime as enabling environment, including incentives and financial mechanism

Some leverage points in China 2

- Infrastructure sectors, such as power, transport, and construction/building should be paid an urgent attention.
- Streamlined designs at strategic, policy, and technological levels are crucial
- Integrating:
  - water strategies, policies and investment with adaptation
  - CO2 mitigation with air quality and energy security

Key Energy Intensive Sectors in China

- Industry used about 71% of the total energy in 2005 and 2006;
- and the following 6 sectors account for 72% of the industrial energy use, more than 50% of the total energy use in China.



Data source: China Statistics

Some important fields in China

- **Integrated assessment and design**:
  - global VS local concerns;
  - technologies VS economy;
  - transportation VS urban planning
- **Advanced coal technologies**: linking with desulphurization and NOx reduction and CCS (IGCC, CFB, breeze)
- **High efficient vehicle**
- Implementation of **building/construction** energy conservation
- **Energy intensive manufacture sectors** (metals, cements, chemical products, etc.)

Primary technology needs assessment in China: findings from a pilot study by RUC

List of some technology needs

Sectors	**Technology**	**Degree of technology diffusion in China**	**Degree of technology diffusion worldwide**	**Abatement potential**	**Cost information**
Industrial boilers	High-efficient coal-fired industrial boilers	Medium (the scale of boiler manufactures is mainly small and key technologies such as coal combustion devices and automatic control devices are lack).	High	5-10%	Estimated cost for the retrofit project is 60 billion Yuan
Cement industry	NSP cement kiln technology package	High (but technical level in key technology fields still lags behind such as the automatic control device and the overall operation level).	High	15%	Estimated cost for the retrofit project is 100 billion Yuan

District cogeneration				Emission reduction rate is more than 20% compared to regional heating boilers	Total cost of cogeneration will be lower than the separate production of heat and power, but the corporate profits will depend on the pricing mechanism for heat and electricity
	combined heat-power-cool system based on gas-steam combined cycle	Low	Medium		
	heat-electricity-coal gas triple co-supply system	Low	High		
	cogeneration technology using biomass	Low	Medium		
Transportation	The technologies for the more efficient gasoline and diesel engine	Medium	High	10%-20%	Increase by 10%
	The technologies of diesel engine for cars and light trucks and the technologies to produce high quality diesel	Low	High	20%-30%	Increase by 20%
	Light-weight Vehicle Technology	Low	Middle	5%-10%	Increase by 10%
	Homogeneous charge compression ignition engine technology	Low	Low	10%-20%	Not clear
	Advanced and efficient transmission system	Low	Middle	10%-30%	Increase by 20%

Building materials	Technology for Oxy-fuel Combustion in Glass Furnace.	Very few by now	High	20%—30%	Increase by 30%
Petroleum and chemistry	Technologies for natural-gas-based chemical products (except for methanol and acetic acid)	Very few by now	High	10%—15%	Increase by 20%
Electric Motor System	Medium and Large size frequency modulated equipment(MLFME)	Around 5% in 2006	High	11mt-C/year, 50TWh/year in 2010	300 to 600yuan/kW higher than normal electric motor
	Direct Current Permanent Magnet Brushless Electric Motor(DCPMBEM)			Electric saving is around 8.8TWh in 2010	
Green Lighting Program	white light conduct LED	Very few by now		Electricity saving is 100TWh, 3.45Mt-C, NOx 0.5million ton, SO2 6.75million ton	32yuan by 2006, and then 24yuan by 2020
Iron and steel	low calorific value gas combustion turbine technology	low		20%	6 hundred million
Cement	the steam turbine units	medium		5-10%	

Building	technologies and materials of heat-insulation of external walls	low		20-30%	50-200yuan/m^2 higher than usual
	the ground source heat pump system	medium		40-50%	500 yuan/m^2
Petroleum oil industry	Highly efficient heat exchangers and burners	Low		15-20%	Investment will be 2.25 ~ 3.20 billion yuan at crude oil processing capacity of 45Mt
Petrochemical Industry Petrochemical industry	New type energy saving and separating technology for ethylene industry	Low		Approximately 10%	Technical renovation for a 4.0Mt capacity project calls for an investment of 810.0 million yuan
	radiant short tubes for ethylene cracking furnace use	Medium		5-10%	Technical upgrading of the existing SRT-II and SRT-II furnace calls for an investment of 580.0 million yuan
Iron and steel industry	production energy management center	Low		15-20%	Investments in a total of 10 large- and medium-sized companies totaling 2.0 billion yuan

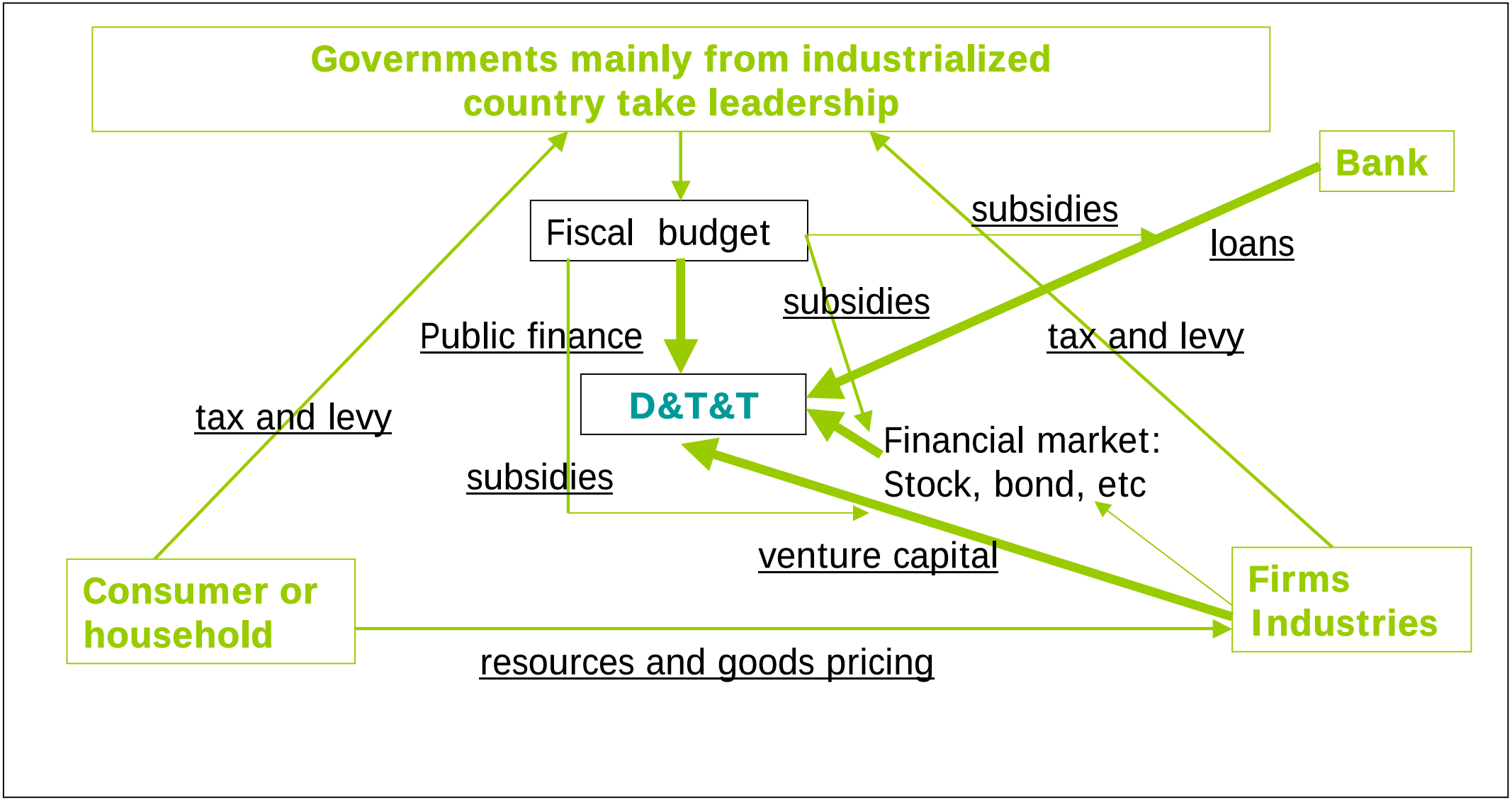
Source: Zou Ji, *et al., 2008*

How to measure the effectiveness of D&D&T?

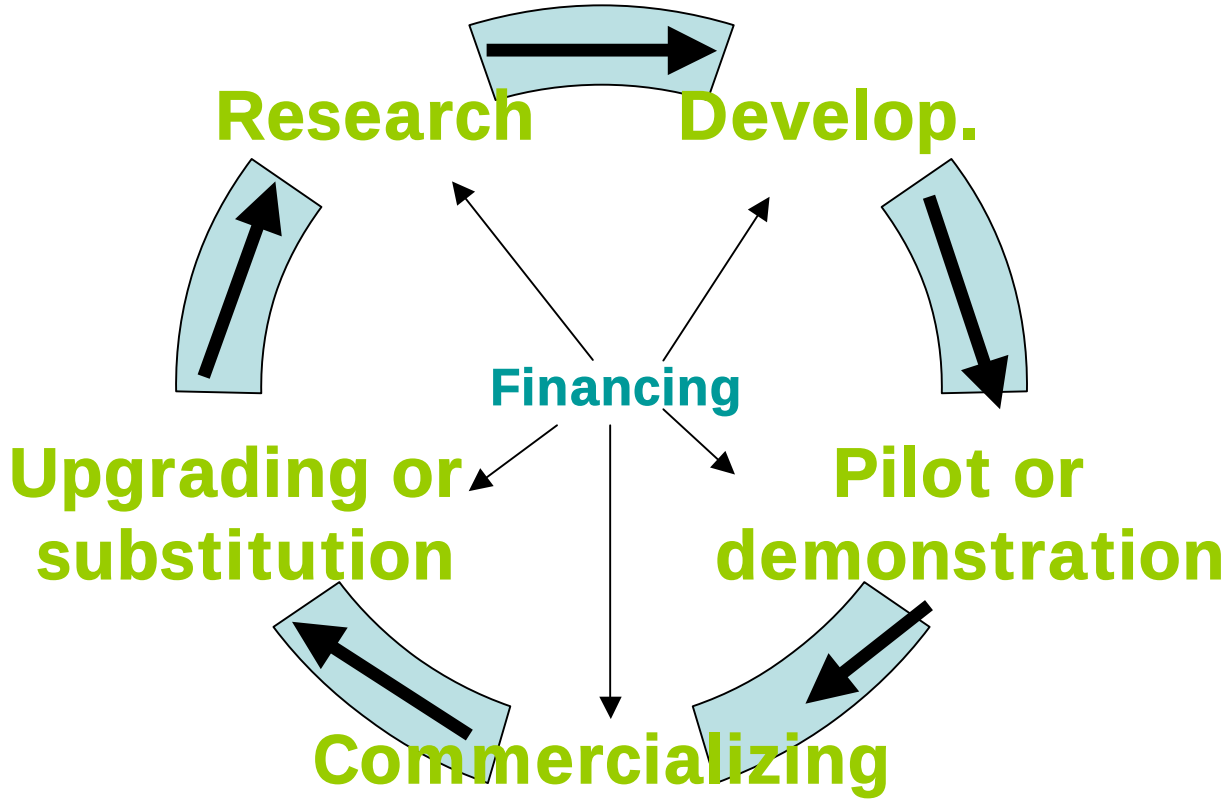
- Speed of technology flow
  - Considering to avoid lock-in effects in developing countries
  - Needed time for innovation (R&D) and diffusion
- Range of technology flow
  - Covering most of the meaningful sectors
  - Larger market share and penetration
- Effectiveness
  - Emission reduction
  - Affordable and least cost and expected benefits

Enabling Environment: Promoting Policies and Innovative Financing

The roles of different stakeholders in financing D&T&T



Financing leverage points based on technology cycle



Needs for innovative mechanism as part of international climate regime

Objectives: *Win-win*

to speed up, widen, and enlarge international technology cooperation to catch the historic opportunities, meanwhile ensure the poor to be better off and the companies to make profits and boom economies.

Major Components of the Innovative Mechanism for International Development and Transfer of ESTs

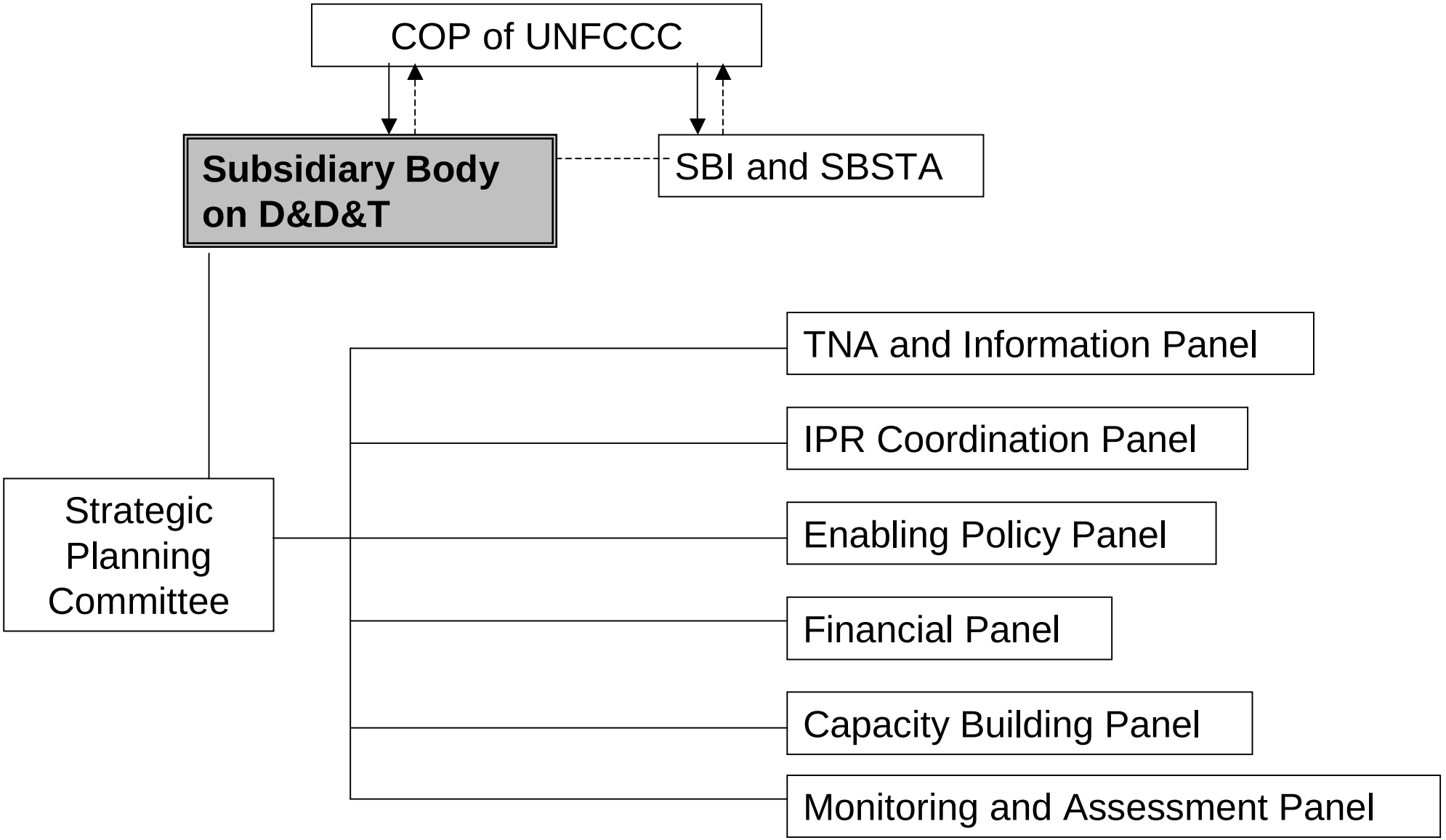
- Intergovernmental Cooperation Mechanism
- Special Financial Mechanism for TT
- Mechanism for TT Performance Assessment and Monitoring
- IPR Protection and Transfer Mechanism
- Mechanism Promoting CSR and Public Participation
- Platform for Technology Exchange/Trading

Intergovernmental Mechanism 1

- Enhance mechanism within UNFCCC: need a more effective and implementation-oriented body to:
  - Provide for advices, guidance, and recommendation;
  - Coordinate actions by different international stakeholders and governments, e.g., fiscal policies;
  - Guide and supervise utilization of special TT fund based on public finance;
  - Promote communication and info/knowledge sharing; and
  - Monitor and assess the performance and progresses.
- Cooperation on other bilateral and multilateral bases

Intergovernmental Mechanism 2

Organizational Structure



Intergovernmental Mechanism 3

With priorities on:

- Policy dialogues and coordination for better incentives to private sectors and markets;
- Financing basic research and R&D; and
- Direct transfer and diffusion of publicly owned technologies.

Intergovernmental Mechanism 4

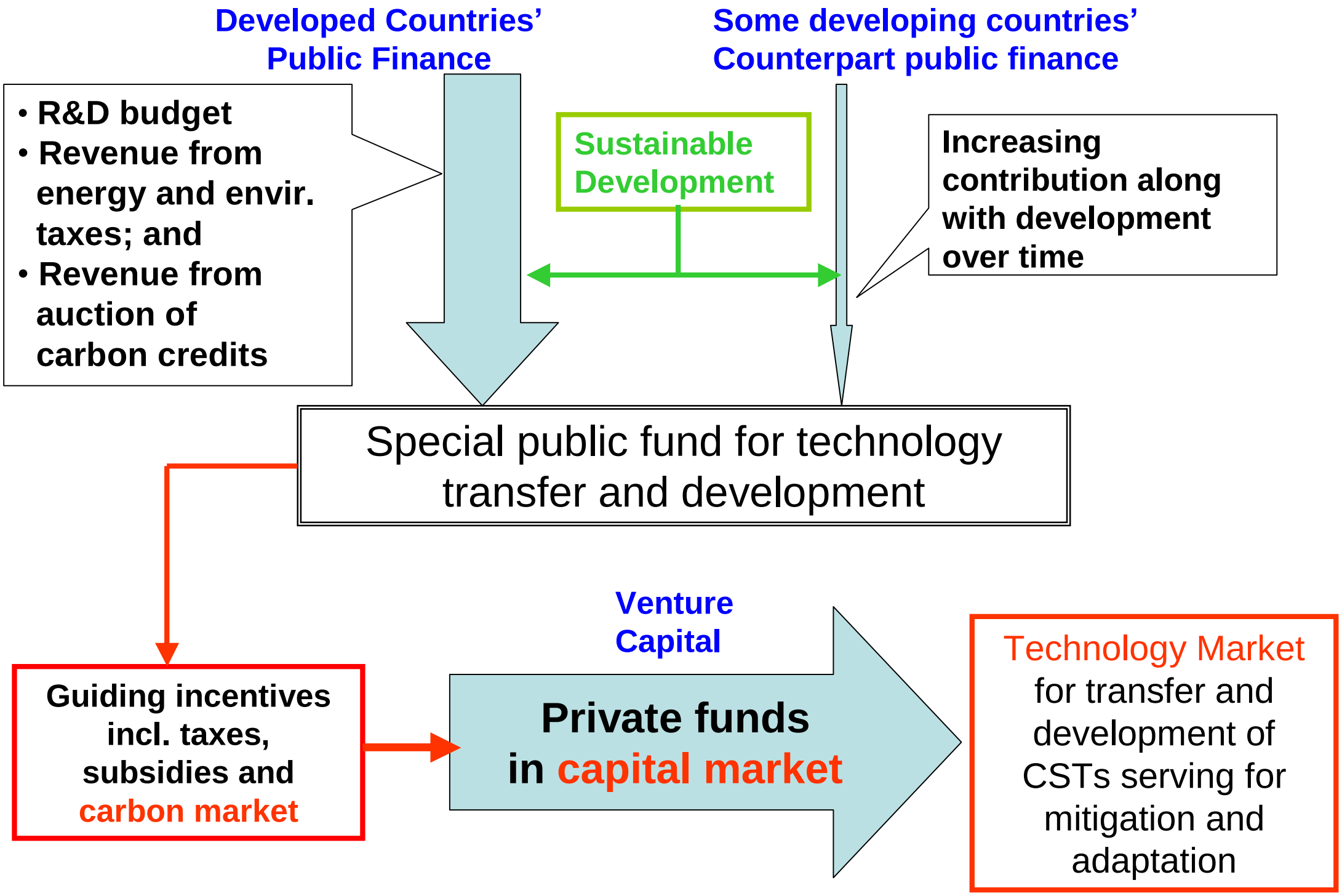
Policy coordination to provide private sectors with incentives

- Tax exemption for CSTs exports of companies in developed countries;
- Subsidies to encourage R&D and transfer of CSTs;
- Favored conditions for CST-related export credits: guarantee for technology export credits, subsidies, etc.;
- Removal of technology export bans; and
- Other policies and measures.

Back to Major Components of the Mechanism

Special Financial Mechanism for TT

- A PPP framework for financing D&D&T of technologies may be feasible by linking public and private finance;
- Significant amount of public finance should play a leading role in guiding and attracting private financial resources into D&D&T of technologies
- A special fund based on public finance need to be established and used to create incentives to private sectors through various of policy instruments with impacts on capital market
- A range of financial instruments may be applied for financing D&D&T.
- Venture capital might be a typical form for private investment in ESTs


Developed Countries' Public Finance
Some developing countries' Counterpart public finance
• R&D budget
• Revenue from energy and envir. taxes; and
• Revenue from auction of carbon credits
Sustainable Development
Increasing contribution along with development over time
Special public fund for technology transfer and development
Guiding incentives incl. taxes, subsidies and carbon market
Venture Capital
Private funds in capital market
Technology Market for transfer and development of CSTs serving for mitigation and adaptation

Considerations on Different Financial Sources for D&D&T of CSTs

financial sources	policy instruments	challenges to address	specific targets	typical technologies	stage of technologies	barriers for D&D&T	adequacy and performance assessment	solutions
Public	fiscal budget: ODA & additional for CC; subsidies for T&T,GEF, Tax exemption; R&D, Gov't guarantee for Export Credit, venture investment etc	CB, LDC, small islands, adaptation, R&D, market tapping, infrastructure, etc	1.CB,2. R&D in strategic areas, 3. catalyzer of T&D, kick-off market; 4. prototype/pilot/demonstration, 5. adaptation, 6. policy development	pre-commercial or pre-competitive techs in power, transport, building (infrastructure), adaptation tech, etc.	basic researches; pre-competitive and in process of commercializa-tion	political will	Effectiveness: scale, speed, and range	to improve awareness of politicians and the public , increase scale via current tunnels and potential new pipelines.
Private	FDI incl. CDM, trade of IPR, service and product, and C-credits; fund and loans from commercial banks, venture invstment	massive investment	substantial GHG reduction with a win-win manner	manufacture sector: end user technologies	pre-competitive and in process of commercializatio n; commercialized	1.market force, 2. technical capacity, 3.export permits, 4. others	1. Guidance and incentives; 2. Effectiveness: Scale, speed, and range	1. Guidance from gov’ts policies; 2. enforcement of laws; 3. incentives; 4. breaking negative market forces (limit monopoly)
PPP	combination of public and private financial resources: joint venture, subsidies, managing C-market, funds, …	attract private investment in climate public goods	guiding financial flow into the targeted areas	Infrastructure: power, transport, building, and relevant energy intensive technologies	R&D, Market tapping; Massive investment; etc.	market force	Effectiveness: scale, speed, and range.	Initiatives by governments: cooperation between the North and the South.

Framework for Performance Assessment

- Speed of technology flow
  - Considering to avoid lock-in effects in developing countries
  - Needed time for innovation (R&D) and diffusion
- Range of technology flow
  - Covering most of the meaningful sectors
  - Larger market share and penetration
- Effectiveness
  - Emission reduction
  - Affordable and least cost and expected benefits

Key Elements of Indicators for Performance Assessment 1

- The frequency and intensity of activities in technology needs assessment, technology information, creating enabling environment, capacity building, and development of mechanism;
- the scale of investment in R&D, innovation/demonstration, diffusion and deployment of ESTs and the contribution from Annex II parties;

Key Elements of Indicators for Performance Assessment 2

- the speed of international flows of ESTs from developed to developing countries;
- the range of ESTs transfer in geographical and setoral terms;
- the obstacles in development and transfer of ESTs and the degree to which these obstacles are obviously overcome and corresponding measures and actions are in place.

IPR Protection and Transfer Mechanism 1

- Although managing global externality, rather than IPR, is the real core issue in the context of climate change, improvement in IPR protection may contribute to faster and more technology transfer
- IPR protection should not be an excuse to postpone international development and transfer of ESTs;
- Compulsory licensing and different pricing for public climate protection may be introduced, as it has been in public health domain, on a newly developed international legal basis; and
- Efforts to protect private IPRs should be made together with the ones to avoid over-making monopoly profits and to fulfill corporation social responsibility in climate protection

IPR Protection and Transfer Mechanism 2

- Legislating and enforcing laws and regulations are still the mainstream measure for IPR protection;
- Improving enforcement capacity and efficiency and lowering enforcement costs;
- Continuous efforts to improve awareness of companies and the public on IPR protection;
- Establish awarding fund for encouraging exposure of information on violence of IPR;
- Development of both governmental and non-governmental organizations providing for IPR consultancy service;
- Exploring commercial patterns of joint R&D for sharing IPR; and
- Support by incentives based on public finance.

Mechanism Promoting CSR and Public Participation

- Request companies provide annual report on implementation of CSR
- Institutional arrangement for exposure of information on environmental and D&T&T performance of companies;
- Promote D&T&T by anti-monopoly measures and re-arrangement of patent protection period
- Promote development of intermediary organization providing for technological and legal service
- Make efforts to improve public awareness for an enabling governance based on wide public participation

Platform for Technology Exchange

- Develop rules for technology assessment and trade;
- Improve technology information; and
- Improve infrastructure to support technology trade

Conclusions

- Establish and operate a Special Intergovernmental Body for D&D&T of CSTs under COP of UNFCCC;
- Develop an involvement mechanism for owners, developers, and potential receivers of CSTs and policy makers;
- Identify prioritized strategic areas of CSTs by TNAs;

Conclusions (Cont'ed, 1)

- Develop a special PPP financial system to combine and bridge:
  - public finance (mainly from developed parties)
  - Combining markets for carbon permits, CST, and capital

Conclusions (Cont'ed, 2)

- Select appropriate financial instruments and pipelines
  - Share-holding in climate sound projects
  - Venture capital to invest in R&D of CSTs
  - Funds
  - Bonds
  - Insurance for adaptation
  - Long-term soft loans
  - Others
- Initiate series of programs/schemes targeting at specific technological areas in developing countries

Thank you for your attention!

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