

Ocean Energy Sector

Canadian Capability

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Growing Interest

- For the past few years, a lot of interest has been generated in Canada on the potential for ocean energy to provide clean and continuous power.
- For example the Ocean Energy Renewal Group (OREG) started in British Columbia and is now a pan-Canadian industry association.
- The federal government has established an inter-departmental working group on ocean energy.
- Federal and provincial labs are showing a growing interest in ocean energy research and development.

Canada's Ocean Energy Value Chain

- My company, Acton White Associates Inc. has prepared an ocean energy study for the Canadian federal government in association with the NRC Institute for Ocean Technology.

Methodology

- Our study involved three phases:
 - **Phase one:** involves an overview of the ocean energy technology development screening and options.
 - **Phase two** involves an assessment of the Canadian ocean energy value chain or potential capabilities of Canadian firms to effectively participate in this emerging sector.
 - **Phase three** involves an environmental issues scan associated with the ocean energy industry and an overview of related regulatory and jurisdictional issues.

Ocean Energy Value Chain

- My presentation is focused on **Phase two** or the assessment of the Canadian ocean energy value chain or potential capabilities of Canadian firms to effectively participate in this emerging sector.

Strong Capacity in Marine Technologies

- Canadian industry and government / university labs are part of a strong value chain (cluster) in marine technologies and in designing and building offshore structures tied to hydrocarbon developments.
- Canadian engineering firms are experts in the design and the build of offshore structures for harsh ocean environments.

Canadian East Coast

- The East Coast has a vibrant marine technology cluster that provides high technology products and services for the offshore oil and gas sector as well as information and communications that are tied to an ocean economy.
- There is extensive capacity in all aspects of installation requirements including project management, onshore construction / assembly, cable laying, transportation, offshore construction and environmental monitoring.
- There are several existing yards as a result of offshore oil and gas development adjacent to the ocean which has experience in building / assembling large structures.

St. John's NL Marine Technology Cluster

- St. John's, NL is home to numerous firms that are part of a vibrant marine technology cluster.
- This cluster is supported by strong post secondary capability in marine technologies through Memorial University, the Marine Institute and the Canadian Centre for Marine Communications (CCMC).
- The NRC Institute for Ocean Technology (IOT) has the following capabilities:
 - World class wave basins and ice tank as well as highly qualified research scientists in marine technologies.
 - Numerical simulation and model testing, field trials monitoring and evaluation.
 - Ocean Technology Enterprise Centre to support ocean technology start-ups.

Canadian West Coast

- British Columbia has a strong base of firms and academic / government research support in marine technologies as well as several highly respected marine engineering and architectural firms and shipyards.
- The University of Victoria has strong expertise in ocean observation systems and in related marine technology applications.

BC Power Technology Cluster

- British Columbia has a strong power technology cluster with capabilities in large hydro, small hydro, biomass, solar and in providing specialized machinery and equipment.
- In addition to over 300 power technology firms, this sector is supported by the NRC Institute for Fuel Cell Innovation, Fuel Cells Canada, UBC, UVIC, BC Hydro (including Power Tech Labs) and the Power Technology Alliance.

Value Chain Elements

- The ocean energy value chain developed by the Scottish Enterprise (see next chart) was considered to be quite relevant to the potential Canadian ocean industry value chain.

Ocean Energy Value Chain

| Research & Development | Feasibility Assessment | Planning | Design | Manufacture | Installation | Operation | Decommissioning |
|------------------------------|------------------------|---------------------------|--------------------------|---------------------------------|-----------------------------|--------------------------|----------------------------|
| Energy Conversion Technology | Geophysical | Project Planning | Project Design | Moorings | Onshore Assembly | Integrity Management | Offshore Disassembly |
| Energy Storage / Usage | Oceanographic | Permits | Offshore Design | Floating / Offshore Structure | Cable Laying | Performance Evaluation | Transportation |
| Prototype Testing | Heritage | Insurance | Mechanical Design | Energy Coupling System | Transportation | Recovery and Repair | Recycling / Waste Disposal |
| Investment | Environmental | Finance | Hydrodynamic Design | Power Generation Equipment | Offshore Construction | Reliability Management | Refurbishment |
| | Competing Use | Legal | Electrical System Design | Power Transmission Equipment | Civil (Onshore) Engineering | Structural Monitoring | Environmental Compliance |
| | Financial Feasibility | Power Purchase Agreements | Civil (Onshore) Design | Navigation / Comms Equipment | Environmental Monitoring | Environmental Monitoring | |
| | | | Control System Design | Control Equipment | | | |
| | | | | Energy Storage System | | | |
| | | | | Onshore Structures Construction | | | |
| | | | | Resource Assessment Equipment | | | |
| | | | | Component Testing | | | |
| | | | | Component Verification | | | |

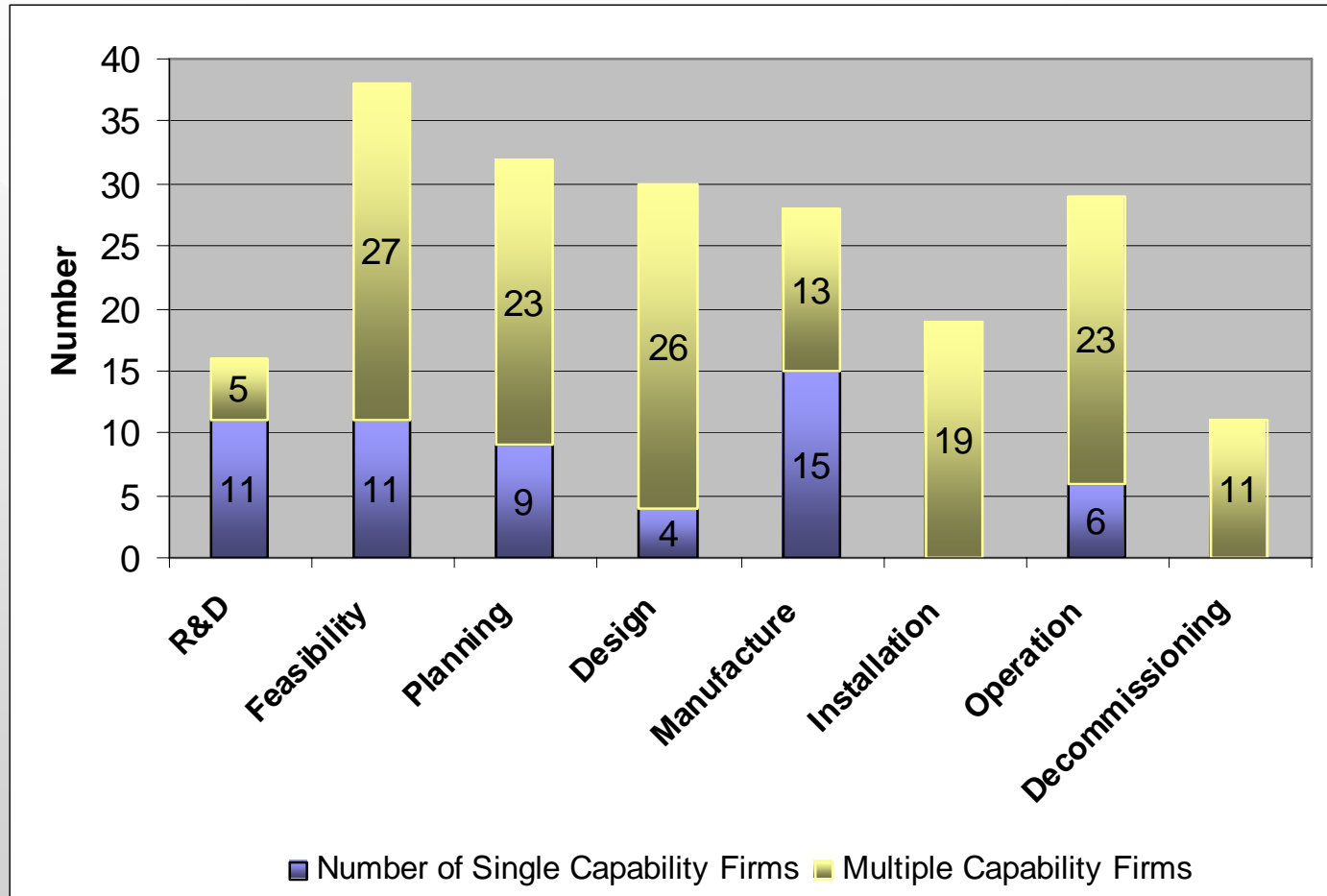
Potential Ocean Energy Organizations (1)

- We examined several Canadian company directories and association lists and prepared a long list of some 200 organizations that potentially could offer products or services supportive to ocean energy projects.
- Based on interviews and company web sites, we shortened this list to 100 companies and categorized their products and services being offered to the First Tier of the Scottish Enterprise ocean energy value chain.

Potential Ocean Energy Organizations (2)

- 56 of the 100 companies in our short list provided products or services for only one of the following value chain categories or tiers:
 - R&D
 - Feasibility
 - Planning
 - Design
 - Manufacture
 - Installation
 - Operation
 - Decommissioning
- 44 companies offered products or services for more than one (often several) of the above tiers.

Value Chain Distribution



Research and Development Tier (1)

- A few Canadian companies are developing ocean energy conversion technologies. However, relative to other maritime nations ocean energy R&D is low.
- Canada, however, has world class wave and ice tank facilities which has strong potential in supporting ocean energy R&D.

Research and Development Tier (2)

- The National Research Council of Canada (NRC) is developing energy storage technologies which is needed to even out inherent fluctuations in energy supply and demand.
- This activity is centered on fuel cell technology, materials and chemical process (NRC Institute for Fuel Cell Innovation and the NRC Institute for Chemical Process and Environmental Technologies).

Feasibility and Planning Tiers

- There is extensive capacity to undertake feasibility studies across all categories of supply chain involvement including geophysical, oceanographic, environmental, competing use, and feasibility studies for ocean renewable energy projects.
- There is also strong capacity in many aspects of planning for ocean renewable energy projects including project management, insurance, finance, and legal.

Design Tier

- There is extensive capacity in all aspects of design related to ocean renewable energy projects including overall project design and management, offshore structures, mechanical systems, hydrodynamics, electrical systems, onshore structures and control systems.
- Canada has several multifaceted national and regional engineering companies which cover all or most of these aspects.

Manufacturing Tier

- Supply of manufactured items in areas such as energy coupling systems, power generation equipment, and power transmission systems consists of a mixture of Canadian manufacturing capacity and international manufacturers with Canadian distributors.
- Much of these products consist of established product lines or established designs custom manufactured to client requirements. Any areas in which there are gaps in Canadian capacity are being filled by international suppliers and there are presumably larger competitive reasons for this. The same is true for instrumentation and control systems.

Installation Tier

- There is extensive capacity in all aspects of installation requirements including project management, onshore construction / assembly, cable laying, transportation, offshore construction and environmental monitoring.
- There are several existing yards on both coasts but particularly on the East Coast as a result of offshore oil and gas development adjacent to the ocean which has experience in building / assembling large structures.

Operations Tier

- Operational requirements for an ocean renewable energy project are similar to those for offshore oil and gas projects with elements from the electrical generation industry.
- There are a number of international and national engineering companies in Canada as well as specialized companies which provide the complete range of offshore management services including integrity management, performance evaluation, recovery and repair, reliability management, structural monitoring and environmental monitoring.

Decommissioning Tier

- Offshore disassembly and transportation associated with decommissioning are similar in requirements to the installation stage are well covered by existing Canadian capacity.
- Similarly, there are numerous companies providing recycling, waste disposal, and refurbishment services in all areas of the country including both coasts.

Direct and Indirect Ocean Energy Industries

- In addition to mapping some 100 Canadian firms against the First Tier elements of the Scottish Enterprise ocean energy value chain, we estimated the direct and the indirect industries that are part of this value chain via Statistics Canada's detailed inter-provincial input-output matrices.

Statistics Canada's Input-Output Model (1)

- Statistics Canada publishes detailed inter-linked tables for each province representing over 200 industries and 700 input commodities that are consumed by these industries.
- For example lumber production relies on the logging industry. Electrical generation requires highly specialized machinery and equipment including generators, transformers, wire and cable and so forth.

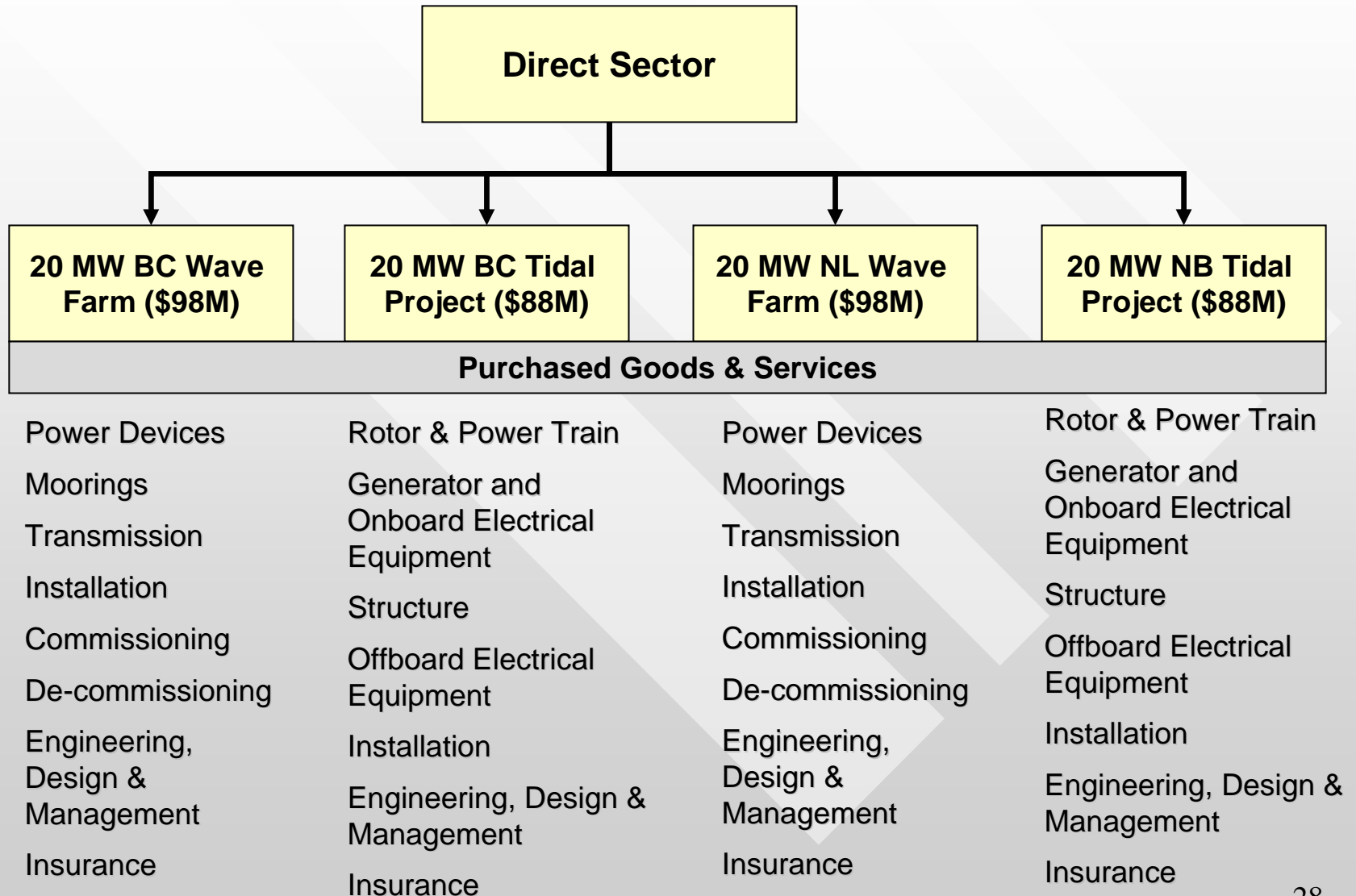
Statistics Canada's Input-Output Model (2)

- According to the United States Bureau of Economic Analysis, the annual input output accounts can be used to study changes in the structure of the economy and the relative importance of an industry to all other industries.
- These accounts can be used to examine the direct and indirect effects of changes in final uses on industries and commodities; for example, to estimate the effects of a strike or a natural disaster on the economy, or, to estimate the effects of an increase in exports on employment.

Hypothetical Ocean Construction Projects

- We estimated the direct and indirect industry impact of building four hypothetical ocean energy projects including one tidal and one wave plant on both the West and the East Coast of Canada.
- A considerable effort was made to determine the appropriate commodities and services that contributed to these four hypothetical projects.
- The inputs and costs for these four hypothetical projects are illustrated in the next chart.

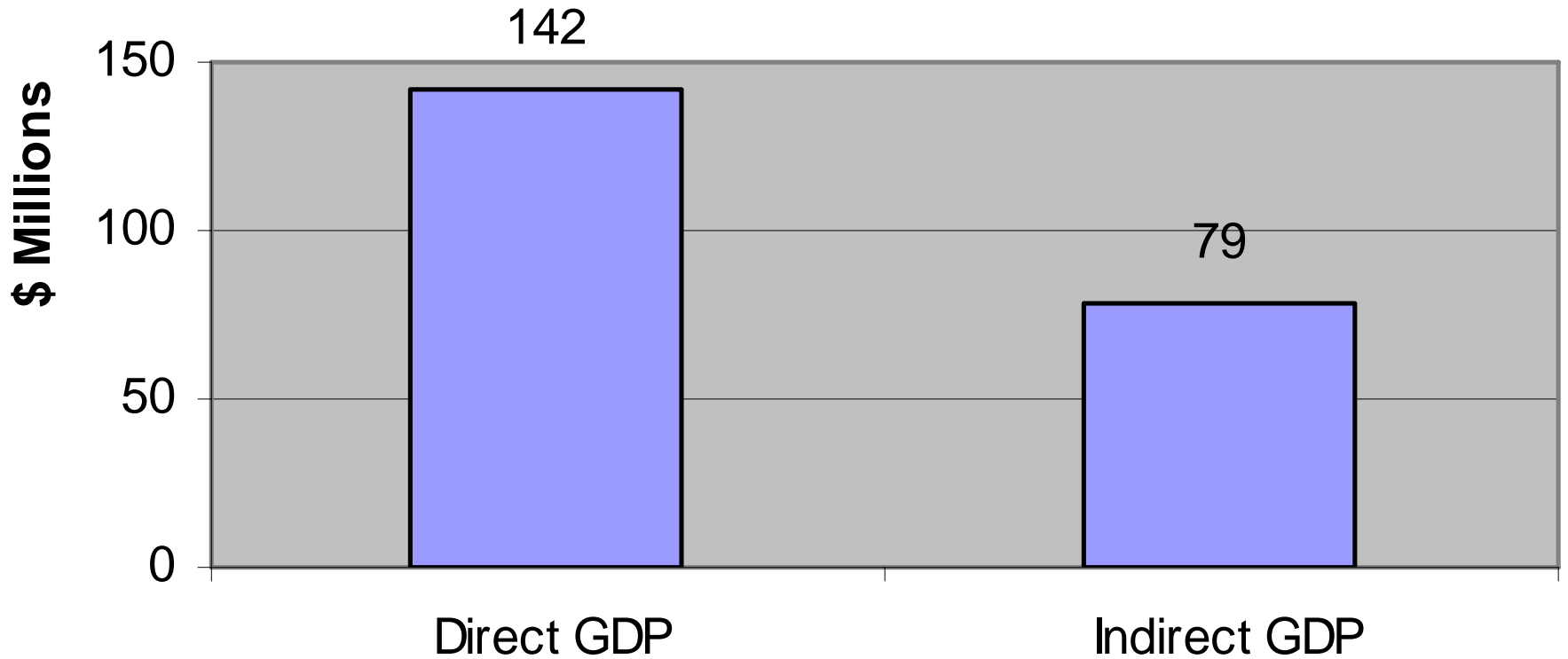
Hypothetical Ocean Energy Projects



Possible Indirect or Second Round Impacts

- Computer Systems
- Transportation
- Metal Products
- Concrete
- Control Equipment
- Plate Work and Fabricated Structural Products
- Other Professional, Scientific and Technical Services
- Ship Building and Repairing
- Specialty Transformers
- Wholesale Trade

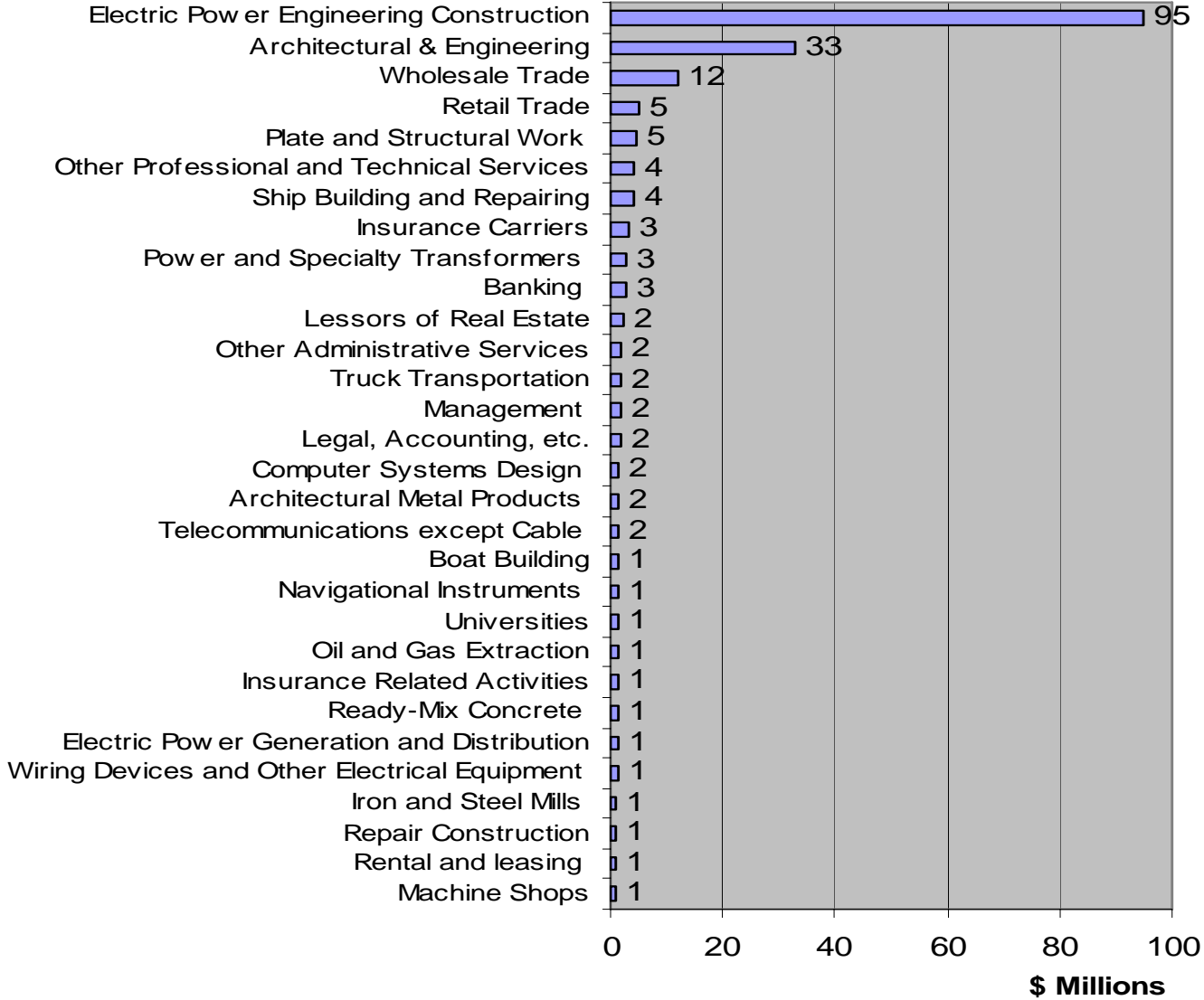
Canadian GDP (\$ Millions) Hypothetically Generated by Ocean Wave and Tidal Power Investments, 2006



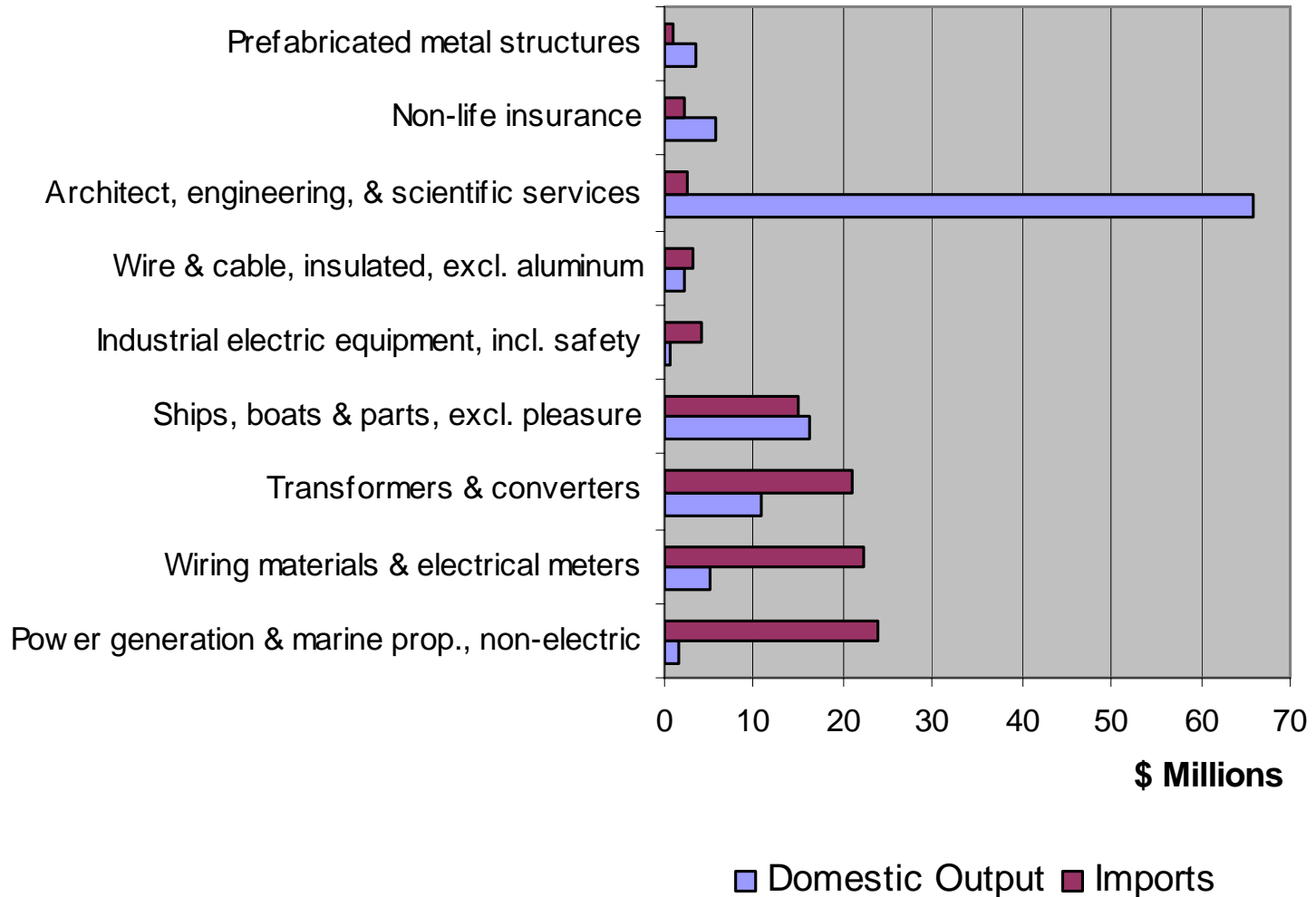
Canadian Employment Hypothetically Generated by Ocean Wave and Tidal Power Investments, 2006



Direct and Indirect GDP Associated with Hypothetical Ocean Wave and Tidal Energy Investments, 2006



Key Domestic Commodities and Imports Possibly Associated with Ocean Wave & Tidal Power Investment, 2006



Canada is Part of the Global Economy

- While the results of our modeling showed that a high amount of the power technology machinery and equipment could be imported, we believe that the Canadian power technology sector is well positioned to provide a significant share of the requisite machinery and equipment for future ocean energy projects.
- The following charts show that power technologies are associated with both high export orientation rates and import penetration rates, which is indicative of a healthy global economy that is fueled by trade and specialization.

Export Intensity of Key Machinery and Equipment Inputs for Ocean Energy Projects

| Export Intensity | 2002 | 2003 |
|--|--------------|--------------|
| Other Communications Equipment Manufacturing | 64.9% | 52.5% |
| Power, Distribution and Specialty Transformers Manufacturing | 42.0% | 33.5% |
| Motor and Generator Manufacturing | 94.4% | 78.7% |
| Switchgear and Switchboard, and Relay and Industrial Control Apparatus Manufacturing | 92.8% | 82.5% |
| Battery Manufacturing | 94.5% | 94.2% |
| Communication and Energy Wire and Cable Manufacturing | 13.2% | 10.8% |
| Ship Building and Repairing | 7.0% | 15.5% |
| TOTAL | 51.5% | 47.0% |

Import Penetration of Key Machinery and Equipment Inputs for Ocean Energy Projects

| Import Penetration | 2002 | 2003 |
|---|--------------|--------------|
| Other Communications Equipment Manufacturing | 66.0% | 58.6% |
| Power, Distribution and Specialty Transformers Manufacturing | 35.3% | 29.8% |
| Motor and Generator Manufacturing | 97.0% | 88.7% |
| Switchgear and Switchboard, and Relay and Industrial Control Apparatus Manufacturing | 95.2% | 88.3% |
| Battery Manufacturing | 98.6% | 98.0% |
| Communication and Energy Wire and Cable Manufacturing | 24.8% | 25.4% |
| Ship Building and Repairing | 90.7% | 93.0% |
| TOTAL | 77.6% | 76.2% |

Canadian International Trade: Power Technology Machinery and Equipment

| | | 2005 |
|--|---------------|----------------------------|
| Boiler, Tank and Shipping Container Manufacturing | Exports | \$776,085,776 |
| | Imports | \$924,591,089 |
| | Trade Balance | (\$148,505,313) |
| Industrial Machinery Manufacturing | Exports | \$3,240,495,015 |
| | Imports | \$4,222,022,374 |
| | Trade Balance | (\$981,527,359) |
| Metalworking Machinery Manufacturing | Exports | \$2,003,730,213 |
| | Imports | \$2,722,653,802 |
| | Trade Balance | (\$718,923,589) |
| Engine, Turbine and Power Transmission Equipment Manufacturing | Exports | \$4,627,054,234 |
| | Imports | \$6,096,461,716 |
| | Trade Balance | (\$1,469,407,482) |
| Electric Lighting Equipment Manufacturing | Exports | \$614,324,363 |
| | Imports | \$1,597,607,091 |
| | Trade Balance | (\$983,282,728) |
| Electrical Equipment Manufacturing | Exports | \$2,592,576,962 |
| | Imports | \$4,338,330,783 |
| | Trade Balance | (\$1,745,753,821) |
| Other Electrical Equipment and Component Manufacturing | Exports | \$2,156,960,752 |
| | Imports | \$4,730,682,354 |
| | Trade Balance | (\$2,573,721,602) |
| Sub-Total | Total Exports | \$16,011,227,315 |
| | Total Imports | \$24,632,349,209 |
| | Trade Balance | (\$8,621,121,894) |

Bottom Line

- Canada has an a strong capacity in both the design and build aspects of the ocean energy value chain.
- While this capacity spans the entire ocean energy value chain, Canadian expertise is particularly strong in the engineering, design and systems integration components of this value chain, especially for offshore structures designed and built for harsh ocean environments.
- Canada's power technology machinery and equipment industry is a significant player on the global international trade field. This capacity could be effectively employed in the ocean energy domain when this sector migrates from a pre-commercial to a commercial phase.