



Status report on the Application and Support of Thermoelectric Devices in Asia and Europe

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Proprietary Information of Marlow Industries, Inc.

This is a continuation of an effort started at the first of these meetings. The data is mostly publicly available data with some added data to fill in gaps. The added data was necessary to compensate for the imperfections in the web available data.

While this data is still imperfect the overall impression is as accurate an impression as can be achieved with a reasonable effort, and probably not to different from what could be achieved by expending a great deal more effort.

First The Numbers on Industry

By Country	
Canada	3
China	25
Finland	1
France	3
Germany	6
Iceland	1
Italy	5
Japan	7
New Zealand	1
Russia	5
Spain	1
Sweden	2
UK	1
Ukraine	4
US	44

◇ Some considerations

- Data from Web identifying entities involved in Thermoelectrics
 - ◇ With some judgment as a CTO
- Doesn't reflect details but ...
 - ◇ Reflects our reality
- US numbers reflect primarily small business
- Japanese numbers reflect primarily large multi-nationals
- European Numbers primarily small business, more of a mix

....Let's look at the mix

The numbers in the columns represent the number of firms in the final list. There are several web sites on the internet that provide links to companies rising under the search words thermoelectric or thermoelectric.

First The Numbers on Industry

By Sector	
Material	25
Device	30
Systems	73
Rep/Dist	12
Services	3

◇ Some considerations

- Material means either produce for own consumption or sell as product (Raw, Ingot, Wafers Elements)
- Device means same thing for TEC
- Again, details are not to important, general impression is.
- Most of participants are OEM who incorporate a device, or a sub assembly into their end item

... despite my comments, lets look at the details.

The same list can be represented in terms of categories, in many cases one firm can appear in several categories. For example, Marlow Industries itself, produces material, devices and systems.



First The Numbers on Industry

	Material	Device	Systems	Rep/Dist	Services
Canada	2	1	2	0	0
China	2	7	17	2	0
Finland	0	0	1	1	1
France	0	0	3	0	0
Germany	3	2	5	0	0
Iceland	0	0	1	0	0
Italy	0	1	5	0	0
Japan	5	4	5	0	0
New Zealand	0	0	1	1	0
Russia	4	3	2	1	0
Spain	0	0	1	0	0
Sweden	0	0	2	0	0
UK	0	0	1	1	0
Ukraine	3	4	1	0	0
US	6	8	26	6	2
Check Totals	25	30	73	12	3

This is the overall matrix where both the country and the function are shown. What lies behind most of this is that there are several captive capabilities where companies produce for their own consumption and do not advertise their internal operations. In addition there seems to be an over capacity in most markets at this time, which is caused by the down turn in the overall economy of the past two years, and by the structure of the industry into commodity and special design sectors as well. The net effect of this has been to drive prices down.

First The Numbers on Industry

	Material	Device	Systems	Rep/Dist	Services
Canada	2	1	2	0	0
China	2	7	1	2	0
Finland	0	0	1	1	1
France	0	0	3	0	0
Germany	3	2	5	0	0
Iceland	0	0	1	0	0
Italy	0	1	5	0	0
Japan	5	4	5	0	0
New Zealand	0	0	1	0	0
Russia	4	3	2	0	0
Spain	0	0	1	0	0
Sweden	0	0	2	0	0
UK	0	0	1	0	0
Ukraine	3	4	1	0	0
US	6	8	26	6	2
Check Totals	25	30	73	12	3

Primarily small refrigerators and water chillers
 > 6 million TEC/yr + exports (over capacity)

The main point of this chart is that there is a large internal market in China. This market consumes primarily commodity type thermoelectric devices, and provides a base for participation in external markets at very competitive prices, prices that are so low Western manufacturers cannot compete on a price basis.

First The Numbers on Industry

	Material	Device			
Canada	2	1			
China	2	7			
Finland	0	0			
France	0	0	3	0	0
Germany	3	2	5	0	0
Iceland	0	0	1	0	0
Italy	0	1	5	0	0
Japan	5	4	5	0	0
New Zealand	0	0	1	1	0
Russia	4	3	2	1	0
Spain	0	0	1	0	0
Sweden	0	0	2	0	0
UK	0	0	1	1	0
Ukraine	3	4	1	0	0
US	6	8	26	6	2
Check Totals	25	30	73	12	3

Primarily mix of internal and external telecom and semiconductor
Increasing emphasis on power generation

The point of this chart is that there are several thermoelectric suppliers in Japan. These entities are included within large multi-national firms, and most have a basis of internal R&D enhanced in part by the central laboratories of the firm.

First The Numbers on Industry

	Material	Device			
Canada	2				
China	2				
Finland	0				
France	0				
Germany	3	2			
Iceland	0	0			0
Italy	0	1	5	0	0
Japan	5	4	5	0	0
New Zealand	0	0	1	1	0
Russia	4	3	2	1	0
Spain	0	0	1	0	0
Sweden	0	0	2	0	0
UK	0	0	1	1	0
Ukraine	3	4	1	0	0
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Privatized FSU entities have done rather well in serving some of western demands. Internal Russian consumption is slow in emerging ... some reports that it is beginning to build

The point of this chart is that the Former Soviet Union which was a power house in the research, development and consumption of thermoelectrics in the 50's to the 80's built a large infrastructure. That has become the basis of several firms that have survived rather difficult times and have become a base of a competitive industry, especially in commodity markets.

The Numbers on Universities

Universities	
US	36
Japan	35
France	10
Germany	8
China	6
Russia	6
Czech Republic	5
Spain	5
Korea	4
Poland	4
Canada	3
Moldova	3
Thailand	3
Ukraine	3
Austria	2
India	2
Italy	2
Mexico	2
Sweden	2
Uzbekistan	2
Australia	1
Belarus	1
Croatia	1
Denmark	1
Israel	1
Lithuania	1
Portugal	1
Switzerland	1

The source of this data were the authors for the ICT 2003 in Le Grand Motte France.

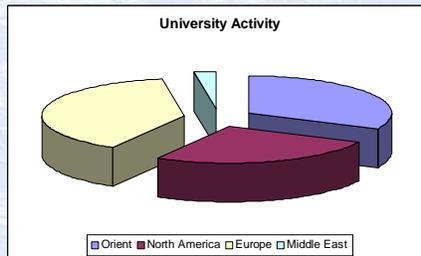
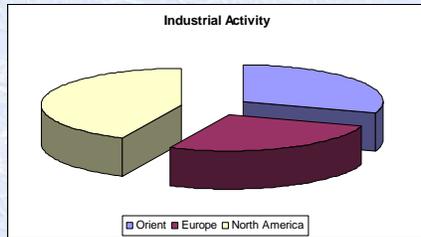
- ◊ A large contingent from China and Japan.
- ◊ Ease of access for Europeans
- ◊ Adapted to include the known US presenters when the conference is in the US.

Again ... the details are not as important as are the overall structure.

One must not let the European challenge be lost by including them as separate companies. Added up there are 60 authors from Europe.

This is the introduction of data from a different source, namely the participants in the International Thermoelectric Society annual meetings and published in their proceedings. These meetings alternate between Asia, US and European locations. Each location has a large number of participants that often do not attend or publish in the meetings when in other locations. This list was derived from the authors presenting at the recent meeting in France (2003) and was augmented from the known participants in other meetings held in the US.

The Numbers on Universities



There are several points in this comparison:

1. The shares of presenters and authors do not convey all of the message even though apparently balanced.
2. If other ICT meetings were used the differences would have reflected the meeting location more than the activity in the regions.
3. I included the middle east because they were there.
4. For some reason no participation comes from Brazil and Argentina directly.

These pie charts demonstrate that no one area has a monopoly on academics and industry researchers. It also points out that the South American and Latin American markets are sorely misrepresented in this data, but the extent of the misrepresentation is not easy to estimate.

Regional Issues

Japan - discussion to follow provided by:

- **Prof. Dr. Takenobu KAJIKAWA**

Europe - abstract from the opening paper at ICT
2003

- **Prof. Michael Rowe**

US Assessment - HBL comments

Professor Kajikawa of Japan was kind enough to assist in the preparation of this presentation. The European assessment was taken from the opening presentation at the 2003 International Thermoelectric Conference.



National Project on Development for Advanced Thermoelectric Conversion Systems

Prof. Dr. Takenobu KAJIKAWA
Shonan Institute of Technology

Proprietary Information of Marlow Industries, Inc.





Japanese - National Project on Development for
Advanced Thermoelectric Conversion Systems

- **Sponsor**
 - **NEDO** (New Energy and Industrial Technology Development Organization)
- **Project Leader**
 - Prof. Dr. Takenobu KAJIKAWA, **SIT**(Shonan Institute of Technology)
- **Participants**
 - **ENAA** (Engineering Advancement Association of Japan) and Six Companies



marlow
Industries, Inc.

Japanese - National Project on Development for Advanced Thermoelectric Conversion Systems

- **Budget scale**
 - Grant
 - 2,700 million Japanese Yen (approx. 25.2 million \$)
 - Total project budget
 - 4,050 million Japanese Yen (approx. 37.8 million \$)
- **Period of the Project**
 - FY2002 to FY2006 (five years)
- **Interim Evaluation**
 - End of FY2004
- **Final Evaluation**
 - After the Project Completion
- **Evaluation of practical Pervasion**
 - in FY2010

This project is apparently focused upon power generation (Seebeck) aspect of thermoelectrics. This is logical with the dominant theme that Energy supply and use has had in the development of modern Japan.



An Overview of European Thermoelectrics

Professor David Michael Rowe NEDO Centre for Thermoelectric Engineering
Presentation to ICT 2003 Le Grand Motte, France 17 – 21 August 2003

- **NanoThermal - 2000 the first European multi-national collaborative thermoelectric project funded by the European Union**
 - 8 research groups in 6 European countries
 - Work concluding in 2003.
 - Focus on “Nano-engineering of high performance thermoelectrics”
- **NAMTEC - The 116 research group with 450 researcher proposal to the European Commission submitted on March of 2003 for E3 million**
 - While the proposal was not successful in obtaining funding it does provide a census of the activities in Europe.
 - It also brings a widely dispersed community under a more coordinated and focused environment.

... something will happen in the future as a result.

The European View is difficult to assess because there are so many possible participants in Europe. For several years the leaders in thermoelectric research sought to find a way to influence the Common Market research funding mechanisms to support multinational projects. The most recent proposal was for funds to increase collaboration and communications between all of these entities.

While the most recent request was unsuccessful, there is a sizeable resource of talented individuals in very capable institutions which are steadily improving their ability to work together.

US Programs

After nearly a decade of Advanced Thermoelectric Materials Research sponsored out of:

- ◊ Army Research Office
- ◊ DARPA
- ◊ Office of Naval Research
 - ◊ With a focus on ZT enhancement

NASA has provide some focus in the Prometheus Program for RTG use of thermoelectrics

DARPA and ONR have shifted focus on Direct Conversion for Power Generation

DOE in "Basic Research Needs to Assure A Secure Energy Future" highlighted

"Thermoelectric Materials and Energy Conversion Cycles for Mobile Applications"

And here we are at the end of DOE EE conference, looking to the future.

... but you all know this better than I do anyway.

The assessment of the US situation was presented in short hand notation primarily to contrast the different character from that just recently highlighted.

The offer was made to share the basic data base behind this presentation, the cost for which is the agreement to share additions and improvements with the authors of this presentation, Dr's Lyon and Kajikawa.