A country's material requirements vary with its level of industrialization and development, with emerging economies showing higher material demand than mature economies. A key question is how emerging economies can achieve their goal of higher living standards for all without exhausting the resources of our planet. To answer this it is helpful to understand the current and past material intensity of use for countries at different economic development stages. Results for aggregated material flows, gained through economy-wide material flow accounting, suggest, for example, strong growth patterns during the 1950s and 1960s for the per capita material use in today's industrialized countries, with a slowing thereafter. However, at the substance level material intensity results have been sporadic so far, with a systematic historic analysis across countries of all world regions and of differing economic status still missing.

In this study we seek to close this gap by presenting an analysis of the use of nickel for the period 1950-2010 (global). Our study covers 52 countries from all world regions, including the major industrialized and emerging economies plus a set of low-income countries (with datasets for most countries available for 1974-2010). Nickel is a metal widely used in modern technology, in such diverse applications as piping in the petrochemical industry, turbine blades in aircraft engines, kitchenware and cutlery, to gearings in wind turbines. Data on nickel's historic end use sector mix is available from a detailed characterization of nickel's life cycle through material flow analysis (MFA). An advantage of our detailed MFA approach is that, by accounting for trade at all life stages, we can calculate the material intensity at the end use level, i.e. we consider the amount of nickel that the final consumer uses over time, as opposed to what the domestic industry uses (as done when material intensities are calculated based on refined metal use, due to a lack of better data).

China's intensity of nickel use per capita has grown quickly since 1985 but it still at a much lower level than in industrialized countries. For industrialized countries, our results show no clear pattern on the per capita nickel intensity of use. While it continues to grow in some European countries and in Japan, it has stagnated in the USA and in Australia. To a large extent, this can be explained with different consumer preferences in the mentioned regions. Nickel's largest use is in alloyed form in stainless steel. A variety of stainless steel applications allow for adequate substitution through other materials, for example through aluminum in buildings and construction, through plastics in dishwashers, and through nickel-free stainless steels in cutlery

and tableware. Substitutes of nickel are often of lower quality, show shorter lifetimes, and are less expensive when compared to the nickel-containing materials.

To analyze the influence of substitution further, we compare nickel's material intensity of use to that of stainless steel. We can compute the historic stainless steel intensity of use for the same 50 countries as in our nickel study, based on a similar dynamic material flow analysis that we just completed. About two thirds of all stainless steels contain nickel, but over the past two decades the growth in nickel-free and low-nickel grades has been higher than that of the nickel-containing grades, both in response to the high price of nickel and its price volatility, particularly since around 2000. The results show stark differences in the growth of nickel and stainless steel use in China, where substitution away from high-nickel stainless steel grades is a phenomenon well-known in the metal industry.

These examples show that dematerialization at the substance level is not necessarily a sign of a move to a green economy, but can have its roots in substitution effects that stem from different consumers priorities in terms of performance, appearance and price of materials.