

POLICY INSTRUMENTS FOR A SUSTAINABLE BUILT ENVIRONMENT

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I. INTRODUCTION

I have been asked to address policy issues that can move the industries that create, operate, and dispose of the built environment to a condition approximating sustainability. Many of the generally acknowledged global environmental problems (greenhouse warming, ozone depletion, soil erosion, acid rain and eutrophication, to name a few) are directly or indirectly caused by the creation, operation, or disposal of the built environment. For instance, 30% of all primary energy in the U.S. is consumed by the built environment, with approximately 40% in many of the Organization for Economic Cooperation and Development (OECD) countries. Consequently, much of the impact of energy (coal, oil, natural gas, and uranium) extraction and processing, power plant construction and operation, associated transmission lines, and transportation (trucks, trains, barges and ships) can be attributed to building operation. Much of the impact of automobile manufacture, operation, and disposal is tied to the distribution of the built environment on the landscape. Therefore, the impacts of buildings extend far beyond the physical boundaries of the

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structures and infrastructure themselves. Similarly, 40% of all materials extracted in the U.S. end up in buildings or infrastructure.

For policy instruments to be effective, they must comprehensively and holistically address the wide range of activities directly or indirectly connected to the built environment. Clearly this is an enormous undertaking and an appropriate scope must be selected to address these problems in a reasonable manner. The main categories of policy instruments applicable to the built environment will be explored here for their use in improving the performance of the various stages of built environment activity: the supply chain, building creation and disposal, and building operations.

II. RESOURCE AND ENVIRONMENTAL IMPACTS OF THE BUILT ENVIRONMENT

The construction industry dominates worldwide materials consumption. About 40% of all materials extracted annually in the U.S. end up in the built environment.¹ Construction activity amounts to about 8% of the U.S. GDP, meaning that the material impacts of construction far outweigh its relative size in the economy. At present, over 2.1 billion metric tons (BMT) of materials are incorporated into buildings and built environment infrastructure each year. In 1999, cement consumption in the U.S. was 105 million metric tons (MMT). The lifetime of buildings is relatively long compared to other artifacts, resulting in the accumulation of vast quantities of materials (Figure 1). It has been estimated that over 90% of all the materials ever extracted in the U.S. are in today's built environment.² Consequently, policy must address this enormous, burgeoning stock of materials to ensure that it becomes, to the greatest degree possible, a resource for future generations rather than an enormous waste disposal problem.

1. I.K. Wernick & J.H. Ausubel, *National Materials Flows and the Environment*, 20 ANN. REV. ENERGY & ENV'T 463-92 (2000).

2. C. Kibert et al., *Defining and Ecology of Construction*, in CONSTRUCTION ECOLOGY: NATURE AS THE BASIS FOR GREEN BUILDINGS (C. Kibert et al. eds. 2002).

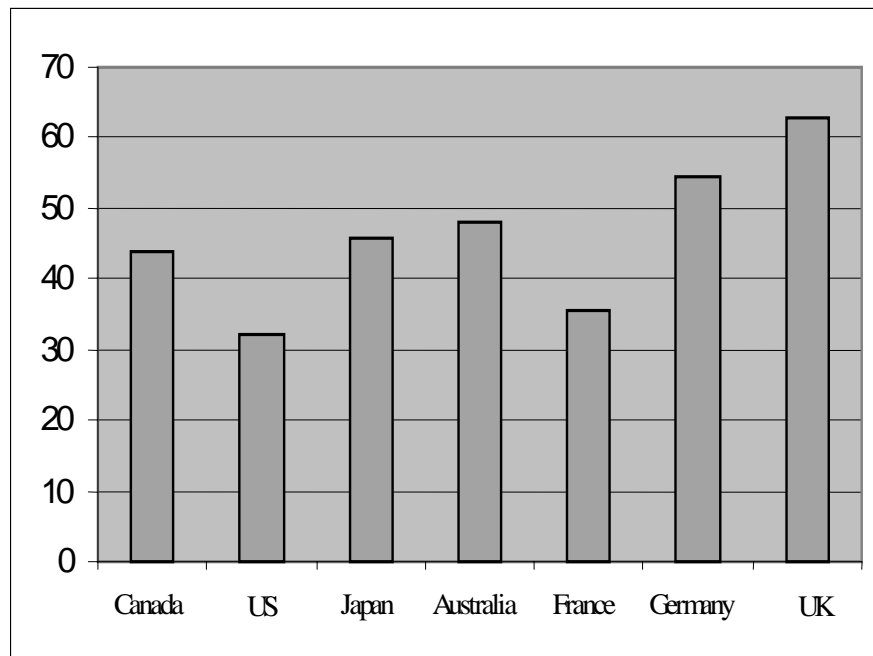


Figure 1. Estimated average service life of buildings in selected countries³

Waste from construction activities is enormous. Presently, the U.S. annually creates over 145 MMT of construction and demolition waste. This compares to a municipal solid waste (MSW) stream of about 280 MMT, meaning that construction and demolition waste comprises about one-third of the total materials being landfilled. Of the total construction and demolition waste stream, about 92% is attributed to demolition activities and 8% is waste from construction activities--either new buildings or renovation of existing structures. Waste from new construction amounts to 27 Kg/m², while the quality of waste from renovation activities in typical commercial buildings can be as much as 320 Kg/m².

Of possibly greater consequence is the Ecological Rucksack of construction, or the total quantity of material that must be extracted to obtain a unit of pure material. For example, for iron ore extraction, the Ecological Rucksack can be expressed as the ratio 14:1, that is, 14 metric tons of waste in the form of tailings or mine

3. T. Hasegawa, *Policy Instruments for Environmentally Sustainable Buildings*, Organization for Economic Cooperation and Development, ENV/EPOC/WPNEP 6 (2001).

waste is the result of producing 1 metric ton of iron. For rarer materials, such as gold and platinum, the ratio can range up to 350,000:1. For the most massive quantities of materials used in the built environment--sand, gravel, and stone--the Rucksack is not so unfortunate, with a ratio of 1:0.86 for gravel and 1:1.2 for natural stone. Coal extraction's ratio is 1:5 while that for petroleum is 1:0.1. In addition to the Ecological Rucksacks, the relative scales of extraction need to be considered. For the materials mentioned here, 10 BMT of sand and gravel, 5 BMT of stone, 5 BMT of coal, 5 BMT of petroleum, 0.5 BMT of iron, and 0.0001 BMT of gold were extracted worldwide in 1994 (see Table 1).⁴

Material	Ecological Rucksack	Scale (BMT)
Oil	1:0.1	5
Sand/Gravel	1:0.86	10
Natural Stone	1:1.2	5
Coal	1:5	5
Gold	1:350 000	0.0001

Table 1. Ecological Rucksack and scale of selected materials.

Buildings as artifacts of human society are also distinguished to a large extent by their relatively large land requirements, and the environmental effects of the cooption of this valuable ecological resource. The built environment significantly modifies natural hydrologic cycles, contributes enormously to global environmental change, has tremendous effects on biodiversity, contributes to soil erosion, has major negative effects on water and air quality, and, as noted above, is the source of major quantities of solid waste. In the U.S., as noted earlier, construction and demolition waste is the major source of industrial waste, amounting to perhaps 500 Kg per capita, or on the order of 145 MMT annually. The reuse and recycling rates of this waste is not well known, but is probably under 20% of the total mass and probably closer to 10%. Only concrete recycled for its aggregates and metals are recycled at high rates because of their relatively high economic value.

4. E. VON WEISZKER ET AL., FACTOR 4: DOUBLING WEALTH, HALVING RESOURCES USE (1997).

III. STATUS OF GREEN BUILDING

Describing the current state of movements to green the built environment would be useful in establishing a context for understanding the need to develop a sound basis for policy development. There are many terms used to describe these movements. In addition to green building, terms such as sustainable construction, sustainable architecture, ecological architecture, ecologically sustainable design, and ecologically sustainable development have been used. The term *sustainable construction* seems to be the most comprehensive description of all the activities involved in trying to better integrate the built environment with its natural counterpart. Begun as an international movement in 1993, sustainable construction can be defined as "creating a healthy built environment based on ecologically sound principles." It looks at the entire life cycle of the built environment: planning, design, construction, operation, renovation and retrofit, and the end-of-life fate of its materials. Sustainable construction considers the resources of construction to be materials, land, energy, and water and has an established a set of principles to guide this new direction (See Table 2).⁵

Table 2. Principles of Sustainable Construction

1. Reduce resource consumption
2. Reuse resources to the maximum extent possible
3. Recycle built environment end-of-life resources and use recyclable resources
4. Protect natural systems and their function in all activities
5. Eliminate toxic materials and by-products in all phases of the built environment

Many of the organizations involved in the greening of the built environment have set out similar principles, all of them having much in common with the principles of sustainable construction. Progress in implementing these principles has been impressive. A comprehensive overview of programs in countries around the world would be lengthy and, for the sake of brevity, a review of the United States' progress will be used as indicative of how rapidly change is taking place worldwide. In the U.S., there are several major entities driving the emergence of green buildings: the U.S. Green

5. C. Kibert, *Establishing Principles and a Model for Sustainable Construction*, 1994 PROC. FIRST INT'L CONF. ON SUSTAINABLE CONSTRUCTION 3-12.

Building Council, the National Association of Home Builders, and the federal and local governments.

A. The U.S. Green Building Council

The U.S. Green Building Council (USGBC), established in 1993, represents a wide range of actors- architects, engineers, product manufacturers, academics, and public institutions- who concluded that the construction industry must change course to be sustainable. In the U.S., the construction industry clearly has disproportionate impacts on the environment compared to other sectors of the economy. At present, although it represents just 8% of the U.S. Gross Domestic Product, the construction industry is responsible for over 40% of total materials extracted to produce and alter buildings and infrastructure, and the operation of buildings consumes over 30% of the nation's primary energy. In a fashion similar to its counterparts in other major industrial countries, as its response to changing the playing field, the USGBC organized a system of rating buildings that would add new criteria for the siting, design, construction, and operation of new and renovated buildings in the U.S. This rating system, known more commonly by its acronym of LEED (Leadership in Energy and Environmental Design), proposed to classify buildings into four categories, depending on their level of performance with respect to energy and environmental issues: platinum (highest), gold, silver, and LEED-rated. In the short time since its proposal and subsequent piloting, the LEED Standard must be declared a major success. Scores of buildings have been designed and built using its criteria and many more are queuing up to employ it as perhaps the key focus for building design, ranking only behind the client's requirements for the building's function. The LEED Standard is being expanded into other sectors of building construction to include residential housing. Starting in 1998, the beta testing of the Standard was conducted, and over 30 buildings received ratings based on Version 1.0. In April 2000, the final Standard, Version 2.0 was issued and is now being used to rate commercial and institutional buildings.⁶

6. See the U.S. Green Building Council website for information on the LEED standard at <http://www.usgbc.org>.

B. The National Association of Home Builders

The National Association of Home Builders (NAHB) is generally considered to be the most powerful construction industry organization in the U.S., with over 200,000 members organized into 800 local chapters. The NAHB stated there were over 1.6 million single and multi-family housing starts in 1999. In 1998, the private sector produced over 214 billion dollars of family housing, constituting about one-third of the value of total construction in the U.S. Home ownership is a significant aspect of American culture. Ownership of a home is highly valued and homes represent a significant portion of wealth. Approximately 44% of the nation's total net worth was represented by the homes ownership in 1993.⁷ The high level of home building also represents a significant proportion of the environmental impacts of construction, especially in terms of its land consumption. Fortunately, several homebuilder associations have actively engaged in determining how to build homes in an environmentally friendly manner. At least six of these associations, often in cooperation with local jurisdictions, have established a variety of green builder programs. In addition, the NAHB now has an annual national conference devoted to green home building.

C. Federal and Local Government

Of all the organizations involved in green building efforts in the U.S., the federal government is both the largest customer and arguably its greatest proponent. A wide array of federal agencies have demanded better environmental and health performance for new buildings, such as the U.S. Post Office, the National Park Service, and many of the military services. Many of the buildings that were rated by the first version of the LEED Standard in the beta testing effort were federal buildings. The U.S. Department of Energy has been a major supporter of the development and implementation of the LEED Standard. Presidential Executive Orders have directed a variety of actions on the part of federal agencies that directly or indirectly supported the construction of green buildings. Several highly visible federal building efforts such as the "Greening to the White House" and the "Greening of the Pentagon" have been effective in publicizing green buildings in the U.S.

7. See the National Association of Home Builders website for statistical data on home ownership and construction at <http://www.nahb.org>.

Local government has also been a major force in the green building movement in the U.S. The municipal government of Austin, Texas initiated a green building program in the early 1990s. The Austin effort was initially directed at the procurement of city buildings and produced the first guidelines for municipal building--the Sustainable Building Sourcebook. The city's efforts soon produced a parallel effort in the local homebuilding industry, and the Austin homebuilders association formed the first NAHB green residential construction program. The city of Seattle, Washington now requires conformance to the LEED Standard for all municipal buildings and similar requirements for the use of the LEED Standard are emerging from local government across the U.S. The city of Boulder, Colorado was the first municipality to require some level of green building measures for all housing constructed within city limits and enforces this requirement through the building permitting process.

IV. CATEGORIES OF POLICY INSTRUMENTS

A wide array of policy instruments is available to assist citizens and government in altering the present unsustainable course of human behavior. Table 3 contains a general list of these instruments.

Regulatory Instruments

- **Technology-based standards:** mandatory standards which describe an approved technology for a particular industrial process or environmental problem and greatly emphasize the design and use of preventive methods.
- **Performance-based standards:** mandatory standards which define a firm's duty in terms of the problems it must solve or the goals it must achieve, focusing on the outcome and avoiding overt prescription.

Economic Instruments

- **Emission charges and taxes:** direct payments based on the quantity and quality of a pollutant.
- **Product charges and taxes:** payments applied to products that create pollution when manufactured, consumed or disposed (e.g. fertilizers, pesticides, or batteries).
- **User charges:** payments for the cost of collective services. They are primarily used for the financing of local authorities, e.g. for the collection and treatment of solid waste and sewage water. In the case of natural resource management, user fees are payments for the use of a natural resource (e.g. park, fishing, or hunting facility).
- **Marketable (tradable, transferable) permits:** these consist of environmental quotas, permits, maximum rights allocated to economic agents by a competent authority. Once the initial allocation is made, these permits can be transferred (traded) between sources, geographical areas or time periods (see Section II).
- **Deposit-refund systems:** payments made when purchasing a product (e.g. packaging). The payment (deposit) is fully or partially reimbursed when the product is returned to the dealer or a specialized treatment facility. I).
- **Non-compliance fees:** payments imposed under civil law on polluters who do not comply with environmental or natural resource management requirements and regulations. They can be proportional to selected variables such as damage due to non-compliance, profits linked to reduced (non-) compliance costs, etc.
- **Performance bonds:** payment of a deposit (in the form of a "bond") imposed on polluters of users of natural resources. The bond is refunded when compliance is achieved.
- **Liability payments** made under civil law to compensate for the damage caused by a polluting activity. Such payments can be made to "victims" (e.g. in cases of chronic or accidental pollution) or to the government; can operate in the context of specific liability rules and

<p>compensation schemes, or of compensation funds financed by contributions from potential polluters (e.g. funds for oil spills).</p> <ul style="list-style-type: none"> ● Environmental subsidies: all forms of explicit financial assistance to polluters or users of natural resources, e.g. grants, soft loans, tax breaks, accelerated depreciation, etc. for environmental protection. In general, environmental subsidies are in contradiction with the Polluter-pays principle, except in exceptional circumstances, as defined by the OECD Recommendation (OECD 1972).
<p><u>Information tools</u></p> <ul style="list-style-type: none"> ● Public information campaign: a campaign that aims to raise public awareness of environmental issues. ● Technological information diffusion programs: provision of technological information for producers with the aim to change the behavior of firms to be more environmentally friendly. (e.g. information services, demonstration program) ● Environmental labeling schemes: provision of information on the environment-related performance of products which is certified by third parties or the producers themselves according to predetermined criteria.
<p><u>Voluntary policy tools</u></p> <ul style="list-style-type: none"> ● Unilateral commitment or declaration: a program created unilaterally by an enterprise and/or a business without any public organization being involved. ● Negotiated agreement or commitment: a program involving a contractual arrangement between a public organization and an enterprise or business group. ● Selective regulation or public voluntary program: a program in which governments provide the framework for the policy, but leave participation up to the judgment of enterprises.
<p><u>Research and development tools</u></p> <ul style="list-style-type: none"> ● Support for the research and development in the private sector, direct commitment to the R&D activities or establishment of a partnership with the private sector.

Table 3. Categories of policy instruments for use in achieving sustainability objectives⁸

8. See Hasegawa, *supra* note 3.

V. CASE STUDY

Perhaps the industry most nearly approaching the ideals of a true ecology of construction in the U.S. is the carpet tile industry. Carpet tiles are semi-rigid squares (typically 450 mm per side) of carpet that are used in commercial and industrial applications. The advantage of this carpeting system is that areas of carpet that become worn out due to heavy traffic or damage can be simply removed and replaced with new carpet tiles. For a variety of reasons, several major manufacturers of carpet tiles are competing for market share based, at least partially, on the recyclability of their products. Among these manufacturers are Interface, Collins & Aikman, and Milliken. Each of these manufacturers has evolved a different strategy for competing in this age of emerging awareness of greening issues.

Interface recently released information about a new product called Solenium, a hybrid carpet-resilient flooring material. Although it is a composite of several different layers of materials (PTT face fiber, fiberglass and carbide adhesive, polyurethane cushion, and polypropylene secondary backing), it is designed for disassembly. At about 190°C, the adhesive bonding between the face fiber and urethane cushion dissociates, allowing the materials to be peeled apart for recycling. The secondary backing can be manually peeled away from the urethane cushion (EBN 1999a). Although the new product does require some virgin materials for its manufacture, the bulk of the materials can be recycled into new product. Interface also offers materials such as Solenium as "Products of Service," meaning that they can be leased from Interface who then takes on the responsibility for maintaining, removing worn sections, and recycling the used materials into new products.

Backing materials are one of the most important components of carpeting because they come in contact with the underlying surface and must have adequate toughness, strength, and durability to withstand the wide variety of loads to which they will be subjected. Collins & Aikman created a new backing material which they refer to as Powerbond ER3 and which contains up to 50% post-consumer waste in the form of old carpet from its competitors. The remainder of the ER3 product is internal production waste and post-industrial automotive waste. The manufacturer claims that the ER3 backing may in fact be superior to backing it manufactures made of 100% virgin materials.

Milliken's approach to effective materials use is to remanufacture used carpeting by deep cleaning, retexturing the surface and overprinting a new pattern on top of the old color. As

part of their marketing strategy, Milliken is planning on selling a product called "Precycle" which indicates the carpet tiles are designed for remanufacture and with an eye to potential color schemes for future generations of remanufactured product. Remanufactured carpeting also carries a significant financial incentive, because the cost of the remanufactured version is half that of the new carpet tiles.

Raw materials manufacturers such as Dupont, AlliedSignal, BASF, and DSM Chemicals are also participating in related closed loop materials ventures. In a new venture called Evergreen Nylon Recycling, AlliedSignal and DSM are building a facility that recycles a variety of nylon called *nylon 6*, which is highly recyclable. In effect the recycled polymer is identical to the virgin polymer and thus 100% recyclable. A process known as *selective pyrolysis* uses heat and steam to separate the constituent products of the nylon carpet, and *caprolactam*—the building block of *nylon 6*—rises to the top of the vat during processing. To assist with identifying carpet containing *nylon 6* and to prevent contamination from other types of nylon carpeting, AlliedSignal developed a hand-held infrared device to assist contractors in the collection of the appropriate used carpeting in the field.

These actions and strategic moves by carpet tile manufacturers and raw materials producers for the carpet industry are perhaps the most comprehensive example of the evolution of a construction ecology that has similarities to its natural ecology. For the first time, manufacturers are actually competing not only on the function and cost of their products, but also on the ability of the materials to be kept in a closed loop system of manufacture-use-recovery-manufacture. The question that emerges from observing this one segment of construction materials is: when can we expect to see similar progress in other product segments, such as wall panels or acoustical tiles? The carpet tile industry is providing ample evidence that systems approaching the ideals of a construction ecology with behavior similar to a natural system are both achievable and profitable.

The flooring industry is an anomaly in that the industry has moved towards waste minimization of its own volition without regulatory incentive. However, in other industries, the voluntary adoption of life cycle analysis is unlikely to occur without some regulation and incentives. Therefore, in order to use the lessons learned from the carpet and flooring industry regarding the possible innovation in life cycle approaches to products that result in waste minimization, a framework has been designed using the OECD classification of policy instruments shown in Table 3, focusing on the Regulatory, Economic, and Informational instruments (See

Table 4). Note that in Table 4 the label “consumer” refers to the actor that procures the product from the producer. In the case of carpet tiles, the consumer would be the carpet subcontractor who purchases and installs the tiles. The following paragraphs address the various policy instrument possibilities by phase of the built environment.

A. Design and Construction

Regulations could require producers to take life cycle responsibility for their products, thus designing them for recycling, using Design for the Environment principles. Another regulatory option would be to require producers to use recyclable materials in their products. This could include a scheme similar to Extended Producer Responsibility (EPR), in which the producer is required to take back both used and waste products they had manufactured. For the consumer or builder, a requirement that buildings contain a certain minimum percentage of recycled content and recyclable materials would be in order. Producers could also be required to use specific materials for specific products if technical data indicated that these materials were in fact recyclable while the alternatives were not. Economic incentives for improved materials use behavior could include taxes on virgin materials and subsidies for using recycled materials. It is important to pair incentives and disincentives together across the life cycle of a specific product to ensure waste minimization across the board for existing products as well as new products. To assist the impacts of regulatory and economic instruments, Eco-Labeling and Certification schemes could assist in providing information about products that meet the highest standards with respect to materials recycling and recyclability.

B. Use and Refurbishment

Carpet tiles are one of the shorter lived products of the built environment, requiring replacement in as little as 5 years in heavily trafficked areas such as corridors. It could well occur that carpet tiles are replaced 8 to 10 times over the life cycle of a 50-year building. Consequently, carpet tiles must be designed for easy removal and replacement to minimize their impacts. Keeping carpet tile waste out of landfills must be a primary objective of policy instruments at this stage of the building cycle. The general rules would be to require contractors to extract used carpet tiles and return them to the manufacturer or, in fact, any manufacturer, for refurbishment and/or recycling. When replacing materials, the same incentives and disincentives that exist at the construction

stage would occur once again. Closing materials loops must also include incentives to set up the logistics of moving materials from tens of thousands of building sites back to the manufacturer. Interface's strategy is to create products of service, for example, through their EverGreen Lease program, in which they retain ownership of the carpet tiles while leasing the service of the carpet tiles to the user. A similar strategy could be employed for many building components, with the manufacturers retaining both ownership and responsibility for building products. This type of activity could be encouraged via economic instruments that would provide tax credits for products of service utilized in buildings.

C. Demolition/End Use

Demolition waste comprises the bulk of the construction and demolition waste stream from construction. In the U.S., of the approximately 145 MMT of construction and demolition waste, 92% of this waste stream is connected to demolition activities. To return products to their manufacturers for use as raw materials for new products, it is necessary to ensure that the removed materials are as clean as possible in order to maximize the 'recycling potential' of the waste materials. This generally implies an orderly process of buildings disassembly, a process of 'deconstruction' rather than demolition in which the materials of the former building are all commingled. Consequently, policy instruments that require deliberate disassembly of buildings are needed to ensure materials are removed in as high quality a condition as possible. The primary regulatory instruments would require two actions: (1) the storage of disassembly information in the building, and (2) the provision of adequate time in the permitting process to allow building disassembly. The latter could be implemented by requiring delay times after application for a building demolition permit. Economic instruments for this phase would include increasing the cost of disposal of demolition waste and providing incentives, perhaps in the form of subsidies, for entities that set up deconstruction, recycling, and/or materials reuse businesses. Information instruments could include Eco-Labeling schemes that have as one of their criteria the ability to disassemble products into recyclable materials.

	Design and Construction		Use and Refurbishment		Demolition/End Use	
	Consumers	Producers	Consumers	Producers	Consumers	Producers
Regulatory Instruments	*Require builders to use a minimum level of recyclable and recycled content materials	*Life cycle responsibility for producers, for example, Interface's "Solenium", *Technical standards, requiring that carpet tiles be manufactured from highly recyclable nylon 6	* Require contractors collect carpet tiles and return them to producers *Landfill ban *Require contractors to use materials that are recyclable	*Require producers to take back used product and waste product and recycle it	* Require contractors to collect carpet tiles and return them to producers *Landfill ban *Require contractors to use materials that are recyclable	* Require producers to take back used product and waste product and recycle it
Economic Instruments	*Tax credit /reduced building permit fees for builders who use recyclable flooring *For owner possible property tax credits	*Tax on use of virgin material *Incentive for use of post-consumer waste * Subsidies for take-back scheme	*Reduced permit fees for used recyclable and recycled content materials *For owner possible property tax credits	*Landfill tax *Reduced fees for contractors who recycle existing materials	*Incentives for using post-consumer materials in product ex. Collins & Aikman's Powebond ER3	* Landfill tax
Information Instruments	*Eco-labeling *Information campaign to explain certification and labeling schemes	*Certification scheme	*Eco-labeling *Information campaign to explain certification and labeling schemes	*Certification scheme	*Eco-labeling *Information campaign to explain certification and labeling schemes	*Certification scheme

Table 4. Application of Policy Instruments to carpet tile manufacture, use, and disposal.

VI. SUMMARY AND CONCLUSIONS

In summary, waste minimization and resource conservation can be achieved by designing policy instruments that will help industries develop life cycle approaches to their products both in design for reuse, recycling, refurbishment, and deconstruction. The legal profession can provide the expertise needed to craft an array of intelligent and flexible policy instruments that cover the broad range of issues that affect the supply chain of construction--from raw materials extraction through use and disposal. The carpet and flooring industry is a good example of how companies can simultaneously design for the environment and be economically successful, by reducing their consumption of virgin materials while

developing technology to reuse their products. When designing policy instruments, utilizing the industrial ecology model will enable governing bodies to encourage that existing products will be diverted from the waste stream and become resources, while new products will be designed to contain post-consumer materials as well as to be reused and recycled into new products in the future. Of course, policy instruments must target both the producer and consumer groups to ensure that all stakeholders are similarly motivated to make a material choice that will minimize waste and reduce resource consumption.