

Cogeneration and On-Site Power Production

- Cogen: a powerful tool in achieving Kyoto targets
- The falling size of power plants
- How electricity transport regimes influence the economics of cogeneration
- Certification of power quality
- Cogeneration, industrial efficiency, and climate change



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1920–1995 AND BEYOND: trending downwards

What some would call a paradigm shift has occurred in the U.S. electricity industry. Since 1980, average power plant size has been plummeting, and recently reached its lowest level since just after World War II. Philippe Dunsky, of the Montreal-based *Helios Centre*, examines the data and suggests that this new trend is supported by fundamental changes in power technology, market structures and economic imperatives.

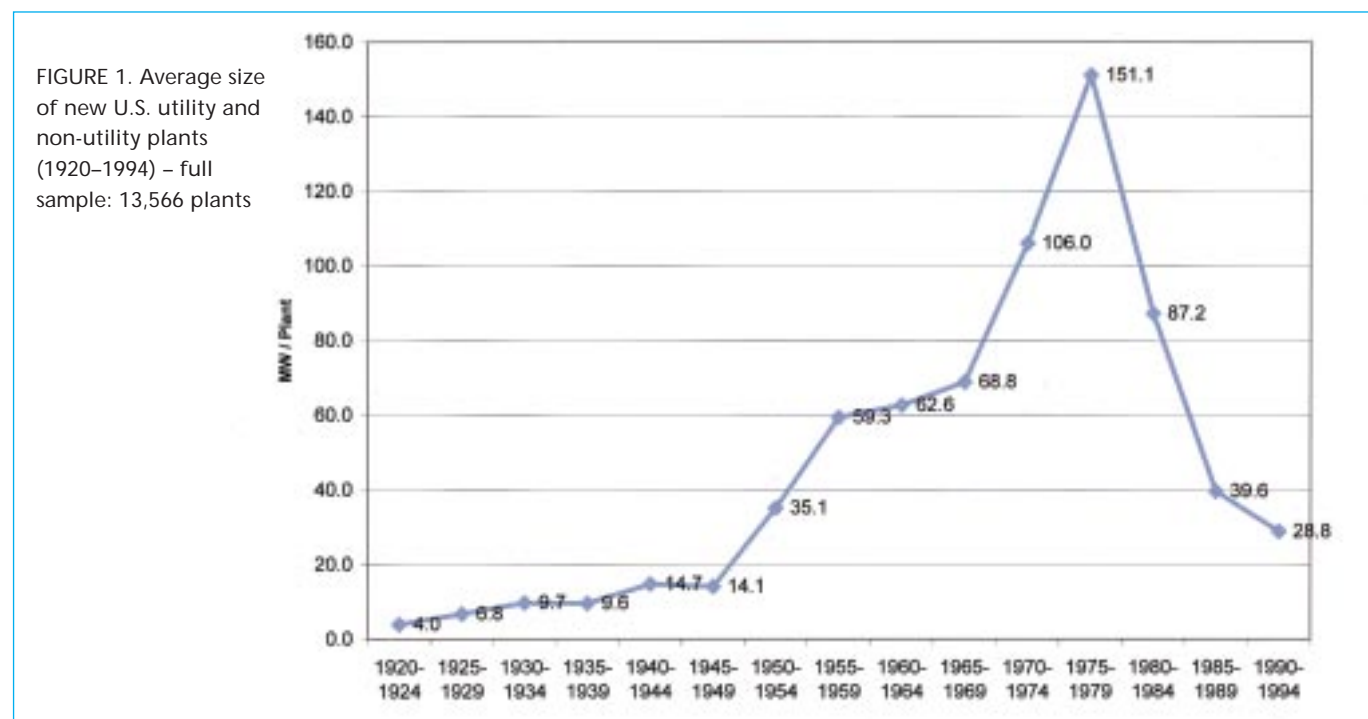
Most players in the electricity industry have come to recognize the trend toward smaller-scale power generation plants, even if the evidence for this is often anecdotal. Yet while the big picture is glaringly obvious – enormous nuclear and coal plants of the 1970s and 1980s have been replaced by other technology, such as smaller gas turbines – the degree of real change is startling.

WALKING THROUGH THE CENTURY

Based on detailed data from the U.S. Department of Energy, we were able to determine average plant size in five-year periods from 1920 through 1995. As seen in Figure 1, average unit size rose steadily from World War I through to World War II, at an average annual rate of just under 5.5%. But the rate of growth increased rapidly in the

following decade, at more than 17% per year, leading to a quadrupling of average plant size. While unit size generally remained stagnant over the following ten years, the 1970s signalled a resurgence of the previous trend, with average nameplate capacity leaping to more than 150 MW, or ten times the average only three decades earlier. As we'll see later, this was not an artefact of changes in the number of smaller plants. Rather, the new peak in average plant capacity was fuelled by a combination of the coming-of-age of new, large-scale nuclear and coal plant technology, and grossly exaggerated demand forecasts (which, in turn, required adding significantly *more* big plants to the overall equation). Figures 2 and 3 show the distribution and average size of new capacity installations by primary energy source.

Yet the ascent of gas turbine technology, followed



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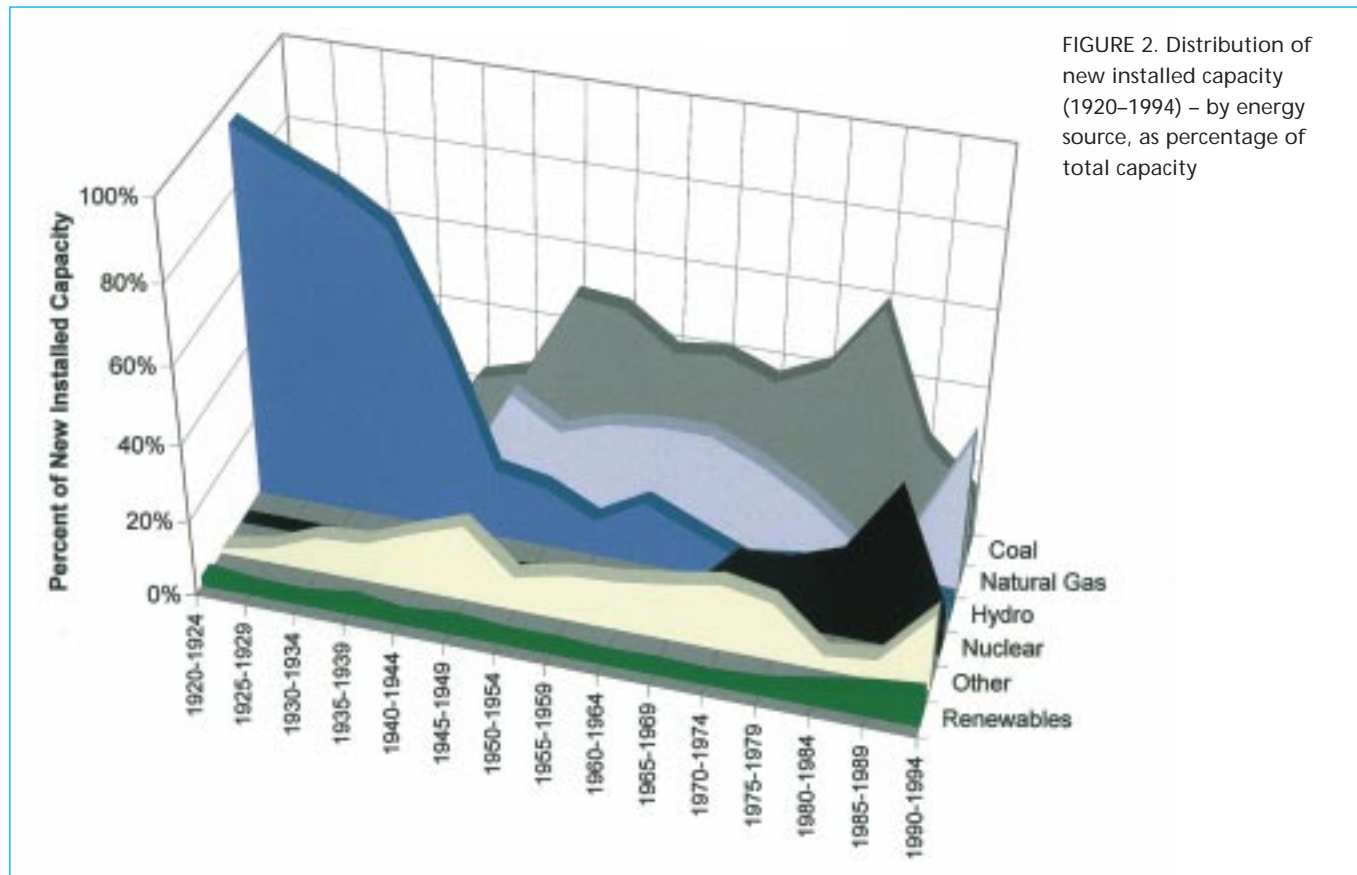


FIGURE 2. Distribution of new installed capacity (1920–1994) – by energy source, as percentage of total capacity

closely by the sudden end of the nuclear era, would soon usher in a significant reversal of the trend of previous decades. By the early 1980s, with the advent of PURPA (the Public Utility Regulatory Policies Act of 1979) – which for the first time offered non-utility generators access to the wholesale market – the average size of new plants plummeted to below 90 MW. The new trend of diminishing scale was to be confirmed in the years that followed, with size dropping first to just under 40 MW in the latter half of the decade, then to a meagre 29 MW in the first half of the 1990s. By this period, the last for which accurate historical data are available, average plant size was at its lowest since just after World War II.

The ascent of gas turbine technology, followed closely by the sudden end of the nuclear era, soon ushered in a significant reversal of the trend of previous decades.

These data include nearly 99.9% of all 13,583 known units brought on-line in the U.S. throughout the 75-year study period. Plants included in the dataset range from coal and nuclear megaprojects of 1300 MW, down to wind, solar-PV and other units of less than 50 kW each. To verify that the thousands of micro-units were not affecting the overall portrait, we proceeded to remove from the sample all projects below 1 MW, then 10 MW, then 25 MW (see Figure 4). In each case, the basic pattern – and degree – of market transformation remained unchanged.

‘TALKING ABOUT A REVOLUTION’

This revolution in plant size indicates a fundamental change in the economies of scale previously associated with large power projects. And, as gas turbine and renewable energy technologies continue to improve, we can expect that economies of scope will soon take over.

Indeed, while in the past power plants were *built* (constructed), many in the future will be *manufactured*. Capstone and other micro-turbine producers are now joining Astropower and other solar and wind energy manufacturers in producing assembly-line power plants that will be available to small, individual consumers. And the advent of fuel-cell technology – which may eventually become standard fare in homes and businesses throughout the developed world – will only accelerate this transformative development. In the process, the very physical structure of the electricity industry, with central power plants serving loads through long, high-voltage power lines, is set to become, if not obsolete, then limited to a supporting role in the theatre of power markets.

The transformation of the electricity power market in recent and coming years stems from a timely and interdependent combination of fundamental changes in technology, market structure and economic imperatives.

- **Technology** To a surprisingly large extent, new gas turbine technology has allowed for the miniaturization of power plant technology with relatively few losses in conversion efficiency. This has led to a significant reduction in economies of scale, paving the way to standardized, ‘off-

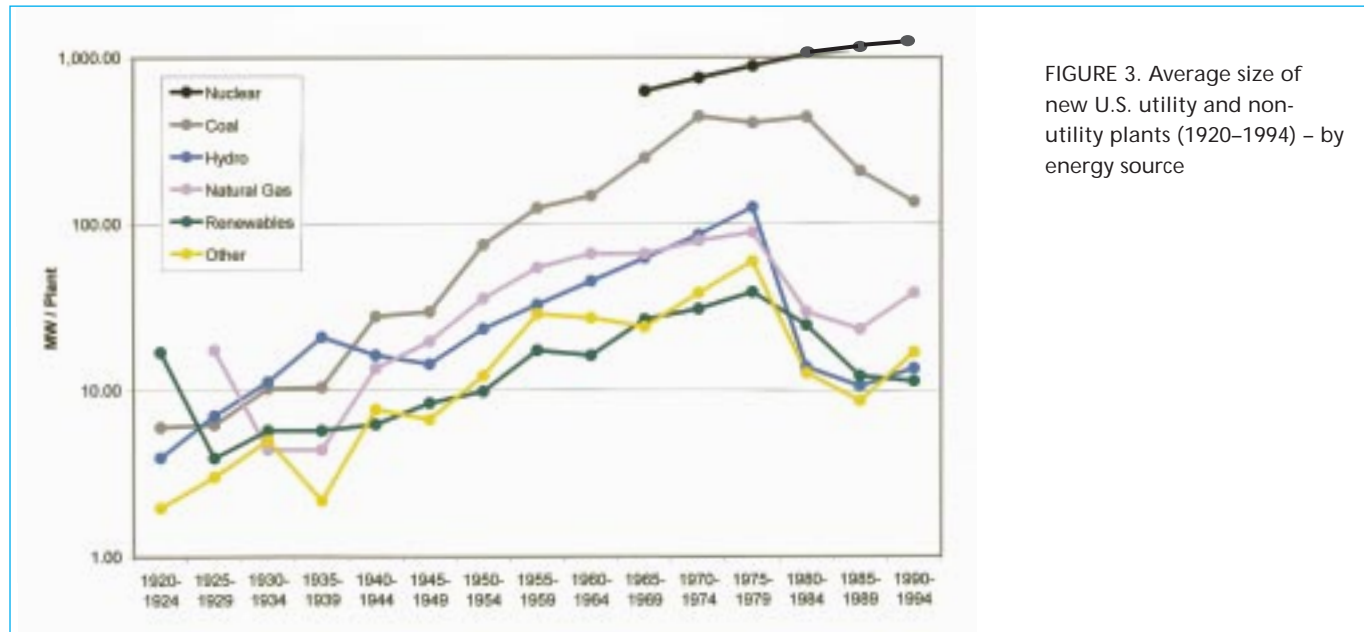


FIGURE 3. Average size of new U.S. utility and non-utility plants (1920-1994) – by energy source

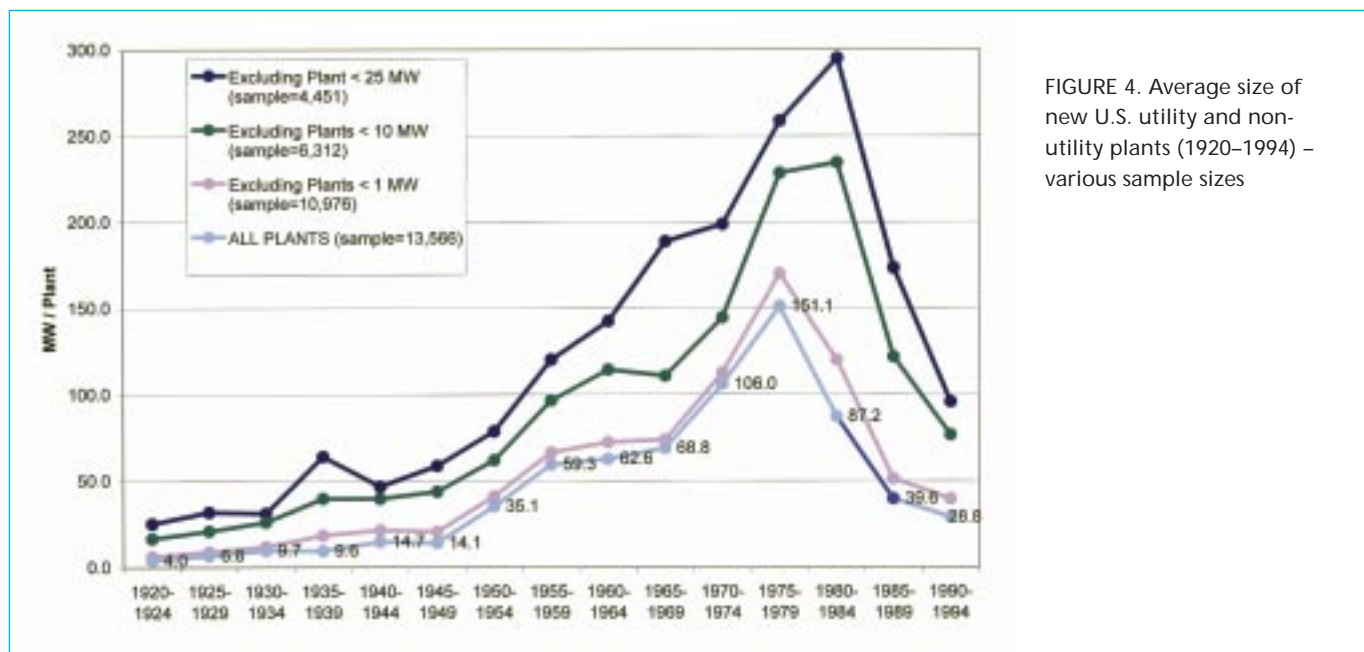


FIGURE 4. Average size of new U.S. utility and non-utility plants (1920-1994) – various sample sizes

the-shelf' power units and, ultimately, decentralization of generation. Order-of-magnitude improvements in wind turbines and other renewable energy technologies have added to the market acceptability of increasingly distributed energy options, a trend that is bound to be accelerated in the future by the advent of fuel cells.

- **Market restructuring** Furthermore, losses in efficiency stemming from smaller-scale units can now be counterbalanced by the added value of reliability gains, the ability to bypass transmission and distribution charges, and the avoided costs of emissions reductions. Indeed, as competition brings an end to supply-demand planning, and as competitive pressures force some remaining utilities to cut back on reliability-related investments, the value of on-site power will continue to increase.

Meanwhile, rate unbundling has brought increased price

transparency, and in some cases volatility, to the cost of using transmission and distribution assets, which small-scale plants can avoid. The cost of sulphur allowances (traded in the U.S. as a commodity, under an open-market cap-and-trade policy), and more stringent emissions requirements for other pollutants, and possibly, in the near future, for greenhouse gas abatement, can only add to the value of *relatively* clean-burning natural gas – especially in cogeneration processes – and zero-emissions renewable energy facilities.

- **Economic imperatives** Finally, as the transformation from a resource- to a knowledge-based economy continues its forward stride, the added value of reliability takes on greater significance. This holds true both for information-dependent industries (such as financial markets), and users of increasingly power-sensitive equipment. These 'special needs' clients are likely to emerge as the early niche

1920–1995 AND BEYOND: TRENDING DOWNWARDS

markets for what ultimately will be the mass marketing of individual, small-scale power plants.

In addition to these fundamental changes come increased environmental awareness (and the ability, in deregulated markets, to make a choice based on conscience), as well as an emerging ethic of individualization, bringing with it a reluctance toward dependence on large, complex and interdependent systems.

In the end, we seem destined to return to Edison's initial vision of a world of decentralized, small-scale power generation.

WHAT OF THE IMMEDIATE FUTURE?

While a small portion of the historical pattern can be linked to specific U.S. policies (such as PURPA), the underlying factors for future change apply equally well to the rest of the developed world. Furthermore, the lack of grid infrastructure in many under-developed countries, coupled with the increasing technological maturity of distributed energy options, adds to the likelihood of worldwide market acceptance of this new technological paradigm.

Nevertheless, in the short term we may see a resurgence of larger plants. Indeed, as considerable power shortages and diminishing reserves continue to wreak havoc on U.S. electricity prices (this summer, for example, California's average wholesale power price increased by a massive 270% over the same period last year), a number of projects-in-waiting are likely to be fast-tracked. And analysis of the host of new plants already scheduled to come on-line within the coming decade points to increasing, not decreasing, average sizes. Still, these data should be taken with a healthy grain of salt, as reported data for future projects is invariably limited to bigger plants – that is, those that require more approval time and take longer to build.

In any event, the confluence of several independent yet mutually-strengthening forces is unlikely to leave room – excepting the odd blip – for a reversal of the current trend. On-site cogeneration and trigeneration, micro-sized turbines and fuel cells, and a host of improved renewable energy technologies all provide the reliability, efficiency and environmental attributes that customers and new market structures alike have begun to demand. In the end, we seem destined to return to Edison's initial vision of a world of decentralized, small-scale power generation. Indeed, the data do support the claim.

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