large-scale expansion. For example, thin-film solar has been promoted as a much lower-cost, more flexible, and more widely applicable solar-conversion technology compared to traditional silicon panels. Thin-film solar currently uses indium because of its versatile properties, but indium is also widely used as a component of flat-screen monitors. Reserves of indium are limited, and a 2007 study found that at current rates of consumption, known reserves of indium would last just thirteen years.[7]

Can greatly increased demand for these resources be accommodated? As shown in Table 1, successful deployment to 2030 of a range of new energy technologies (and some non-energy advanced technologies) would substantially raise demand for a range of metals beyond the level of world production today. In the case of gallium, demand from emerging technologies would be expected to reach six times today's total global production by 2030; for indium, more than three times today's production—compared to just fractional increases in the demand for ruthenium and selenium.

Although alternative metals and materials exist for certain technologies (albeit often with performance trade-offs), embarking on a particular technology deployment path without consideration of long-term availability of material inputs can substantially raise risks. These risks are not limited to physical availability and price; they include potential supply disruptions as

TABLE 1 Global Demand on Raw Materials from Emerging Technologies

RAW MATERIAL	FRACTION OF TODAY'S TOTAL WORLD PRODUCTION		EMERGING TECHNOLOGIES (SELECTED)
	2006	2030	
Gallium	0.28	6.09	Thin-layer photovoltaics, integrated circuits, white LEDs
Neodymium	0.55	3.82	Permanent magnets, laser technology
Indium	0.40	3.29	Displays, thin-layer photovoltaics
Germanium	0.31	2.44	Fiber-optic cable, infrared optical technologies
Scandium	Low	2.28	Solid oxide fuel cells, aluminum alloying element
Platinum	Low	1.56	Fuel cells, catalysts
Tantalum	0.39	1.01	Microcapacitors, medical technology
Silver	0.26	0.78	Radio-frequency ID tags, lead-free soft solder
Tin	0.62	0.77	Lead-free soft solder, transparent electrodes
Cobalt	0.19	0.40	Lithium-ion batteries, synthetic fuels
Palladium	0.10	0.34	Catalysts, seawater desalination
Titanium	0.08	0.29	Seawater desalination, implants
Copper	0.09	0.24	Efficient electric motors, radio-frequency ID tags
Selenium	Low	0.11	Thin-layer photovoltaics, alloying element
Niobium	0.01	0.03	Microcapacitors, ferroalloys
Ruthenium	0.00	0.03	Dye-sensitized solar cells, Ti-alloying element
Yttrium	Low	0.01	Superconduction, laser technology
Antimony	Low	Low	Antimony-tin-oxides, microcapacitors
Chromium	Low	Low	Seawater desalination, marine technologies

Source: Gerhard Angerer et al., "Raw Materials for Emerging Technologies," (Karlsruhe: Fraunhofer Institute for Systems and Innovation Research ISI; Berlin: Institute for Futures Studies and Technology Assessment IZT, February 2, 2009).