Discussion paper issued without formal editing

FOR PARTICIPANTS ONLY
27 September 2011
ENGLISH ONLY

UNITED NATIONS
CENTRE FOR REGIONAL DEVELOPMENT

In collaboration with

National Environment Agency (NEA), Government of Singapore
Ministry of the Environment, Government of Japan

THIRD MEETING OF THE REGIONAL 3R FORUM IN ASIA
5-7 October 2011
Singapore

POLICY AND INSTITUTIONAL FRAMEWORK FOR PROMOTING TRANSFER OF 3R TECHNOLOGIES

(Background Paper for Plenary Session 2 of the Provisional Programme)

Final Draft

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1. Overview

Introduction of integrated solid waste management (ISWM) and recovery and recycling of waste has shifted the paradigm from waste as nuisance to the "resource". This shift from ***"waste management"*** to ***"resource management"*** perceives waste as lucrative employment and business opportunities. The global market volume for environmental technologies, mainly comprising products and services amounted to approx. $1370 billion in 2008, according to Germany-based Roland Berger Strategy Consultant, with a projected $2740 billion by 2020. Of this, the share of waste management and recycling is estimated at $41 billion in 2008 and $63 billion by 2020. Such vast potential of recycling and waste management business opportunities can hence trigger the Reduce, Reuse, Recycle (3R) technology transfer in the Continent with support from facilitative policy and institutional framework to promote recycling. En-cashing the waste economy as a green business opportunity is one of the most convincing ways to smoothen 3R technology transfer across the boundaries. Developed countries, especially the private sector are hence investing on 3R technology development and exploring a business and the governments in developing Asian countries starting to recognize the need for 3R technologies for co-benefits of waste management; are expected to bring a number of recycling businesses. These businesses will inevitably need appropriate technologies, and professionals with sound knowledge and background on waste management principles and practices.

Policies of host countries play a vital role to facilitate 3R technology transfers in the sector of waste management. This background paper captures the role of policy and institutional framework for 3R technology transfer in Asia as found out in the *policy study on 3R technology transfer* conducted by the AIT in collaboration with the IGES under the Asia Resource Circulation Policy Research Project. Optimizing effective policy tools to regulate important elements of technology transfer such as Intellectual Property Rights (IPR), Foreign Direct Investment (FDI), Multilateral Environment Agreements (MEAs) are very crucial to establish technology transfer facilities successfully in the host countries. Policy framework is interlinked with institutional capabilities, legal and financial infrastructure, macroeconomic conditions such as lack of access to capital, fluctuating inflation and interest rates, high import duties, uncertainty over stability of tax and tariff policies, identified and real investment risks. Therefore, effective policy tools to address the above issues are necessary to promote 3R practices in developing countries.

Generally, development of 3R policy schemes and initiatives are expected from the government sectors to strengthen the policy and institutional framework for ensuring successful technology transfer of 3Rs for multiple benefits. However, a plethora of corporate conglomerates is becoming involved in recycling not in reaction to legislation, but rather attracted by the lucrative return on investments from recycling and waste management. Hence waste management and recycling has shifted from a local government unit's jurisdiction to a business opportunity. Similarly, companies are also expected to outsource recycling to third party specialists to achieve a better scale of economies and expertise, thus recycling may constitute a new concern in business process outsourcing. For example, Tetrapak, a leading beverage carton manufacturer has created a line of businesses to recycle beverage cartons. Similarly, Apple has partnered with the Hong Kong based Li Tong Group to operate a product take-back program in the Asia-Pacific region, where Li

Tong collects the end-of-life products and recycles them. Though with proactive environmental legislation and potential waste economy, 3R practices are being recognized as an integral part of waste management, however the difficulties in investing in state of the art technologies may create pressures in promoting and consolidating the recycling industry. As a consequence, third party recycling giants are likely to emerge, and a rise in trans-national movement of recyclable wastes, aimed at taking advantage of economies of scale is foreseen. Recycling activities in industrialized countries may gradually shift towards developing Asia, where the cost of recycling is lower. This in turn would lead to a rapid diffusion of advanced recycling technologies and businesses in developing Asia. It is evident that the lower labor costs and increasing industrial growth would all serve to place developing Asian countries in a favorable position for recycling industries. This creates an opportunity for businesses, researchers, and academicians to develop a stream of technologies, along with fully qualified professionals to understand and deal with the dynamics of the system and cope with the changing landscape of waste management and recycling business.

The national and international policies that promote 3R technologies could significantly contribute towards multitude of global goals such as tackling waste management issues, conservation of natural resources, mitigation of climate change, creation of sustainable circular resource economy and an overall environmental protection. These policies hence help in promoting green technology transfer. 3R-based technologies in Asia are gaining momentum as recycling activities provide excellent business opportunities. Wide range of policies, regulations, economic incentives, knowledge networks and agreements are responsible for the promotion and transfer of 3R technologies in developing Asian countries. Regulatory policies to facilitate optimal Intellectual Property Right (IPR) for instance play a crucial role in transfer of technology, because it determines knowledge transfer, technological modifications and complete diffusion in the host countries. Similarly a right mix of policy sets facilitates the process of selection of appropriate technology and the implementation thereafter in the local context; facilitate capacity building for decentralized diffusion of transferred technologies. Sufficient guidance and support from national governments to the local municipalities would help them build suitable network and systems for the sustainability and long-term viability of technologies acquired. It also helps in the participation of all stakeholders of the system including the public for better stability and social acceptability of a technology facility. Effective policies to implement the concepts of 3Rs contribute towards the national development goals as well as the Millennium Development Goals (MDGs) such as poverty alleviation, mitigating climate change and improving the overall environment and economy of developing countries.

2. Concepts of Technology Transfer and 3R

Development of technology plays an important role in fostering 3R practices and this should be initiated at the national government level with the help of suitable policies and mechanisms. Significant amount of tasks needs to be done in terms of technical and policy issues to yield the desirable results. Developed Asian countries have been actively building up technologies and are looking out for suitable markets in the developing countries to establish their businesses via 3R technology transfers. It has been observed that there is a

huge gap between the technologically-rich and technologically-deprived countries. Development of suitable technologies is very important to create resource circulating economies and this would consume significant amount of time and resources. To overcome these barriers and to reduce the gestation time, *'technology leapfrogging'* is often preferred, primarily in the form of *'Technology Transfer'*, which avoids re-inventing the wheel.

Technology Leapfrogging:

This is a mechanism of bypassing various technological stages, which other countries have already gone through. It helps faster growth of countries with less technological advancements.

Technology development method:

Generating ideas → Basic research → Patenting → Bench scale testing → Pilot scale

testing → Field testing → Commercial development of technology

Leapfrogging:

Commercially developed technology →Transferred, with appropriate adoption or modification based on local needs → implemented and established in other countries via 'technology transfer'.

Developing countries of Asia are in real need of 3R technologies because of the magnitude of the waste management problems that are currently prevailing. The magnitude of the problem in both developed and developing countries are the same, but it is due to the futile policies and lack of suitable technologies in the latter makes the situation worse. 3R related technology transfer seems to be the one-stop-solution to overcome the challenges in waste management, and at the same time generate revenue form the waste. Through multilateral collaborations, a partnership is established between two countries to transfer technologies and disseminate knowledge for the betterment of societies. However, differences in culture, socio-political structure, institutional setup and most importantly the policy framework poses challenges for 3R technology transfer in the developing countries of Asia. Under the policy framework, technical and management issues play a crucial role in adhere to the overall process of 3R technology transfers that need to be dealt with priority. Proper selection and implementation of 3R technologies via technology transfer could alter the environmental conditions, economical status of nations, transforming societies from a resource consuming one to a circulating one. National policies of host countries facilitating 3Rs could reduce the technological gap between developed and developing countries of Asia.

2.1 Technology Transfer Models

There are two basic modes of technology transfer, namely, vertical and horizontal, as shown in Figure 2.1 below. Vertical transfer model shows the technology being transferred within a country and the horizontal transfer model demonstrates the transfer of technology between two different countries. The horizontal transfer can occur as North-South or a South-South deal. The North-South technology transfer is between industrialized/developed

countries and developing countries while South-South trade happens only among developing countries.

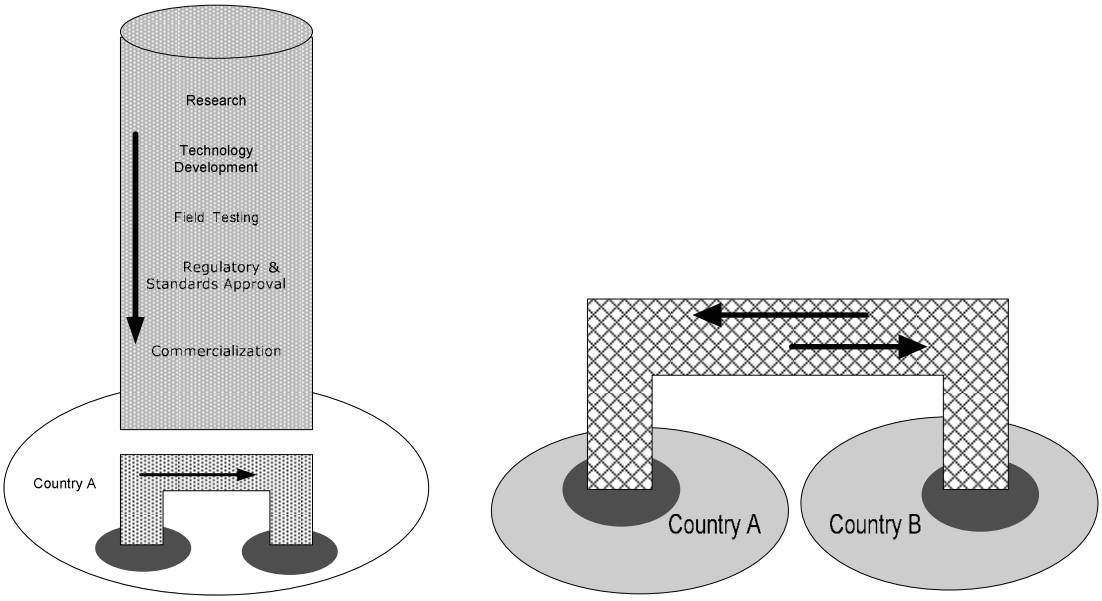

Figure 2-1 Technology transfer models

There are different modes and mechanisms of technology transfer between the transferor and transferee based on the intentions of the actual transfer. The technology transfer arrangements could be examined under four major groups or modes and possible transfer mechanisms via these groups are listed below:

- Sales intensive – Sales and service agreement either as an agent or sole distributor
- Manufacturing intensive – Subcontracting arrangements, original manufacturing arrangements, production licensing, and joint ventures
- Development intensive – Original design manufacturing (ODM), production licensing, joint ventures
- Research intensive – Joint R&D and production, university-industry licensing, Government R&D institute-industry licensing

Meanwhile, the private sectors identified waste management as an independent business proposition. Private sectors, academia and research organizations have been collaboratively and competitively developing 3R technologies to their favor. Such developmental aspects have helped the society beneficially in various dimensions. For a successful 3R technology transfer, the choice of technology needs to consider the local conditions such as the waste characteristics, generation rate, geographical distribution, socio-economic profile, presence of informal sector, etc. It is important to implement relevant technologies, or else, it would be rather impossible to cope up with the changing landscapes of waste management issues. Whatever be the waste stream, the most important issues that need to be addressed are: volume and diversity.

2.2 Assessment of 3R Technologies for Transfer

Development of technologies is a continuous process. The big question is the choice of suitable technology. The technology choice for waste management is influenced by its cost, effect on environment, health, aesthetics and amenity to application. A 3R technology can be simple or complex and can involve different methods and fields of expertise for each stage. Technology choice also varies according to the economic performance of the region (developed or developing; urban or rural) and type of the waste generator (residential, commercial or industrial). In many developing countries, the option of labor-intensive technologies makes more sense financially and economically rather than considering capital-intensive technologies.

The suitability of a 3R technology for transfer needs to be determined before decision making so as to ensure the viability of the same in all aspects. Some of the important aspects to be included during the assessment include technical, environmental, economic, institutional, socio-cultural and policy/legal regulations. There are various methodologies and statistical tools to assess a technology on the basis of the above aspects. One such efficient methodology is the Technology Needs Assessment (TNA), developed by the United Nations Development Programme (UNDP). This approach has been widely used by environmental professionals for sustainability assessment and selection of technology. The purpose of this methodology is to identify, evaluate and prioritize technologies that are suitable for implementation and wherein the national policy setup is conducive for a successful technology transfer.

In recent times, there has been a growing interest from developing countries for TNA application in the field of low carbon technologies. Since this is also a co-benefit in promoting 3R technology transfer for waste sector, application of TNA methodology here becomes a prominent activity that could be undertaken. This needs to be done based on certain criteria as below:

- The extent to which institutional infrastructure and policy support are available or can easily be introduced to develop, transfer, and utilize the technology.
- The extent to which the technologies desired are available, ease of transfer, scope for partnerships, extent to which technological capabilities can be built through the transfer, resources available, extent to which institutional capacity can be built (ICT usage) etc.

3. 3R Technology Transfer Facilities in Asia

Some representative technology transfer facilities in Asia were assessed during the policy study on 3R technology transfer in three developing Asian countries namely; Sri Lanka, Thailand and Vietnam. The policy study conducted by the AIT and IGES analyzed 11 different cases of technology transfer that catered municipal solid waste (MSW), health care waste (HCW) and hazardous waste (HW) stream. The technology included: waste composting facilities, anaerobic digestion plant, plastic recycling technology facilities, hazardous and non-hazardous waste incineration plants, solvent recycling facility, and plastic to oil technology. Besides field observation a structured interviews were performed with the

stakeholders in the recycling chain, i.e., technology user, waste/recycling material supplier and the end-users to assess socio-economic-environmental and technology performance. Barriers to technology transfer and policy needs for facilitating such technology transferred were hence identified.

Study findings revealed that very few of the existing 3R technology transfer facilities in the developing Asian countries are found to be adapted to local conditions and are operating successfully and beneficially. Most of them have failed to solve the purpose of technology transfer due to ineffective policy measures and lack of capacity and knowledge at the receiving end. Hence, there is a real need for effective policy tools and institutional capacity in the host countries to establish sustainable and viable 3R technologies via transfer. It was observed that diffusion of technologies transferred through North-South deal takes a very long time and sometimes, it never happens due to managerial incapability, as well as other factors such as issue of IPR. On the other hand, it was noticed that the technologies transferred via South-South mode takes lesser time for diffusion and has been observed to be more stable and viable for a long term. Effective networking of national and local governments to frame policies to create suitable conditions for the operations of technologies such as continuous supply of input materials and creating market demand for recycled acts as incentives for the success of technology transferred. It also reside as the role of policy framework to ensure that the 3R technologies transferred are environmentally sound, economically feasible, socially acceptable and personnel of the host country are technologically equipped to operate and modify the system according to the local needs.

Based on the study, following recommendations are placed for consideration to the national policy and decision makers for successful 3R technology transfers in the future.

3.1 Existing favorable national policies in promoting 3R technology transfer

The policy and institutional framework of developing countries of Asia determine the fate of 3R practices and the related technology transfers. Therefore, the national and international policies are responsible for fostering the 3R culture via regulated and normalized transfers. They act as a bridge to facilitate such trade between countries of various economic statures in the continent. The section below briefs how the national policies in the three countries of study favour 3R technology transfer.

Sri Lanka

Under the national policies of Sri Lanka, Regulation on prohibition of manufacture of polythene or any product (Gazette Notification No.: 1466/5 of 10/10/2006) helps to reduce the manufacture, sale and use of all thin plastic films less than 20 micron in thickness. Such regulatory instruments help in promoting reduction of plastic bags as well as encourage plastic recycling in the country. Moreover, the tax introduced on plastic imports help generate revenue for waste collection and recycling.

For organic waste recycling the Sri Lankan policy 'Sri Lanka Standard for Compost From Municipal Solid Waste and Agricultural Waste (SLSI 1246 : 2003)' promotes composting of solid waste arising from Municipal Councils and agricultural practices with minimum impacts on the environment. Any composting plants proposed under the ISWM Plan have to meet the standards prescribed in the policy. Such national policies help in the establishment of 3R technology transfer facilities in the country as well as maintain a check on technology and environment standard. Similarly, there are several other laws, regulations and standards with technical guidelines prepared by the Central Environmental Authority on the management of several waste types such as used lead acid batteries, used tyres, etc. But, there lacks such regulations for other elements of municipal solid waste management such as segregation of waste, primary storage, intermediary transfer station, treatment of solid waste, design construction and operation of sanitary landfills, design construction and operation of recycling plants, healthcare waste, electronic waste, construction and demolition waste. This leaves for ample space in the policy framework to be included for successful promotion of 3R practices and technology transfers.

Thailand

In Thailand, the policy on natural resources and policy on environment under the Ministry of Natural Resources and Environment promotes material recovery and recycling projects in the country. National policies are supportive of funding or joint ventures for 3R technologies, however the policy is not favorable to Foreign Direct Investment (FDI). The policy on promotion of zero waste from industrial estate authority of Thailand is supportive of establishment of 3R technology facilities in this sector. The policy initiative by the Pollution Control Department (PCD) of Thailand 'Household hazardous waste management scheme' positively supported the recycling of used fluorescent tubes instead of being disposed in landfills and dumpsites.

Financial support for the transfer of 3R technology facilities are encouraged via policies for investment promotion under the Thai Board of Investment (BOI). The National Renewable Energy Policy (20:20) also is very much favorable for the establishment of 3R facilities, which are capable of generating energy and resources from components of municipal solid wastes.

Vietnam

Vietnam has progressive national recycling target, to achieve a recycling rate of 70% from the total municipal solid wastes by the year 2015. The policy paper on recycling states sell and buy recycled materials – resin, plastic, paper, metal, and lubricant. This paper was passed on 18th Aug 2004 and replaces the decision 78/2002/QĐ-UB approved on 8th July 2002.The national policies of Vietnam are highly favorable for FDI.

Among three countries, both national and international policies were seen to have played a decisive role in the transfer of 3R technologies. However, specific guidelines and regulations needs to be developed at national level to make sure that these technologies operate successfully, become viable in all aspects and deliver the desired results. Correct national regulatory instruments; often assist to promote certain type of 3R technologies. For example the banning of incineration technology in Philippine facilitated promotion of other

waste to energy technologies in the MSW sector. When it comes to 3R from industrial waste sector, Corporate Social Responsibility (CSR) related activities seems to the prime driver in promoting the technology adaptation and transfer.

From technology exporting country's perspectives, it was noted that they need more specific information on the following issues:

- Size of the local recycling market, and associated local business risks;
- Local regulations and institutional arrangements to promote 3R, who is responsible for what? Is one-stop service is provided?
- Proper matching of business and/or technology user partners.

3.2 Need for Institutional arrangements

Along with facilitative policies, institutions to implement those polices into actions are the important aspects of technology transfer process. Along with transfer of mechanical equipment, transfer of skills, information and knowledge is a crucial part of technology transfer. Development of effective information networks (both at national and regional level) is hence yet another important ingredient of successful technology transfer. Efficient and effective two-way communication and cooperation between key stakeholders through information management systems, knowledge management tools and formal and informal networks both centralized and dispersed is a requisite to harmonize the processes of technology transfer.

Existing information networks are more generic and lack country specific information on 3R practices and technology transfer processes. Similarly, the information networks are concentrated and limited up to the national experts at centralized system. Infiltration of information to decentralized local authorities (municipalities), specially in local language, can facilitate the transfer of technologies, as they are the real implementers of 3R projects. Hence along with high-end expert knowledge network, a local consortium including all local stakeholders (local government authorities, communities, informal sector, formal private sector, local businesses and academia) is one of the area that national policies need to build upon. Such information networks can play a role in promoting and upgrading the indigenous technological innovations.

3.3 Identifying Barriers and Policy Needs

In developing Asia, opportunities to green technology transfer is equated with number of barriers in the form of policy issues, financial issues, practical problems and socio-economic-cultural issues. Transfer of technologies has many barriers, which includes restrictions on the movement of information and materials, under-performance of technology and overall lack of enabling environment. Based on the analysis of technology transfer facilities, the following barriers and the required policy interventions have been recognized:

Choice of the appropriate technology

To remove the barrier of technology transfer, the first step is to make an informed choice of technology. The host countries need to consider the complexity of the technology and the available knowledge before making a decision on the technology transfer, if it has to avoid inadequate, unsafe and unsustainable technology. Developing countries need more labor-intensive technologies rather than technology-intensive ones for better diffusion and implication. This will also ensure sustainability of the technology in all aspects. In a few cases analyzed during the study, capital-intensive and complex technologies were found to discontinue their operation after a certain time period because the operators in the host country did not have enough technical expertise to deal with the problems and modify the technology to suit local conditions. Thus, assessing the technology (input and output information) should be done before making the decision for technology transfer. Consultation with experts or provision of independent national technical review committee needs to be in place to facilitate the choice of technology.

Governments of the developing countries of Asia should discourage the transfer of outdated technologies, which creates major impacts on the environment and society. Also, when the technology transfer involves with government to government through bilateral or regional cooperation, it should adhere to Multilateral Environmental Agreements, when signatory to them.

Mechanisms of financing the technology transfer

Technology transfer can occur through various channels of financing, for instance, through Official Development Assistance (ODA), FDI, commercial export/import or international research cooperation. The modality of technology transfer hence remains one of the crucial factors for the technology transfer. In technology transfers facilitated via FDI and joint venture, the business seems to be more stable in terms of financing the technology. In case of such financing measures, local authorities were supportive in securing raw material as input, creating market for the recycled products and also creating appropriate legislations, and sustainability of the technology in operation was on a positive shed. However, the host countries have very less chances of technical intervention and had to abide by the terms and conditions mandated by the technology provider. The observation and analysis showed the need for both the technology provider and receiver to work together at the beginning of the transfer process to perform a proper waste characterization, calculating the correct design capacity, and cost analysis before implementation of such technologies so as to avoid any modifications in the later stage. Technology financed through Official Development Assistance (ODA) though provides large scale budget to cover capital expenditure, it does not secure the sustainability of the technology, and more importantly such ODA funded technologies are unable to generate revenue for the continual operation of the technologies and generally tend to fail. FDI on the other hand creates business opportunities, and works wonder when worked hand-in-hand with local partners (local authorities, local business networks and the informal sector and communities).

Despite the modality of financing technology transfer, national regulations still has the larger role to play for making the technology provider also responsible for making the technology really work on a long term basis through binding contracts for technology transfer. These contractual agreements should focus on developing local capacity building, as a priority than working with unreliable local partners as a "marriage of convenience" type of contract to win a project. In this regards, public/social acceptance of a project with more transparency in final decision making should be encouraged.

Optimizing the transaction cost

The transaction costs of 3R technology transfer from developed to developing countries are noticeably high, which poses as the major constraint to technology transfer in the developing host countries. Hence, appropriate trade policies should be mandated with acceptable optimum transaction costs of technology imports by the host countries.

Employment Opportunities

Opportunities of social and economic benefits to the local communities in the vicinity of the technology facility also act as a factor of success of technology transfer. Provision of job opportunities to the local people comes as the most distinctive social benefit. However, not all the technology transfer facilities provide adequate green job opportunities for the local communities. Usually the machinery intensive technology facilities require skilled manpower hence employs people from outside the locality and the country as well. Local capacity building and the local context/skill suitable technologies need to be prioritized and implemented. Policies addressing the local innovations through promotion and up-scaling of the indigenous innovations can facilitate social benefits via vertical technology transfer.

Selection of location for the technology facility establishment

Selection of location for setting up a technology facility is very crucial and the decision should consider impacts of the technology on the society as well. If this is ignored, the facility would not be able to operate as planned due to possible potential opposition from the local community and organizations such as NGOs/CBOs. There were cases where NGOs and communities living in the nearby region of the facility expressed severe opposition towards the operation of the technology fearing the potential risks of health concerns and environmental pollution.

IPR and technology diffusion

Generally capital-intensive technologies transferred from developed countries do not allow personnel of the host country to understand the mechanism and processes even after the IPR period of the technology completes. Thus, the technology diffusion does not happen efficiently. There were instances form the field visits that some of the facilities with technical managers/operators from the technology provider countries refrain to disclose technical specifications or share knowledge/skills with the fellow colleague from host countries. Such rigidity in IPR would hamper the success of 3R technology transfers, as technology transfer is just not the machinery/equipment transfer but the long lasting skills

and know-how, organizational and managerial procedures too. But, in case of labor-intensive technologies, IPR does not play a major role.

Building effective partnership with local stakeholders

It was found that local governments do not take much initiative in conducting campaigns/ meetings for effective waste collection, segregation, and marketing to promote the use of secondary resources/ products generated from the operation of the facilities, which is the basis for the successful implementation of 3R technologies. There are cases of discontinued efforts of awareness rising programs. Local authorities along with local NGOs/CBOs should continue education and awareness raising programs, as waste management and recycling after all is based on the behavioral change of the consumers. All key players and stakeholders are expected to understand and perform their responsibilities, which could be brought by high levels of awareness, motivation and empowerment within the public and private sectors and in civil society.

Taking informal sector on board

The operations of recycling facilities by huge private organizations, which utilize municipal solid waste as input, seldom consider the informal waste recyclers. This often causes competition for the waste as raw materials and sometimes conflicts too. It has to be considered that how the big private recycling industries if uses the waste can snatch livelihood of informal waste workers, or in the contradiction where informal waste collection networks are strong, it gives stiff competition to the formal recycling industries to find waste as input, hence running the facility at lower capacity than designed. Therefore, as to avoid conflicts and to institute cooperation the formal and informal sector may have contractual of non-contracted forms of agreements to acquire waste collected from informal sector with a good wages. Policies therefore need to look into these aspects also.

Revenue generation for the sustainability of the technology

A regulatory mechanism should be in place for collecting a nominal waste tipping fee from organizations/commercial set up for collecting and disposing their waste by the recycling industries. Such fee collection serves as one of the income sources to cover the operational cost of the technology facility. However, fixing of the optimum collection fee is a challenge and is purely contextual. There had been instances where the waste fee was above normal to cover the high operational cost of the technology. Standard guidelines to take control of such irregularities needs to be developed by the national governments and monitor on a regular basis to make sure that the policies are implemented.

Good governance

As important as technical aspects of technology transfer, governance issues require the same level of attention. Due to lack of proper national policies on technology transfer and the facility standards, some of the government agencies and personnel engage in collection of illegal money for providing permits, license and approval for the establishment of 3R facilities. This hampers the relationship between public, private and government bodies and

hence effective networking becomes a marathon task, also discourages the private sector to come forward for investment.

4. Recommendations

Based on the representative cases on 3R technology transfer facilities in three developing Asian countries and in consultation with the Asia Resource Circulation Policy Research Group, IGES Japan, it is recommended that for smoothening 3R technology transfer in Asia, an enabling policy environment and institutional frameworks with the right mix of technical and managerial competencies is essential.

On the technical front, technology transfer process needs to concentrate on the choice of appropriate 3R technology that suits the local context of waste generation and makes maximum uses of local skills and experience to generate economic and environmental benefits along with social capital building. For example, choice of labor intensive technology transfer in the region caters the large cheap labor from informal waste sector, and produces more favorable social outcomes along with environmental benefits.

Government's policies incentivizing the 3R technology transfer through market based financial instruments such as tax exemption, favorable FDI policies and other effective trade mechanisms are recommended for favorable technology transfer. Capacity building of local human resources is another crucial consideration of technology transfer process. Building a stock pool of local skills on the technology in operation will favor the sustainability.

Promoting and practicing recycling activities is a collective effort of all the stakeholders in the chain. Hence an effective networking, participation and coordination among the local government authorities, local non-governmental organizations (NGOs) and community based organizations (CBOs) and the technology users, and informal recyclers can create a win-win working environment performing their delineated yet coordinated roles and responsibilities. Use of NGOs/CBOs platform for awareness raising on waste segregation, encouraging recycling habits of the communities can contribute the recyclers with enough quality waste to feed their technology operation without much opposition from the communities. Similarly, tie-up with informal waste collectors along with local municipalities can also assure the quantity and quality of waste as feed to the formal recyclers, thus avoiding fierce competition for waste, and also contributing on secured livelihood of informal waste collectors by ensuring rightful wages to their occupation of waste picking. Local government authorities on the other hand can altogether facilitate the smooth technology transfer in its locality with continuous regulatory/policy support for operation (licensing of the recycling facility and joint venturing through public-private participation), as well as monitoring and evaluation of technology's environmental performance for a greater societal good.

5. Conclusions

The study shows ample opportunities for 3R technology transfer in developing Asia, which is facing an increasing waste volume as well as a business opportunity to bring back the waste into material cycle through recycling. This new business opportunity requires appropriate

technologies, which the developing countries are deprived of. Therefore, 3R technology transfer becomes the ultimate need. As discussed above, there are institutional, investment, skill, trade related, and socio-cultural challenges to technology transfer. These barriers needs to be and can only be removed with a facilitative set of national policies that support 3R practices and the transfer of appropriate technologies within and across the borders. Basically government is the principal player in creating an enabling environment for technology transfer, but other stakeholders are also equally required to fulfill their roles and responsibilities. An appropriate mix of enabling policy environment from the government and private sectors' investment, meaningful participation from the community and civil society are required to address such financial, trade, capacity, policy related issues.

Therefore identification of shortcomings in existing policy frameworks, and strengthening the weaker areas of policies such as facilitating coordination, cooperation among government and other non-governmental stakeholders; protection of intellectual property rights; political support, and institutions that foster technology transfer; economic incentives to stimulate private sector investment; capacity enhancement for major stakeholders; demarcation of the roles of the private and public sectors; integrating and strengthening regional and country level activities on 3R technology transfers through information sharing and joint activities; and ensuring that the benefits of technology transfer are in line with broader national and global development and environmental goals is what is needed for the successful technology transfer.

Based on the research findings and panel meetings with the members of Asia Resource Policy Circulation Research Group, the following sectors have been identified as the top three 3R related technologies priority focus for the next 10 years in Asia:

- Priority 1: Promotion of waste to energy/resource systems (Organic waste management including food waste)
- Priority 2: E-waste
- Priority 3: Vehicles – End of Vehicles (ELV)

The above mentioned barriers and policy needs have been identified by analyzing technology transfer cases only from selected sectors (MSW, HCW, and HW) in three developing countries, viz., Sri Lanka, Thailand, and Vietnam. An up-scaling of such technology transfer analysis in few more developing countries and in further waste streams as identified above, would give a clearer picture on the predominant barriers and need for policy interventions to address issues of 3R technology transfer for future. The approach to be taken for successful technology transfer is the creation of enabling policy environment where the well informed and well capacitated local stakeholders can operate (use, replicate, improve and possibly re-sell the technology) the transferred technology, generates the outcomes of their technology investment as simultaneous environmentally sound, socially acceptable and economically viable results.