Timo Myllyntaus

Electrifying Finland

The Transfer
of a New
Technology
into a Late
Industrialising
Economy

ELECTRIFYING FINLAND

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Electrifying Finland

The Transfer of a New Technology into a Late Industrialising Economy

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in association with
ETLA
Helsinki

To my parents

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Preface

When a few years ago I became a member of a research project dealing with the technology and economy of the Finnish energy sector I found myself with the interesting opportunity to study the history of technology from a multidisciplinary viewpoint. I had the privilege to be one of the pioneers in the history of technology in Finland and I took advantage of that by selecting electrification as the primary theme of my research. However, I did not find the selection easy because there were many unexplored themes within the energy sector. Inspiration from abroad, however, stimulated me to concentrate on electricity. While leafing through international research literature on energy, the studies on electricity fascinated me most. I noticed that in almost every country at least one historical outline had been published on the development of electricity supply. At the time there was no long-term account on that theme related to Finland. My first congress and research trips abroad sealed my decision to work out such an outline. The encouragement I acquired during visits to Britain, Sweden, Italy, Switzerland and Estonia was vital for my work; without those visits this book might never have been completed.

During a meeting of the project on the history of energy technology, an elderly professor of engineering was asked to write an article on steam engines. He promised to write about developments during the last eighty years, explaining this limitation for the research period by saying 'I remember the significant models of our steam engines only from the turn of the century but who could recollect the engines used before that.' I was one of the youngest in the project and my own experience on the stationary prime movers manufactured before the Second World War is very modest; nevertheless, I can vividly recall wood-burning stoves, horse-driven sledges, oil-lamps and steam locomotives which still, in the 1950s, were part of the everyday life in some parts of Finland. Although history-writing is not committing one's own personal memories to paper, these examples show how recent a phenomenon is large-scale electrification and how rapid technological change has been in Finland. As an undergraduate I was taught the old rule of the humanities that an historian should not deal

with the period after his/her birth. Breaking this rule has always tempted me, and in this research I have good reasons to break it. In the electrification of Finland, the climax took place during the post-war decades. By excluding those decades, a researcher would find only a prologue – although a promising prologue – of an epochal development.

I am deeply indebted to my teacher, Professor Leslie Hannah of the London School of Economics, who encouraged me during the work, read the whole manuscript, and let me draw on his wealth of knowledge. I also owe warm thanks to my two other supervisors, David G. Kirby and Jonathan Liebenau, whose advice greatly contributed to the study.

I wish to express my gratitude to Alan S. Milward, Kaj Pönni and Antony F. Upton for valuable criticism of the work. I am also indebted to Sven-Olof Olsson who read and improved some parts of the manuscript. In editing the text I have received substantial assistance from John Desborough which I gratefully acknowledge.

Special thanks are extended to Professor Emeritus Risto Keskinen of the Tampere University of Technology who backed me up to begin my studies in this field and from whose expertise I have greatly benefited. Other persons who have been involved in the project at various times also deserve recognition. The assistance of Timo Herranen, Timo Matala, Karl-Erik Michelsen, Seppo Mäki, Jyrki Ruutu, Satu Tuuva and Simo Vahvelainen in the tedious work of collecting the vast amount of information required for estimating the generating capacity, electricity output and consumption has been of vital importance. Meanwhile I wish to express my gratitude to all the others who participated in producing the book. Needless to say, any errors of fact or judgement are all mine.

My warmest thanks go to my parents. Both my parents were storytellers and my father's stories about his experience on the electrification of his home province aroused my early interest in the subject. Thanks to his wise advice I survived my first experiments on alternating current, and later under his direction I learned a practical trade which gave me a valuable insight into some parts of technology.

Nothing can exceed my obligation to my wife Tuija and my children Ojelvo, Pauliina and Marjukka, who, while suffering long periods of neglect, managed to prevent me from becoming absorbed in the dusky tombs of history for ever, and from time to time dragged me to the sunshine of the present to revive my energy resources.

For financial assistance, I gratefully acknowledge the fellowships and grants awarded by The Academy of Finland, The British Council, The Finnish Cultural Foundation, The Foundation of Imatra Power and Oskar Öflund's Foundation. In addition, I am pleased that ETLA is including this book in its series of thesis-type publications.

TIMO MYLLYNTAUS

Abbreviations

Ab	Aktiebolag (company with limited liability in Swedish)
AC	Alternating current
ACSOFF	Archive of the Central Statistical Office of Finland
AEG	Allgemeine Elektrizitäts-Gesellschaft (Berlin, Germany)
AG	Aktien-Gesellschaft (company with limited liability in German)
ASEA	Allmänna Svenska Elektriska Aktiebolag (Västerås, Sweden)
BBC	Brown, Boveri & Cie (Baden, Switzerland)
CBAF	Central Business Archives of Finland
CSOF	Central Statistical Office of Finland
DC	Direct current
FEAB	Finska Elektriska Aktiebolag (a subsidiary of the ASEA)
FIM	Finnish mark (equivalent to 100 pennies (FIP))
FRG	Federal Republic of Germany
GEB	Gesellschaft für elektrische Beleuchtung vom Jahre 1886 (St Petersburg, Russia)
GDP	Gross domestic product
GDR	German Democratic Republic
GNP	Gross national product
HBL	<i>Hufvudstadsbladet</i> (a newspaper, Helsinki)
HD	<i>Helsingfors Dagblad</i> (a newspaper, Helsinki)
HEP	Hydroelectric power plant
hp	Horsepower (equivalent to 736 watts)
HS	<i>Helsingin Sanomat</i> (a newspaper, Helsinki)
IVO	Imatran Voima Osakeyhtiö (Imatra Power Ltd)
KHM	Kansanhuoltoministeriö (Ministry of Supply)
KM	Komiteanmietintö (Committee Report)
MESUH	Municipal Electricity Supply Utility of Helsinki
MNC	Multinational company
NAF	National Archives of Finland
NOS	Norges offisielle statistikk (Official Statistics of Norway)
NPP	Nuclear power plant
ORKA	Eesti NSV Oktoobrirevolutsiooni ja Sotsialistliku Ülesehituse Riiklik Keskarchiiv (a central archive in Tallinn, Estonia)

<i>OSF</i>	<i>Official Statistics of Finland</i>
Oy	Osakeyhtiö (company with limited liability in Finnish)
p.a.	Per annum
rpm	Revolutions per minute
SOS	Sveriges officiella statistik (Official Statistics of Sweden)
SPTE	Société St Petersbourgeoise de transmission électrique de la force des chutes d'eau (St Petersburg, Russia)
<i>STVAiFF</i>	<i>Svenska Tekniska Vetenskapsakademien i Finland, Förhandlingar</i> (a series of publication, Helsinki)
<i>SYF</i>	<i>Statistical Yearbook of Finland</i>
<i>TAik</i>	<i>Teknillinen Aikakauslehti</i> (a journal, Helsinki)
<i>TFiFF</i>	<i>Tekniska Föreningen i Finland, Förhandlingar</i> (a journal, Helsinki)
toe	Ton oil equivalent
TVO	Teollisuuden Voima Oy (Industrial Power Company Ltd)
UKAEA	United Kingdom Atomic Energy Authority
UN	United Nations
<i>US</i>	<i>Uusi Suomi</i> (a newspaper, Helsinki)
V	Volt
<i>VV</i>	<i>Voima ja valo</i> (a journal, Helsinki)
W	Watt
wh	Watthour

Multiple units

T	tera	=	1 000 000 000 000
G	giga	=	1 000 000 000
M	mega	=	1 000 000
k	kilo	=	1 000

1 Introduction

1.1 THE SCOPE OF THE STUDY

The purpose of this research is to investigate the adoption process of a new technology in a latecomer economy. Electrical technology is well suited for this kind of examination, because electric power has been a catalyst of the key technological change in the modern industrialised economies during the last hundred years.¹

In its early decades, electricity represented a new type of technology which had been recently innovated and developed with science and several international inventions as its basis. The international exchange of electro-technical innovations provided a stimulus for the use of this very flexible and versatile energy form in all the industrialised countries as well as for the rise of big transnational electrical engineering companies. Consequently, commercial electrical technology having start-up in the nineteenth century represents one of the earliest fields of modern high technology. Studying the long experience of the inter-country diffusion process of electrical technology might help us understand the corresponding processes and future impact of more recent technologies such as electronics, industrial robots, and optical fibres.

Finland, a peripheral North European region with long traditions of isolation from the heart of the Continent, is considered a relevant case for studying a developing economy transferring foreign technology to promote its industrialisation. In this research, the electrification of Finland is examined in an international perspective in order to identify its general and specific characteristics.

Finland is studied as a national and territorial entity defined by its current borders at any given time. Therefore during the period under study, the country has consisted of three, geographically somewhat different areas: that of the Grand Duchy of Finland and its successor up to 1920, that of the 'first republic' between 1920 and 1939, and the area of postwar Finland.²

The study covers the period from 1877 to 1977. In the year 1877, electric lighting with a steam-driven dynamo was experimented with for the first time in Finland. The history of heavy current engineering in the country began with the public demonstrations of electric illumination in Helsinki using imported French arc-lighting equipment.

Gradually, the use of electricity for different purposes spread all over the country. Urban areas and nearly half of the rural households were wired for electricity by 1940. By the mid-1970s, practically all citizens had some dealings with this energy form in their everyday lives. Finland had developed into an electrified, industrialised society where electricity had become a necessity, an integral element of its economic and technological base. At the same time, Finnish society decided to take a new step in energy technology: the first nuclear power station was to be put in operation in 1977. In the Finnish energy economy, that event meant the beginning of a new era which is excluded from this study.

1.2 THE BUILD-UP OF A NEW TECHNOLOGY: SOME THEORETICAL NOTES

A country could obtain new technology³ by creating it or by transferring⁴ it from abroad. For independent creation, a country needs favourable preconditions and sufficient back-up resources. Innovating and developing a new technique usually requires a lot of time and funds. Many less developed countries are, therefore, unable to create an indigenous technology. They mainly rely on imported technology, but its transfer is neither without cost nor trouble-free. Although less developed countries can adopt technology in a fully developed form from the advanced countries, they cannot avoid problems. For those countries, the introduction of a new technology generally means a greater change per decade than for highly industrialised countries. The introduction of a new technology can be defined as a process with four phases:

- (1) transfer of a new technology;
- (2) adoption, application and diffusion;
- (3) use;
- (4) direct and indirect effects.

From the viewpoint of a recipient country, there are two types of technology transfer: general and controlled. General technology is fairly easily available and inexpensive. It is not, as a rule, bought from the first-hand innovators but through middlemen or obtained from commonly accessible sources. In this case, the recipient makes the decisions on technology transfer; he chooses from whom he buys and what.⁵ In the controlled transfer of technology, there is always a

deliverer and a recipient who both make decisions. In this case, the object of transfer is clearly defined and its price is fairly high. This type of technology cannot generally be freely purchased on the world market because it includes at least some secret or somehow protected components of technological expertise. In the controlled transfer of technology, the deliverer has the upper hand; ultimately it is he who decides when and where his technology is transferred.⁶

In the eighteenth and nineteenth centuries, innovative activities in technology were concentrated in a few major industrial countries: first in Britain and France, and later also in Germany and the USA. A great number of other countries attempted to follow the example of these forerunners and to adopt their up-to-date technology. New technology can be transmitted through various channels from the industrial centres to the periphery. The most important channels can be listed as shown in Table 1.1.

Table 1.1 indicates that, as a rule, the role of the recipient is rather **passive** in those kinds of technology transfer which are more strictly **controlled** by the deliverer. In addition, it is frequently claimed that the efficiency of the channels mentioned in Table 1.1 decreases from no. 1 to no. 8. The controlled channels are regarded as more direct and as quicker means for transferring technology from one economy to another. Turn-key deliveries, joint-ventures and direct foreign investments supplemented with the training of native personnel, and the importation of capital goods are evaluated by the OECD as the most efficient ways to transfer technology. They are considered to facilitate the building of a modern production capacity in the recipient economy in a short period of time and to boost competitive and profitable manufacturing with little risk of setbacks.⁷

General transfer of technology greatly depends on the activity of a recipient society and it is regarded as a more inefficient, uncertain and roundabout method. However, it preserves the sovereignty of the recipient country and its autonomous efforts to gain technological self-sufficiency, while the hazards of dependence are involved in the case of controlled transfer of technology. Despite some advantages of controlled transfer and the direct involvement of foreign companies, less developed countries fear the consequences of technology imports on their aspirations for self-reliant growth and self-rule over resources.⁸

Technological change and the transfer process can also be classified as an *embodied* or *unembodied* type. Embodied technological change always emerges in the form of tangible equipment and material

Table 1.1 Channels for the inter-country transfer of technology

<i>Role of the recipient</i>	<i>Channels of transfer</i>	<i>Type of transfer</i>
Passive	1. Receiving direct foreign investments	Controlled
	2. Importing foreign machinery and equipment	Controlled
	3. Acquiring turn-key plants	Controlled
	4. Acquiring foreign licences and patents	Controlled
	5. Setting up joint-ventures with foreign companies	Controlled
↓ Active	6. Recruiting skilled workers, artisans, engineers, teachers and consultants from abroad or permitting mass immigration	General
	7. Encouraging and supporting own nationals' journeys abroad for studying at foreign schools and universities, or training in factories visiting international congresses and trade fairs, making contacts with foreign experts, etc.	General
	8. Utilising 'the low cost diffusion of easily accessible technology': the spread of know-how through trade and scientific publications, analysing foreign products, etc.	General

inputs. The new technology characteristic of each period is regarded as built *into* production machinery. The capital stock of each industry consists of technically different vintages, the productivity of which is graded according to their age. New technology is, however, not entirely embodied in capital goods. Novel technological expertise, know-how, can also be utilised by developing the organisations of production, raising the educational standards of managers and the labour force, and simply by training the personnel to carry out its tasks better than formerly. 'Learning by doing' is one form of unembodied technological change. Erik Lundberg's example of this kind of change has become world-famous. He has stated that the Horndal Iron Works in Sweden had no new investment, and presumably no important change in its methods of production, for a

period of fifteen years; yet the output per worker increased on average by 2 per cent a year. By studying manufacturing processes elsewhere as well, steadily improving performances have been found that can only be attributed to learning from experience on the job.⁹

Formally, the transfer of technology from one economic area to another would seem to be simple. In the industrial centres general know-how is available almost free of charge, and since the mid-nineteenth century, the importation of the most modern machinery seems to have been only a financial problem. But in practice, the transfer and diffusion of technology is generally a difficult and slow process. Technology transfer is not merely a matter of transporting a piece of hardware from one location to another. Frequently, the importation of modern machinery was preceded and accompanied by the adoption of an adjacent, unembodied technology.

Besides the market situation and the production environment in the recipient country, the local natural resources, together with capital and labour markets have an important influence. The success of technology transfer also greatly depends on the social and institutional framework of the recipient country: the level of education, the **craftsmanship** of its labour force, the attitudes and social objectives of the community, and political circumstances, legislation, etc.¹⁰

If a recipient country has a sufficiently good educational infrastructure and domestic R & D capabilities, after some time it can proceed from importing to creating technology. Imported technology may serve as a base and starting point in gradually developing indigenous know-how. Table 1.2 demonstrates different levels of this development.

Table 1.2 Methods for creating technological capability

-
1. Imitating foreign technology
 2. Learning by doing
 3. Adapting foreign technology to domestic circumstances
 4. Improving foreign technology
 5. Making original inventions and innovations
-

Building up a modern electricity supply in a country requires the development or transfer of an entire technological system containing an enormous amount of different components. Installing and maintaining these components demands a great deal of technological knowledge. Therefore, an electricity supply system is very technology-intensive.

It is not enough that a new technology is made available in a recipient country through transfer. In order to become useful and economical, a foreign technology generally needs adaptation to the local circumstances. The practicability of a foreign innovation might be hazardous if a recipient country has very different price relations, for example between labour and capital, and dissimilar raw materials, fuels or other inputs than the supplier country. There are also many products which have needed modifications in some countries because of climatic, cultural, legal or other regional reasons. The adaptation of a new technology in a less developed economy often requires innovative activity which has to be carried out in the recipient country. Frequently, only a successful application opens up the way to efficient diffusion, and this process defines the macro-economic significance of a new technology. In diffusion, there is not only a question of technical feasibility but also of socio-economic pre-conditions.

The electricity supply system presents a technology which demands an adaptation of various details into the local conditions. The diffusion period of electrical technology has proved to vary considerably between and within countries. There are also differences in the forms and methods of electrification. Nevertheless, electricity is a technology which has penetrated into all kinds of twentieth-century societies. Owing to its universality and flexibility, electricity supply technology is well suited for comparative international case studies on the diffusion of a new technology.

Use is the principal purpose of any innovation. How an innovation carries out its tasks and how the opportunities provided by it are utilised have an important bearing on its effect on an economy. Electrical technology has proved to be a success: it suited outstandingly its first commercial function, lighting; although a century has lapsed, it is still the pre-eminent illuminant. In addition, new functions have continually been found for electricity, which keeps on pushing other energy sources aside.

Electricity is an exceptional commodity. It must be produced and consumed at the same instant. It cannot be stored economically on a large scale. Electricity is also a very homogeneous product and it can be transmitted long distances with low costs. It is easily and efficiently converted into the other forms of energy – heat, light or motion.¹¹ Electricity can be generated in units with very different sizes. The trend has, however, been nearly everywhere towards large, interconnected power plants. Because of its nature as a rather homoge-

neous commodity, electricity and its supply are well suited for testing various hypotheses of economic theory.

In studying the transfer process, the final phase is an evaluation of the impact and significance of the new technology on an economy. As a rule, it is difficult to measure the effects of an innovation. This is particularly true in the case of electricity which penetrated everywhere. In studying the impact of an industry based on new technology, we can apply 'Hirschman's linkages'.¹² According to this approach, an expanding sector, which is generally assumed to be an export industry, generates earning opportunities in other sectors, both at home and abroad, when its increased income is spent. These income flows inducing production in other sectors are classified into three linkage effects: backward linkage, forward linkage and final demand linkage.¹³

Melville Watkins defined backward linkage as a measure of the inducement to invest in the home-production of inputs, including capital goods, for the expanding industry. If the domestic economy is not able to supply the inputs needed, the inducement will leak abroad, because the inputs have to be imported. By contrast, the expanding industry is supporting the growth and diversification of the economy in a developing country if all or a substantial part of inputs are purchased from domestic suppliers.¹⁴

Forward linkage is a measure of the inducement to invest in industries using the output of the expanding industry as an input. Increasing the valued added in an export industry has been portrayed as the most representative example.¹⁵

Final demand linkage consists of the inducement to invest in domestic industries producing consumer goods for the factors of production of the expanding industry. The rise of the factors' income in the thriving industry promotes the growth of the home market and gives a boost to the domestic production of consumer goods. A crucial point is how much of the factors' earnings, primarily capital income and wages, is spent in the home market and to what extent domestic production can satisfy this demand. Final demand linkage is reduced by the amount that foreign factors, investors or migratory labour, expatriate their income or that is consumed in imported goods by domestic or foreign factors.¹⁶

By applying the linkage approach to studying the multiplier-effect of the electricity supply industry, we can suppose that this industry has potentially relatively strong backward and forward linkages, but a weak final demand linkage. Building up the electricity supply industry

might support both the engineering industry and fuel production in a country, if inputs are supplied domestically to a large extent. Forward linkages are generally even bigger: electricity is utilised as an input throughout the economy. It is used in industry, transport and construction as well as in the service sector, in agriculture and households. Albeit that the intensity of electricity in industries varies, electricity is presumed to have a substantial impact on the rise of productivity and the decrease of production costs throughout the economy.¹⁷

Final demand linkage is modest, because electricity supply is generally a comparatively small, capital-intensive industry in a national economy. Even its potential impact on the home production of consumer commodities for its factors has to be estimated as weak. The demand for consumer goods is at its highest during the construction of big hydropower or nuclear power plants when a considerable amount of labour is employed. Running the electricity supply industry, in contrast, demands only a relatively small personnel.

1.3 THE OBJECTIVES OF THE STUDY

In studying the transfer of electrical technology, two aspects are underlined in this research: the viewpoint of a recipient country and a survey of long-term development. First, attention is paid to the channels and agents of transfer, and the role of the Finns in this process. Evaluating the measures and reactions of a recipient society is preferred to assessing the implications to the suppliers of technology. Second, instead of separate events, long trends of development and structural changes are examined. An aim is to study whether it is possible to outline the Finnish model of technology adoption and sketch its key features.

This research aims to describe and analyse electrification and the concomitant industrialisation process. Electricity was introduced fairly early in Finland and its use began to grow steadily from the 1880s. On the eve of the First World War, electricity production per inhabitant had already risen almost to the same level as the average of the corresponding figures for Italy and France, as shown in Table 1.3.

In the last quarter of the nineteenth century, Finland was still among the most markedly agrarian countries in Europe.¹⁸ In 1880, 75 per cent of its total population were employed in the primary sector

Table 1.3 Annual electricity output in various countries, 1910–15

Country	Year	Output GWh	Output per capita kWh	Mid-year population 1000
1. Norway	1913	2201	900	2447
2. Switzerland	1913	1600	414	3864
3. USA	1912	24752	260	95331
4. Sweden	1913	1449	258	5621
5. Belgium	1913	1300	172	7541
6. Germany	1913	8000	119	66978
7. United Kingdom	1912	4140	91	45436
8. Czechoslovakia ^a	1913	964	73	(13214)
9. Italy	1913	2200	63	35192
10. Finland	1913	(183)	(60)	3026
11. France	1913	1800	45	39770
12. Japan	1915	2217	42	53124
13. Australia	1910	172	39	4375
14. Denmark	1913	(97)	(34)	2833
15. Spain	1913	500	25	20275
16. New Zealand	1911	18	17	1058
17. Russia ^a	1913	1945	14	139300 ^b

^a With 1937 frontiers.

^b End-year population.

() Author's estimate.

Sources: Appendix Table A.5; B.R. Mitchell, *European Historical Statistics 1750–1970* (London, 1978); A. Maddison, *Phases of Capitalist Development* (Oxford, 1986) pp. 182–5; OEEC, *Statistical Bulletins, Industrial Statistics 1900–1959* (Paris, 1960) table 46; *Historical Statistics of the United States, Colonial Times to 1970, Part 2*, US Department of Commerce (Washington, D.C., 1975); Økonomisk utsyn, 1900–1950 (Oslo, 1955) p. 51; Walter Wyssling, *Die Entwicklung der schweizerischen Elektrizitätswerke und ihrer Bestandteile in den ersten 50 Jahren* (Zürich, 1946) p. 500; V. Lacina, 'Die Entwicklung der Elektrifizierung in der Tschechoslowakei bis zum Jahr 1938', in *Energy in History*, ed. by J. Purs (Prague, 1984) pp. 165–8; *Statistika rocenka ceskoslovenské socialistické republiky 1986* (Praha, 1986) p. 91; R. Minami, 'The Introduction of Electric Power and Its Impact on the Manufacturing Industries', in *Japanese Industrialization and Its Social Consequences*, ed. by H. Patrick (Berkeley, 1976) p. 303; *Anuario estadístico de España 1980* (Bilbao, 1981) p. 55; G. T. Bloomfield, *New Zealand: A Handbook of Historical Statistics* (Boston, Mass., 1989), pp. 41, 206; R. A. Clarke and D. J. I. Matko, *Soviet Economic Facts 1917–81* (London, 2nd ed., 1983) pp. 2, 86.

Table 1.4 GNP per capita in various countries, 1906-13

Indices of GNP per capita (Finland = 100)						
Country	Clark 1913	Craft 1910	Bairoch ^a 1913	Maddison ^d 1913	Krantz 1906-10	Laurila 1913
Canada	300	..	..	186	..	..
UK	288	232	186	180	..	..
USA	276	..	..	227	..	..
Denmark	242	187	166	146	181	229
Netherlands	211	170	145	151	..	..
Belgium	171	198	171	182	..	..
Germany	168 ^c	171	143	80	..	..
Switzerland	159	177	185	164	..	..
Ireland	158 ^b	..	-	..	..	..
France	145	157	133	154	..	..
Sweden	144	136	131	124	159	198
Norway	124	126	144	107	124	205
Austria	113 ^b	143 ^f	(96) ^e	133	..	..
Poland	108 ^b	..	-	..	..	..
Czechoslovakia	103 ^b	..	- ^e	..	..	..
Finland	100	100	(100)	100	100	100
Spain	..	98	71	..	..	..
Bulgaria	89	..	(51)	..	..	..
Italy	88	98	85	106	..	..
Russia	88 ^b	71 ^b	63	..	..	..
Greece	81	81	(62)	..	..	..
Japan	79	..	..	60	..	..
Hungary	60	(107) ^g	- ^e	..	..	..
Portugal	59	98	(56)	..	..	..

^a With 1913 frontiers.^e The Austro-Hungarian Empire.^b With 1937 frontiers.^f The area of Cisleithania.^c With 1950 frontiers.^g The area of Transleithania.^d With 1979 frontiers.

.. No data available.

Note: The figures in parentheses have a higher margin of error than other figures estimated by the same author.

Sources: C. Clark, *The Conditions of Economic Progress* (London, 3rd edn, 1957) pp. 88ff; N. F. R. Crafts, 'Gross National Product in Europe 1870-1910: Some New Estimates', *Exploration in Economic History*, 20 (1983) pp. 387-401; P. Bairoch, 'Europe's Gross National Product, 1800-1975', *Journal of European Economic History*, 5 (1976) no. 2, pp. 273-340; A. Maddison, *Phases of Capitalist Development* (Oxford, 1986) pp. 161, 178-85; O. Krantz, 'Productivity Changes in Scandinavia in the 19th and 20th Centuries', a paper for Productivity-Conference in Bellagio (mimeograph, 1986); E. H. Laurila, *Consumption in the Finnish Economy in the Years 1900-1975* (Helsinki, 1985) pp. 66ff.

(agriculture, forestry and fishing), while only 5 per cent were attached to industry and handicraft.¹⁹ Consequently, compared on the basis of the distribution of labour force, Finland was then roughly 200 years behind Britain and about 30 years behind Denmark, Sweden and Norway, its nearest Western neighbours.²⁰

Table 1.5 The top twelve electricity-consuming countries in 1976
(in per capita terms)

Country	Production		Consumption			GDP per capita, at market prices US \$
	Total	Per capita	Total	Per capita	Per GDP-unit	
	TWh	kWh	TWh	kWh	kWh	
					\$1000	
1. Norway	82.2	20420	75.0	18620	2400	7767
2. Canada	293.4	12680	248.2	12340	1500	8410
3. Luxembourg	1.5	4310	4.1	11520	1810	6102
4. Iceland	2.4	11030	2.4	10910	1750	6612
5. Sweden	86.4	10510	86.4	10510	1170	9029
6. USA	2123.4	9870	2133.0	9910	790	7912
7. Finland	27.8	5880	31.9	6750	1120	5950
8. New Zealand	20.9	6660	20.8	6670	1590	4184
9. Switzerland	36.2	5710	34.3	5400	610	8864
10. Australia	76.6	5500	72.3	5190	770	7387
11. West Germany	333.7	5430	314.4	5110	700	7249
12. United Kingdom	277.0	4950	357.9	4610	1190	3937

Sources: OSF 42:6 *Energy Statistics 1986* (Helsinki, 1987); UN, *Statistical Yearbook 1976-1977* (New York, 1977-8); *Statistical Yearbook of Finland 1978* (Helsinki, 1979); *Statistical Abstract of Sweden 1979* (Stockholm, 1979).

As late as 1913, the country's GNP per capita was about the same as the average for Eastern Central Europe and the Balkans. At the same time, Finland had only two-thirds the GNP per capita of Denmark or the Netherlands and only half of that of Britain, as indicated in Table 1.4.

A small, poorly industrialised Grand Duchy, as Finland was a century ago, could not develop a modern indigenous technological base; it had to import technology for its industry. Taking into account the agrarian economy of Finland, the country managed to increase its electricity production to a relatively high per capita level by the year 1913. Its electricity output per capita was then already on a higher level than would be expected from its GNP per capita. During the following six decades, Finland rose to join the top seven countries in electricity consumption per inhabitant, shown in Table 1.5, although its primary sector remained as the main source of livelihood for the population up to the 1940s. It was not until the postwar period that Finland achieved the final breakthrough in modernising its economic

structure. Since the 1970s, its economic structure has differed only to a small degree from that of other OECD societies which had industrialised decades earlier than Finland.²¹

Since the second quarter of the present century, the Finnish economy has grown exceptionally fast. During the 1960s, its GNP per capita surpassed that of Britain. In 1976 Finland's GNP per capita was the eleventh highest in Europe and the eighteenth in the world. It was roughly by a factor of 2.5 higher than the average GNP per capita of Eastern Central Europe and the Balkans²² and 40 per cent higher than that of Britain. Nonetheless, it was still 9 and 25 per cent lower than the respective figure for the Netherlands and Denmark.²³ Measured by GNP per inhabitant, Finland leapfrogged from the bottom third up to the top third of European countries in six decades.

From various statistics, for example from Table 1.5, we can notice a positive correlation between GNP per capita and consumption of electricity. Hence, this study attempts to find an answer to the question of what role electrification played in the rapid growth process of the Finnish economy. This problem is studied by evaluating the repercussions of electrification.

The emphasis of this research is laid on the analysis of the connections between electrification and industrialisation. These two phenomena are often considered interrelated. At least a moderately industrialised economy, a stable institutional framework and sufficient educational prerequisites are supposed to be necessary for wide-scale electrification which, in turn, is seen to speed up industrial and economic growth and stimulate the overall modernisation of society.

Generally, those few countries, such as Switzerland, Germany, the USA and Sweden, which had a fairly well-developed institutional and educational infrastructure supplemented with a very dynamic, science-orientated industry as early as the third quarter of the nineteenth century proved to become early and rapid electrifiers. Brisk electrification is seen to be tied up in high standards of living, an advanced system of technical education, active indigenous research and development, and many other characteristics of a modern industrialised society. Nineteenth and early twentieth century Finland was not such a society: it lacked a great number of those vital characteristics. Nevertheless, it turned out to be a rapid electrifier.

The central question in this research is why did Finland succeed in transferring and adapting foreign electrical technology so early and so efficiently, although it remained a predominantly agrarian country for such a long time.

2 An Outline of Finnish Electrification

2.1 A BACKGROUND VIEW

The Political Status of Late Nineteenth Century Finland

Among the areas under the rule of the Russian Tsar in the nineteenth century, Finland in some respects enjoyed a privileged position. Its political autonomy was wider than that of other border areas including the Baltic Provinces, Poland and Caucasia. Despite the country being incorporated into Russia in 1809, it preserved its former Swedish legal system and administrative institutions. Furthermore, at the Diet of the Estates in Porvoo in 1809, the representatives of the Finns were given the right to build up a national central government to attend to the internal affairs of the Grand Duchy. However, the laws and statutes prepared by the Finnish government, called the Senate from 1812, had to be confirmed by the Tsar. Additionally, the Russian government answered for military matters and foreign policy.

The Diet, a legacy of the pre-1809 Swedish system, met regularly only from 1863 and included representatives from four estates: the nobility, clergy, burghers, and landowning peasantry. At the close of the nineteenth century, quite a small number of men, under 10 per cent of the adult male population, were eligible to vote in the Diet elections. In 1905 a peaceful, anti-tsarist Great Strike gained universal suffrage for the Finns. For the first time in Europe, women obtained the equal right to vote. In 1907 the Diet of the Estates was replaced by a modern unicameral Parliament with several political parties.¹

During the nineteenth century, the Finns managed to get on with the tsarist regime reasonably well. A Polish-style separatism did not emerge. The national goals included the use of constitutional means to defend the achieved autonomous political status and to develop their own self-governing institutions. Finnish attitudes changed quickly, however, with the implementation of several russification measures under governor-general Nikolaj Bobrikov. These included the February Manifesto of 1899, which effectively eliminated