Materials also play a large role in energy sustainability. "Solving the challenges to achieve fully sustainable energy involves coordinated research in many areas," said Veronica Barone, Assistant Professor of Physics at Central Michigan University. Barone is the principal investigator on an energy-storage-based SusChEM project that seeks to develop new electrode materials for sodium-ion batteries. The ultimate goal of the project is to replace lithium-ion batteries with reliable sodium-ion substitutes because sodium is abundant and inexpensive. According to Barone, "Lithium cost is skyrocketing and due to its low natural abundance will continue to do so. If we achieve reliable sodium technologies the cost of metal-ion battery technologies will be significantly lower."

Energy is also the focus of Robert Lad's SusChEM project, which seeks to reduce energy consumption in the industrial sector. Lad, Professor of Physics at the University of Maine, is developing a new class of thin-film materials and sensor devices based on multilayered borides, silicides, or oxides integrated with platinum alloys. Lad hopes to produce thin films that are stable in harsh environments and at temperatures above 1000°C. "The development of stable high-temperature thin films will improve sustainability by enabling the deployment of miniaturized sensors, actuators, and other electronic components that can be used to reduce overall energy usage and increase the longevity of complex, expensive high-temperature machinery," said Lad.

Eray Aydil and Chris Leighton, Chemical Engineering and Materials Science Professors at the University of Minnesota, are using SusChEM funding to research inexpensive, abundant, and non-toxic materials for solar energy conversion. The Minnesota group is examining pyrite (iron disulfide) as an alternative to current thin-film solar technologies. While pyrite is abundant, non-toxic, and cheap, the challenge is producing solar cells that efficiently convert sunlight to energy, a feat that has not yet been achieved with pyrite. While it is impossible to predict the success of pyrite solar cells, Aydil pointed out that the SusChEM project has another very important impact—namely "well-trained students who are sensitized to the importance of looking for sustainable solutions to the problems facing humanity."

Awards for this initiative are typically in the amount of $300k–$550k, depending on the number of investigators and the amount of funds available. Applicants are encouraged to contact a program officer before submitting a proposal.

Jennifer A. Nekuda Malik

Korea reports on 2012 R&D investments by private companies

Minister Yoon Sang-jick of the Ministry of Trade, Industry, and Energy and President Jeong Jae-hoon of the Korea Institute for the Advancement of Technology reported the results of their study on the research and development (R&D) investment trend of the 1000 Korean companies that made the highest R&D investments. The total R&D investment by these top 1000 companies was recorded as KRW35.6 trillion [~USD$34 billion], up 12.7% from 2011.

Looking at R&D investment by sector in 2012, the semiconductor sector was in the lead with KRW12.3 trillion, followed by the electronics sector (KRW6.9 trillion) and the automobile sector (KRW4.6 trillion). In terms of the year-on-year increase, the machinery sector accounted for 18.3%, followed by the electronics sector (15.1%) and the semiconductor sector (7.8%).

Of the 2012 total of KRW35.6 trillion invested in R&D, large-scale enterprises (over 1000 employees) invested KRW30.3 trillion, followed by high potential enterprises (300–999 employees) and smaller businesses (under 299 employees), which invested KRW2.4 trillion and KRW2.8 trillion, respectively.

The year-on-year increase rate in 2012 was recorded as 13.8%, 3.1%, and 9.5% for large-scale enterprises, high potential enterprises, and smaller businesses, respectively.

According to the Ministry, the government will continue to analyze and review the R&D investment trends of the private sector and reflect the results in R&D policy establishment.

In tracking global R&D performance trends, the US National Science Foundation noted in 2011 that South Korea's R&D/GDP ratio rose to 4.0%. □

Table. R&D Investment and Increase Rate by Sector (KRW billion, %)

Classification	2008	2009	2010	2011	2012	Compound annual growth rate (2008–2012)
Machinery	954 (-)	896 (6.1)	1,058 (18.1)	1,192 (12.7)	1,410 (18.3)	8.1%
Semiconductor	8,088 (-)	8,557 (5.8)	10,451 (22.1)	11,402 (9.1)	12,290 (7.8)	8.7%
Auto	3,734 (-)	3,670 (–1.7)	4,160 (13.4)	4,376 (5.2)	4,631 (5.8)	4.4%
Electronics	4,107 (-)	4,770 (16.1)	6,015 (26.1)	5,963 (–0.9)	6,864 (15.1)	10.8%

Note: Partial list by sector

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