

THE FIFTH KONDRATIEFF WAVE: THE FOSSIL FUELS APOGEE

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I. STRUCTURAL WAVES AND THE ROLE OF THE PRIMARY ENERGY SOURCES

Energy needs are related to three main factors: population growth, economic development and technological progress. It is convenient to enhance two great transitions that were responsible for the structural transformations that occurred in energy systems. First, the steam engine (associated to coal) and, second, the increase of diversification of the final use technologies and the energy sources diversification. The first transition is related to the first and second technological transformations, while the second transition is, even if not exclusively, linked with the third and fourth technological transformations, to highlight electricity as means of energy transportation and internal combustion engine associate to oil. In technological terms, it was during the last 250 years that five major technological transformations happened. These transformations appeared intermittently within a period of about a half-century and are linked with waves in the economic activity, and that result from the convergent development on several fields during the past 250 years. The first transformation (1770-1800) was linked with the substitution of wood for coal as a primary energy source, with consequences in iron-making, in fuelling the first steam engine, in building the first canals and in mechanizing cotton spinning. The second transformation (1830-1850) was related to the use of the steam power to the textile industry and to transportation (railways and steam boat). The third transformation (1860-1900) was a complex one: it centered itself on steel making and on the mechanization of manufacturing, on illumination, telephones, electrification and on the internal combustion engines. It was also characterized by the beginning of the substitution of coal by oil as primary energy source. The fourth transformation (1930-1950) was centered on synthetic materials and electronics. Finally, the fifth, beginning around 1990, centers itself on the convergence of computers, telecommunications and news technologies.

This is to say, the first three had a greater influence on industry, being nicknamed as “industrial revolutions”. However, the fourth transformation had larger impact on the consumer, given the great amount of new products. The fifth one will influence the industry as much as the consumer, due to the emergence of new products and industrial technologies (also new industries) that will lead this wave.

Bearing in mind these data, there are no doubts that the primary energy sources are associated to the major technological transformations and consequently associated to the structural long waves (frequently known as Kondratieff Waves or simply K-waves). Coal began to substitute wood in the eighteenth century (1st technological transformation, responsible for the economic expansion of the 1st K-wave), being diffused in the nineteenth century (it surpassed wood in the peak of the 2nd K-wave), reaching the stagnation (beginning of the decline) in the twentieth century (it reached the maximum point in the peak of the 3rd K-wave). During the period from 1800 to 1920, coal went from providing around 10% to over 60% of the world's total commercial energy requirements, being linked to the iron and steel industries, being the primary energy source of the first and second technological transformations. However, the non-solid fossils (NSF - oil and natural gas) began to substitute coal in the nineteenth century (3rd technological transformation, responsible for the economic expansion of the 3rd K-wave), being diffused in the twentieth century (they surpassed coal in the peak of the 4th K-wave), being foreseen the reach of stagnation in the present century (the maximum point (turning point) in the peak the 5th K-wave). During the period from 1920 to 1973, the oil market share grew from 10% to around 50%, being mainly linked to the automobile industry, being the primary energy source to the 3rd and 4th technological transformations.

II. FUTURE PERSPECTIVES

In the past, it was possible to observe a relation-

ship between primary energy sources substitution and socio-economic development, and consequently a relationship between primary energy sources substitution and K-waves. And in future how will it be? Making use of two of technological forecasting tools, namely the logistics curve and the Delphi technique, three long-term scenarios were built: an exploratory one, using the multiple substitution logistics, an Delphi-based indicative one, and another one resulting from combination of the two previous one (hybrid scenario) [1]. In general terms, the indications of the Delphi survey confirm the dynamics of the logistic substitution. Thus, it can be concluded that a substitution of the NSF for the alternative energies sources will happen in the future, considering the NSF grouping and the alternatives cluster. Our study points out to the leadership of the alternative energies as the main primary energy by 2050-2070. Even if the long structural

waves cannot be considered as a forecast tool, they can aid on tendencies extrapolation, given the substitution of the wood by coal and coal by NSF, such as we can observe in the figure 1. This figure seems to point out a coincidence of the market share peak of a new primary energy source with each third wave, indicating a coincidence of the peak of the alternatives with the peak of the 6th KW. In this sense, we can foresee the fossil fuels apogee for this fifth K-Wave.

REFERENCES

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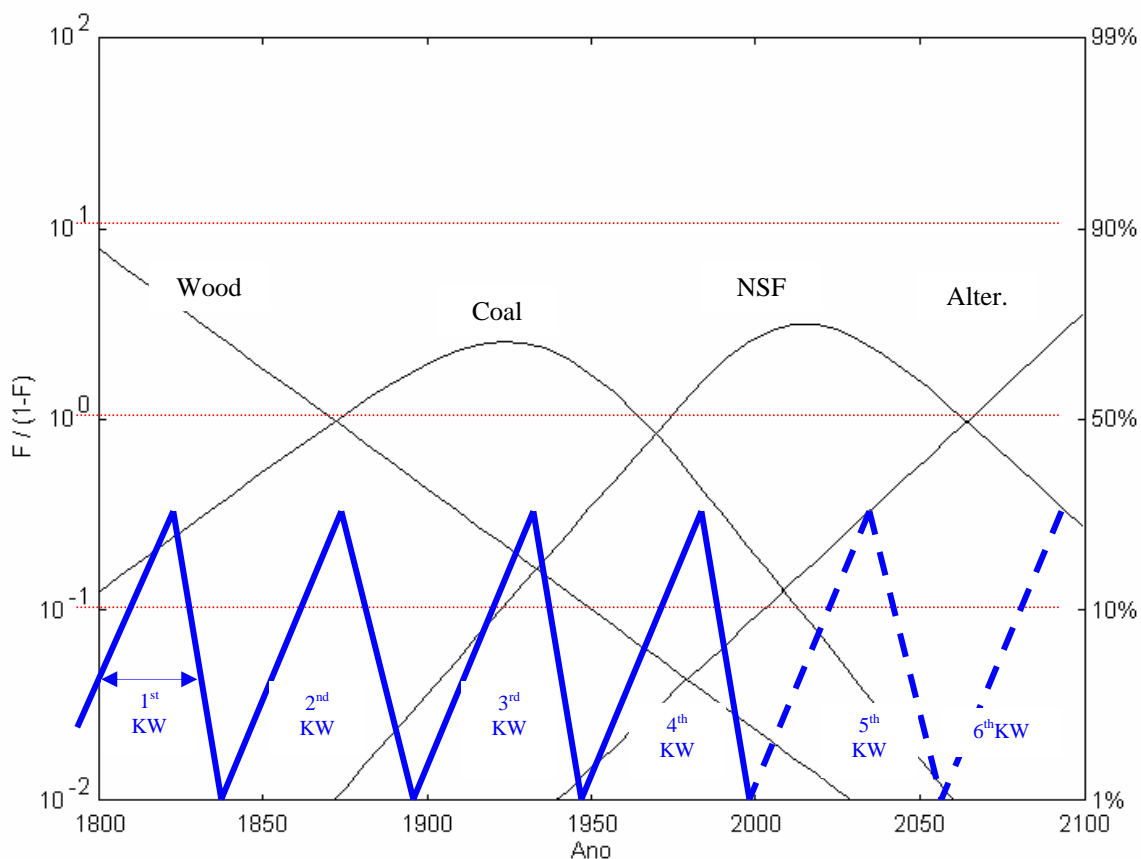


Figure 1 – Correspondence between Primary Energy Sources Substitution and Structural Long Waves (KW – Kondratieff Wave).