Coastal Catalyst

Energy Infrastructure and the Shaping of a Dutch Coastal Town

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Figure 01: Construction of the Borssele Nuclear Power Plant, photographed by Dutch J. den Hollander between 1968 and 1976. Courtesy of Zeeuws Archief, nr 81a

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This thesis investigates how energy infrastructure has shaped the urban and economic development of Vlissingen, a Dutch coastal town positioned along the Scheldt estuary. Through a mixed-methods approach combining historical analysis, archival research, and spatial investigation, the study traces Vlissingen's transformation across three infrastructural epochs: coal (Centrale Zeeland), nuclear (Borssele nuclear plant), and renewable energy (Borssele wind farms). These phases are contextualized within broader national strategies for industrial decentralisation and the evolving use of the North Sea as an energy landscape. Particular attention is given to Zeeland's infrastructural position - connected to the national grid by a singular transmission line - underscoring its historical energy independence and regional distinctiveness. The analysis demonstrates that energy infrastructures have not only supplied power but actively orchestrated urban growth, influenced planning decisions, and redefined the city's economic role within the Netherlands. While the arrival of offshore wind has repositioned Vlissingen as a node in the national energy transition, its socio-spatial impacts remain uneven and gradual. By foregrounding the spatial agency of infrastructure, the thesis contributes to debates on infrastructural urbanism and offers a lens for understanding peripheral cities navigating energy transition and national spatial planning regimes.

Figure 02: A map of the electrical grid in the Netherlands. Zeeland has one connection. Courtesy of Bert Stamkot, cartografisch bureau MAP, Amsterdam

Index

1. Introduction

“Infrastructure space is a form, but not like a building is a form; it is an updating platform unfolding in time to handle new circumstances, encoding the relationships between buildings, or dictating logistics.” (Easterling, 2014)

Energy infrastructures introduce complexities on multiple scales, particularly within the evolving context of sustainability goals and technological advancements. As Easterling suggests, infrastructure space functions as an “updating platform,” constantly adapting to shifting demands and encoding relationships between economies, societies, and technologies. Energy systems, in particular, not only respond to existing needs but also help shape future conditions, introducing new challenges in a dynamic and often unpredictable landscape.

The ability to sustain energy self-sufficiency is increasingly valued in global systems, where energy infrastructures play a strategic role in national development. Coastal geographies offer distinct advantages in this regard - providing sites for importing and exporting, storage, and the exploitation of marine resources. This access allows nations to extend infrastructural footprints into maritime territories, resulting in the ongoing urbanisation of sea space.

The North Sea exemplifies this process. Since the late 1960s, it has transformed from a site of oil and gas extraction into a landscape of renewable energy production. This shift is reshaping not only the sea itself but also the coastal towns and ports that support its operations. Offshore infrastructure - cables, pipelines, artificial islands, and service routes - has further integrated maritime space into national energy networks (Jørgensen, 2020). In this evolving system, ports are no longer mere terminals for goods; they are becoming vital infrastructural nodes.

The Netherlands, with its extensive coastline and long-standing history of water management, plays a central role in this transformation. The Dutch government’s long-term spatial visions, such as the North Sea 2050 Spatial Agenda and National Water Plans, envision an increasingly infrastructural seascape. Projections suggest that by 2050, a quarter of the Dutch sector of the North Sea will be occupied by energy infrastructure (Jørgensen, 2020).

Ports such as Rotterdam and Amsterdam have already become central players in the offshore wind industry. Vlissingen, situated along the Scheldt estuary with direct access to the North Sea, is also adapting to these developments. Historically tied to fishing and shipbuilding, the city has evolved through the expansion of its port - Vlissingen-Oost - into a site of industrial and energy production. Today, it is positioning itself within the national energy transition as a logistical hub for offshore wind and green hydrogen projects.

The development of energy infrastructure has had significant consequences for Vlissingen’s urban form, economy, and demography. As the port expanded and industrial functions grew, the city underwent major transformations - economically, spatially, and socially. This thesis investigates how such infrastructure shapes port cities, using Vlissingen as a case study to explore the broader implications of energy transitions on urban development. Hence, the research question is the following: **How does energy infrastructure development shape port cities in housing, land use, and economics?**

To address this question, the following sub-questions are explored:

1. How has energy infrastructure influenced land use patterns in Vlissingen?

2. What planning and policy decisions have shaped the integration of energy infrastructure into Vlissingen's urban development?

3. How has the growth of energy infrastructure influenced population growth and spatial expansion in Vlissingen?

4. In what ways has energy infrastructure contributed to the broader economic positioning of Vlissingen within the region?

This thesis adopts a mixed-methods approach combining literature review and historical case study analysis. First, academic literature is used to contextualize the Dutch relationship to sea space and to understand the role of energy infrastructures in shaping urban development. Then, a detailed case study of Vlissingen is conducted through historical records, infrastructural analysis, and spatial transformations. By tracing the evolution of energy infrastructures - from coal and nuclear to offshore wind - this research examines how infrastructure development has shaped Vlissingen's urban landscape, economy, and strategic function within the national energy transition.

Figure 03: Aerial photo of Ritthem. Sloe area, the Sloe harbor, and Quarles harbor. In the foreground, the chemical factory Hoechst; in the background, the container terminal of NV Haven van Vlissingen. Courtesy of Zeeuws Archief, Fotocollectie Vlissingen, nr 50578

2. Territorializing the Sea: Energy, Industry, and the Repositioning of Zeeland

2.1 The North Sea's Energy Transformation

The North Sea's transformation into a strategic energy landscape was driven by a confluence of post-war energy insecurity, technological advancement, the rise of an aggressive petroleum industry, and evolving legal frameworks. In the decades following World War II, Western European states faced growing demand for domestic energy sources to support industrial recovery and reduce dependence on politically unstable oil-exporting countries - a dependency that was, in part, self-inflicted, as these states had shifted away from indigenous sources such as coal towards oil (Chapman, 1976).

Historically, the seas have long facilitated material and cultural exchange between major urban centres. The North Sea, in particular, has served as a platform for such interactions, acting as a fixed site of production and exchange tied to landside hubs (Couling, 2022). The historical wealth of cities such as London, Antwerp, and Amsterdam was largely built on maritime infrastructure, as they became progressively more dependent on international trade (Roding et al., 1995).

Until the 1930s, the ocean remained a practical and legal boundary for oil exploration. By that time, however, onshore oil fields - particularly around the Gulf of Mexico - were approaching depletion, even as geological surveys predicted significant offshore reserves. In 1938, the Creole field was recognized as the first oil field located in "open water" (Pratt et al., 1995). After World War II, the petroleum industry surged as steel became more readily available, and companies began expanding their operations further into offshore zones. This push provoked international concern, and the absence of a clear legal framework for offshore sovereignty became increasingly untenable.

These tensions culminated in the first United Nations Conference on the Law of the Sea (UNCLOS), held in Geneva in 1956, which resulted in four foundational legal agreements: The High Seas (1962), the Territorial Sea (1964), the Continental Shelf (1964), and Fishing and Conservation of Living Resources of the High Seas (1966). These agreements, later consolidated under the more comprehensive UNCLOS in 1982 (Kemp, 1972), established the legal basis for states to extend sovereign rights over adjacent seabeds. In 1964, this framework enabled the spatial partitioning of the North Sea, paving the way for extensive petroleum exploration. While this system allowed for tight state and industrial control, its broader implications were never fully interrogated (Couling, 2022).

The discovery of the Slochteren gas field in 1959 confirmed that offshore gas formations existed, yet Dutch legislation still prohibited drilling beyond territorial waters. As a result, exploration in the Netherlands was delayed until 1967. The United Kingdom, by contrast, acted more swiftly. Even before passing its Continental Shelf Act in 1964, it had prepared licensing areas, ensuring that permits were valid the same day the legislation came into force. Further incentivised by attractive bank financing, international oil companies rushed to develop these newly accessible zones (Sandeman, 1977).

As oil and gas discoveries multiplied—most notably the Ekofisk field in 1969—the North Sea quickly became one of the world's most intensively industrialized marine zones. By 1974, one-fifth of all offshore drilling operations worldwide were concentrated in the North Sea (Gilbert, 1972). These developments significantly benefited the participating nations, especially port cities that already possessed supporting infrastructure. However, it was only decades later, once environmental and geopolitical concerns began to shift the

global energy discourse, that the North Sea emerged as a site for renewable energy development. The gradual transition to offshore wind marked the beginning of its transformation into a multi-use energy seascape.

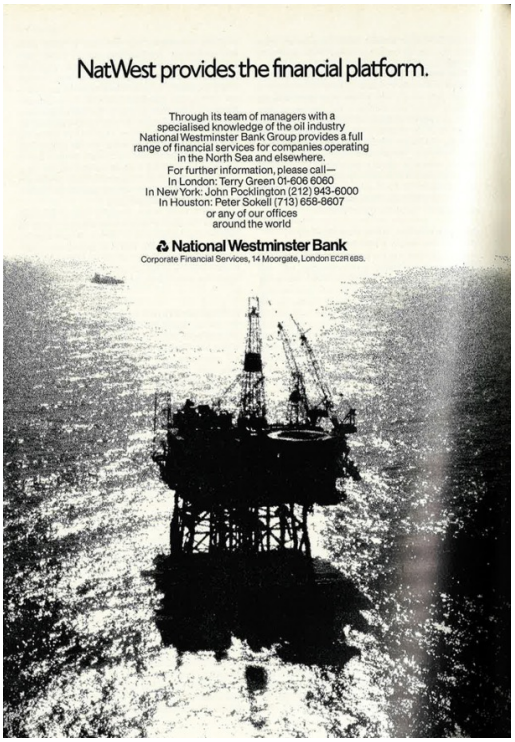

Figure 04: Advertisements for financing in the North Sea, all within 14 pages of the journal. Oil Finance journal from 1977. Courtesy of North Sea Oil Finance.

Figure 05: Boulevard de Ruyter in Vlissingen after the storm on February 1, 1953.. Courtesy of Zeeuws Archief, Fotocollectie Vlissingen, nr 29344.

2.2 From Periphery to Strategic Edge: Zeeland

After World War II, the Dutch government strongly supported policies aimed at industrialisation and economic growth, through both internal measures and external support such as the Marshall Plan. While these policies were implemented nationally, they primarily benefited the Randstad (Schuyt et al., 2000). Due to its position on the Rhine Delta, the Randstad became a key gateway between Western Europe and the world. The growing unity of Western Europe further reinforced this role, establishing the region's ports as critical drivers of national prosperity (Zonneveld, 1991).

By 1956, however, the Randstad's expansion had reached spatial limits. To preserve its open-centre urban model and contain the growth of rival cities, the Dutch government proposed a strategy of regional expansion. This was formalised in De ontwikkeling van het Westen des Lands (1958), which proposed extending economic activity to surrounding areas. That same year, the Sixth Memorandum on Industrialisation (Zesde Nota inzake de industrialisatie van Nederland) was issued, promoting a more balanced spatial distribution of industry. Zeeland was already being explored as a target for this decentralisation (Zijlstra, 1958).

At the time, Zeeland's economy remained weak - especially following the 1953 Watersnoodramp (Verburg, 1996). The province's Economic-Technological Institute (ETI), founded in 1949, initially saw limited potential for industrial renewal. Agriculture boomed in the early 1950s, but arable farming soon lagged behind national trends. Industrialisation also faced resistance from local stakeholders, and Zeeland lacked the urban centres and research institutions required to support large-scale development. Even into the 1960s, the Chamber of Commerce still favoured small-scale industries - such as textile factories - over attracting chemical giants like Hoechst (Schuyt et al., 2000).

Zeeland's fortunes began to shift when, following the 1954 Delta Plan, the province was designated as a development and problem area. This classification allowed the national government to take a leading role in revitalising what was then a peripheral region, providing investments in industrial zones, housing, roads, and subsidies. The planning and execution of the Delta Works became the foundation for Zeeland's modernisation. In parallel, the province launched its own industrialisation initiative - Dienst Deltawerken Zeeland - in 1956 (Arnoldus, 1984). This plan envisioned linking all islands, including Zeeuws-Vlaanderen, through horizontal and vertical connections. The entire Scheldt estuary, from Ellewoutsdijk to Terneuzen, was designated as an industrial corridor. This strategy was, in part, a direct response to Rotterdam's growing industrial dominance.

During this same period, De Schelde, Vlissingen's main shipbuilder, was seeking to expand. The company had long been central to the city's economy, but by the 1960s, it could fulfil only around 20% of incoming repair requests. The area between Vlissingen and Borssele was identified as a potential site for expansion (Brusse et al., 2005). These ambitions aligned with Rijkswaterstaat's land reclamation plans under the Delta Act, which aimed to improve flood safety while also opening space for industrial use.

Meanwhile, Rotterdam was under increasing pressure from multinational chemical firms looking to establish or expand operations. Some even considered relocating to Zeeland due to its deepwater access and available land (Goey, 1990). Although Rotterdam initially deflected this interest, it lost ground after the publication of the Sixth Memorandum on Industrialisation in 1958, which formally

identified Zeeland as a key area for dispersing economic growth (Zijlstra, 1958). This shift led to the development of Vlissingen-Oost, a major port and industrial zone, which officially opened in 1964.

Following this, industrial investment in the region accelerated. Dow Chemical and Péchiney established operations in Terneuzen in 1965, while Hoechst and TotalEnergies settled in Vlissingen-Oost in 1966. These developments laid the foundation for Zeeland's transformation into an industrial region.

As national energy priorities shifted towards sustainability, Dutch policy increasingly positioned the North Sea as a site for renewable development. This agenda was formalised in the North Sea 2050 Spatial Agenda and successive National Water Plans, which designated offshore wind zones, including the Borssele area near Vlissingen (Dutch Ministry of Infrastructure & the Environment and Dutch Ministry of Economic Affairs, 2015). Thanks to its coastal location and robust port infrastructure, Vlissingen was well-positioned to support the construction and maintenance of offshore energy projects, making it a strategic node in the national energy transition.

Historically, the North Sea had always served as a platform for maritime exchange. When its exploitation for oil and gas began in 1964, this space already had the necessary infrastructures in place. Rotterdam, long a hub for imported Middle Eastern oil, began to support offshore extraction as well. With Vlissingen's addition and its direct access to the sea, Zeeland became an active participant - both directly and indirectly - in the North Sea's energy transformation, from fossil fuel extraction to green energy deployment.

Figure 06: Hobeinstraat between Clijverstraat and Kasteelstraat in Vlissingen, with the Sommeijer smithy on the left. In the background, the shipyard of the Royal Company De Schelde with construction number 214, the Willem Ruys. Courtesy of Zeeuws Archief, Foto Dert, nr 12155.

3. Vital energy infrastructures in Vlissingen

The postwar reconstruction of Zeeland, the broader industrialisation of the Netherlands, the urbanisation of the North Sea, and Vlissingen's local context together created the foundation for the city's transformation. To build upon this foundation and realise the development plans set out by regional and national authorities, major investments in energy infrastructure were necessary. These projects were not only functional responses to growing demand, but also active agents of change - shaping Vlissingen's spatial structure, economic base, and demographic growth.

This chapter examines three critical phases of energy infrastructure development in Vlissingen. Each phase is centred on a specific project - Centrale Zeeland, the Borssele nuclear power plant, and the Borssele wind farms - and explores how these infrastructures emerged, what motivated their construction, and how they affected the urban and economic development of the region. In doing so, the chapter traces Vlissingen's shift from a city with a modest industrial base to a regional hub in the national energy transition.

3.1 Coal - Centrale Zeeland

The coal-fired power plant Centrale Zeeland played a regionally significant role in supporting Zeeland's postwar revitalisation. If electricity consumption in the province is indexed to 100 in the year 1939, it had risen to 335 by 1953 (Dwars et al., 1956). After World War II, it became clear that the existing plants in Vlissingen, Middelburg, and Westdorpe could no longer meet this rising demand.

Since its founding in 1919, the utility company PZEM had struggled to keep pace. The company's first plant opened in 1923 in Westdorpe, along the Terneuzen-Ghent canal. This was followed in 1929 by the acquisition of S.A. TVFM, a smaller facility in Vlissingen previously operated by the Belgian firm Société Anonyme des Tramways à Vapeur de Flessingue – Middelbourg (TVFM), which had powered the tram line between Vlissingen and Middelburg (Vredenberg, 2003). This plant supplied electricity not only for the tram line, but also for the municipalities of Vlissingen, Souburg, and Middelburg. Meanwhile, PZEM expanded its reach to the three northern islands of Zeeland. However, it became increasingly clear that the central part of the province - Walcheren and the Bevelanden - required better integration into the grid. This led to the expansion of the Vlissingen plant, which entered service in 1930.

Despite these upgrades, electricity demand continued to outpace supply - particularly during World War II - and this imbalance persisted until 1949. It became evident that a more radical approach was needed. Rather than simply expanding existing plants, three measures were proposed: (1) construction of a new power plant, (2) development of a new grid and distribution station, and (3) connection with the Noord-Brabantsche Electriciteits Maatschappij (Dwars et al., 1956). In 1947, the regional government allocated 25 million guilders for what would become Centrale Zeeland, although final costs rose to 47 million due to the Korean War, rising wages, and the plant's expanded scope ("Moderne centrale in Vlissingen", 1954). The facility officially opened in 1954 and gradually replaced the smaller plants, including the closure of the former TVFM station in 1969 (Antonisse et al, 1991).

Shortly after the plant's inauguration, it became apparent that further expansion would be necessary. In 1955, regional reports already forecasted a renewed capacity shortfall ("Zeelands electriciteitsvoorziening", 1955).

Figure 07: Koningsweg with the electric power plant on the left-hand side around 1920. Courtesy of Zeeuws Archief, Fotocollectie Vlissingen, nr 4922.

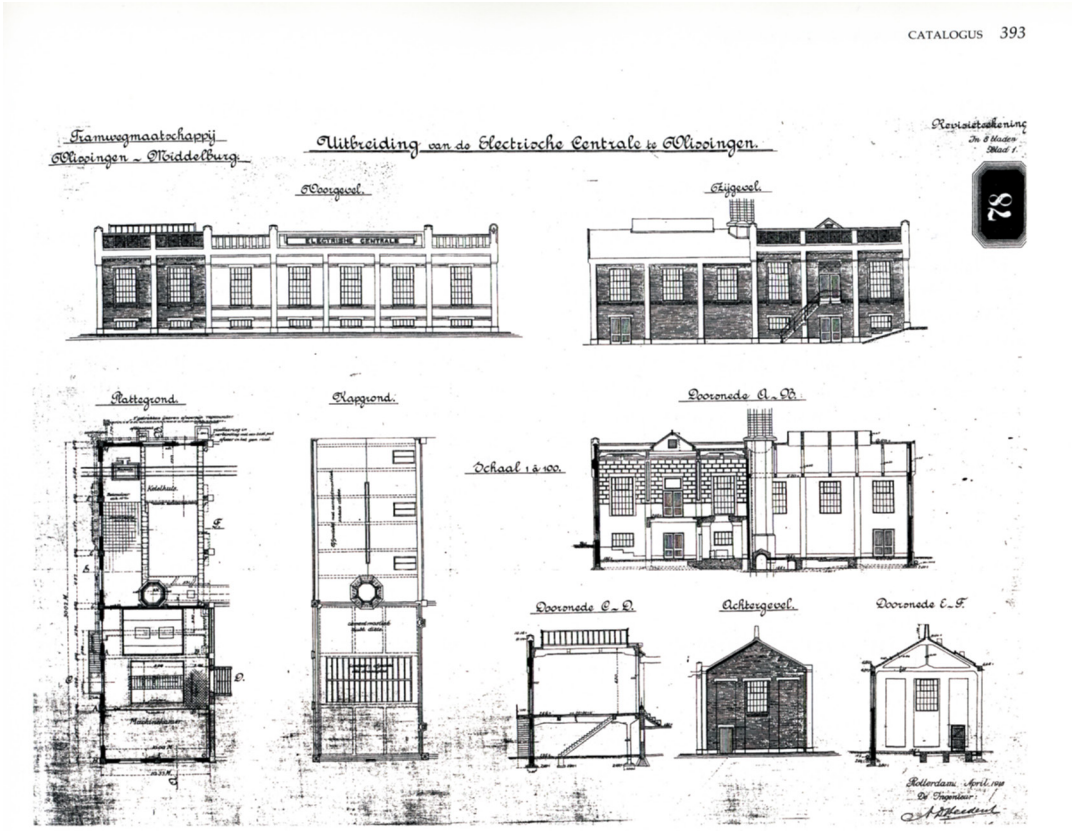

Figure 08: Expansion plan of plant S.A. TVFM. Courtesy of Zeeuws Archief, TVFM, inv. nr. 360.

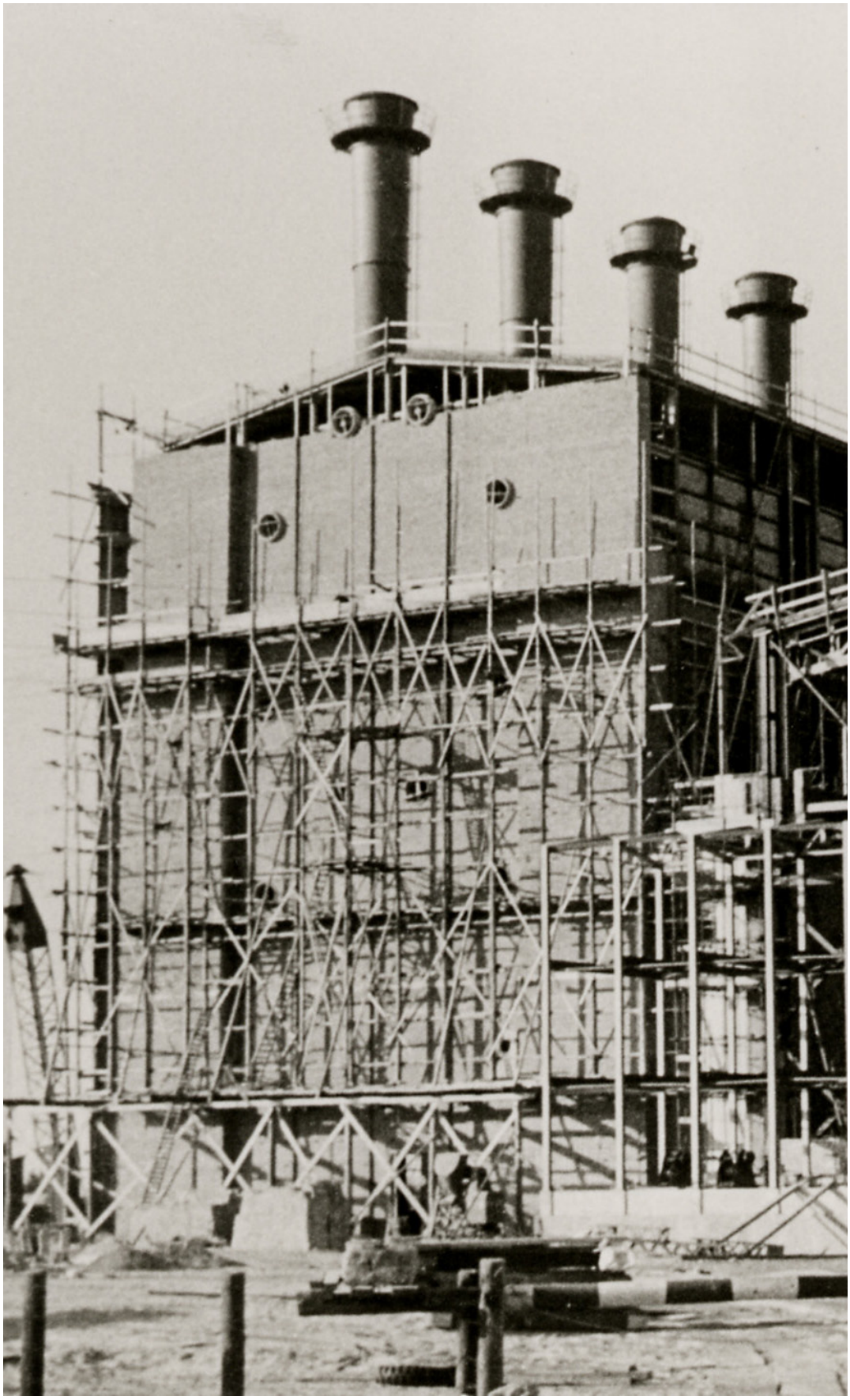

Figure 09: Construction of the PZEM power plant on Edisonweg in Vlissingen in 1953. The first pile was driven in October 1950. On October 1, 1954, the plant was officially commissioned by Minister Zijlstra. Courtesy of Zeeuws Archief, Fotocollectie Vlissingen, nr 10554.

Industrialisation efforts by the regional government, combined with the electrification of key rail lines such as the Vlissingen-Roosendaal route in 1957, continued to increase the strain on the grid. In 1959, a third generator was installed, with the expansion publicly linked to “the determination of the Zeelanders to elevate the province to a higher economic level” (“Nieuwe elektrische centrale”, 1959). This momentum persisted, and by 1972, the plant’s capacity had doubled to 175 megawatts-though this would mark the end of its physical growth (“Zeeland in een stroomversnelling”, 1969).

3.2 Nuclear - Borssele nuclear power plant

While Centrale Zeeland played a critical role in Zeeland's postwar recovery, it consistently lagged behind the growing energy demands driven by regional and national industrialisation. Its location in Vlissingen did, however, give the city a strategic advantage that would form the foundation for its later economic development.

A major driver of Dutch postwar industrialisation - particularly in the Randstad - was the expansion of the chemical industry, especially after the onset of offshore resource exploitation in the North Sea. Between 1950 and 1970, the chemical sector became a pillar of the Dutch economy and a central force in shaping northwest European industrialisation (Homburg et al., 2000; Van Zanden, 1996). This growth began to extend into Zeeland as a result of decentralisation policies and culminated in the establishment of Vlissingen-Oost. However, to sustain this momentum, the existing energy infrastructure, including Centrale Zeeland, proved insufficient. When firms like Hoechst relocated to Vlissingen in 1966, the final expansion of Centrale Zeeland was already underway ("P.Z.E.M. van Dwerg tot Reus", 1966). Around the same time, discussions began about constructing a nuclear power plant to meet future industrial demand, though the plan was initially shelved due to the risk of creating excess capacity.

The development of a Dutch nuclear energy sector had long been a flagship ambition of postwar cooperation between the state, scientific institutions, and industry. Between 1955 and 1971, the Netherlands invested an estimated 1.3 billion guilders in nuclear research and development - around 10% of the total science and technology budget at the time (Lagaaij, 1998). Although the sector remained underdeveloped, a combination of rising energy demands in Vlissingen-Oost, technological advances, and the expected limitations of the Slochteren gas field revived interest in nuclear energy by the mid-1960s. Both the province and the national government expressed willingness to invest, but only under the condition that further industrial growth would follow (Dreunen, 2014).

This condition led to active lobbying efforts by the province to attract new industries. One of the major challenges was pricing: the government's discounted energy tariffs were only available to companies not yet established in the Netherlands, excluding firms already operating in the country. This posed a problem for Péchiney, an aluminium company seeking to build a 250-megawatt facility in Vlissingen. Negotiations revealed that the construction of a nuclear power plant could bridge this pricing gap and allow Péchiney to benefit from the reduced tariffs ("Zeeland maakt kans op aluminiumfabriek", 1968). Moreover, with the recent arrival of Hoechst and its high electricity requirements, PZEM was able to guarantee that three-quarters of the plant's 400-megawatt capacity would be consumed. This made the project financially viable and ultimately led to its approval. The Borssele nuclear power plant went into operation in 1973.

Even before its completion, the project had already influenced the industrial trajectory of the region. Péchiney, for example, settled in Vlissingen in 1971 - two years before the plant was operational - yet still benefited from discounted energy rates, supplied by conventional sources. This demonstrated the strength of regional commitment to industrialisation: the nuclear plant served as both a symbolic and practical anchor for Vlissingen-Oost's transformation into an industrial hub (Zeeuwse Milieufederatie, n.d.). The 1970s saw continued expansion, including the controversial addition of a TotalEnergies oil refinery connected to Rotterdam and gas storage facilities developed by Eurogas

Figure 10: Construction of Borssele Nuclear plant. Courtesy of Zeeuws Archief, Foto Dert, nr 6086.

Figure 11: Aerial photo of Ritthem. The Sloe industrial area and the Sloe harbours. In the foreground, the aluminium company Pechiney Nederland N.V. Courtesy of Zeeuws Archief, Fotocollectie Vlissingen, nr 26710.

(Dreunen, 2014). Industrialisation was now firmly entrenched.

At the same time, the expansion of Vlissingen-Oost had broader spatial effects. Between 1960 and 1990, the city's population grew from approximately 24,000 to 45,000 (see Appendix A), driven by an influx of workers attracted by the industrial boom. In anticipation of long-term growth—projected to reach 80,000—Vlissingen annexed the neighbouring municipalities of Souburg and Ritthem in 1966 to create space for housing and further development (Zwemer, 2000). Following this annexation, new residential areas were built in the former municipalities, pushing the city's boundary inland. One proposal even suggested expanding Vlissingen-Oost south of Borssele, but it was ultimately rejected due to opposition from residents and environmental groups ("ETI-Zeeland: Borsele kan in 1985 21.000 inwoners hebben", 1972).

Infrastructure was modernised to support this urban growth. Among these projects was the planning of a new road to Middelburg in 1964, intended to relieve congestion between the two cities as commuter traffic increased (Rijkswaterstaat Directie Algemene Dienst, 1964). Vlissingen capitalised on the momentum created by industrialisation - using it to reconfigure its spatial structure and position itself as a regional centre of growth.

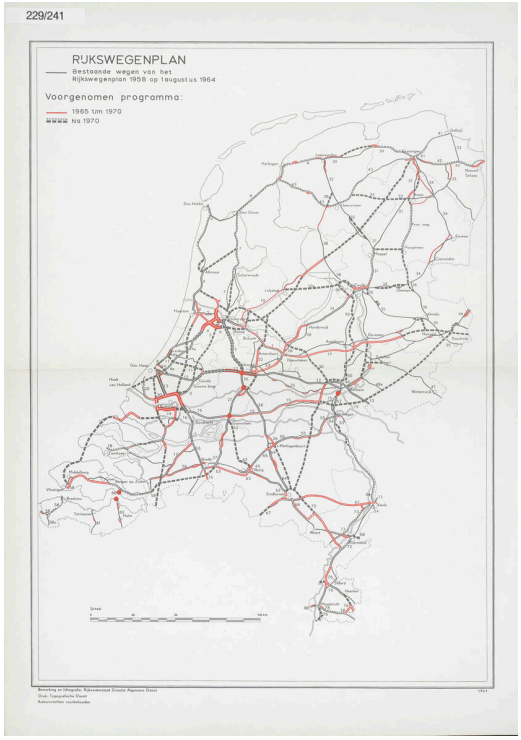

Figure 12: The road infrastructure plan of 1964 with the new road planned between Vlissingen and Middelburg. Courtesy of Rijkswaterstaat Directie Algemene Dienst.

3.3 Renewable - Borssele wind farms

Vlissingen-Oost was not originally designed as a conventional port, but as an industrial zone and shipyard for De Schelde. Over time, however, it gradually evolved into an industrial hub with direct access to the North Sea, acquiring characteristics of a traditional port. Despite this transformation, the region struggled to maintain long-term growth. Although new companies continued to establish themselves in the area after 1990, the number of jobs declined due to increasing automation in the industry (Dreunen, 2014). While Vlissingen-Oost remained the city's main economic engine, the pace of expansion had slowed. Employment did not disappear, but it shifted toward other sectors such as housing and healthcare. Meanwhile, younger residents continued to move away (see Appendix B), and the city lacked the industrial diversification needed to sustain its earlier trajectory. As a result, Vlissingen began to stagnate.

The national energy transition offered an opportunity to reverse this trend. In response to global climate goals, the Dutch government designated specific offshore zones for renewable energy production through successive iterations of the National Water Plan (2009–2015). These included "Hollandse Kust," "Ten Noorden van de Waddeneilanden," "IJmuiden Ver," and most significantly, the Borssele zone, located just off the coast of Vlissingen (Dutch Ministry of VROM & Dutch Ministry of LNV, 2009). These policy decisions reconnected Vlissingen to the broader North Sea energy landscape, offering the city a new role within the Dutch energy transition.

The Borssele Wind Farm Zone is a large-scale offshore wind energy project located 22 kilometers off the coast of Zeeland in the Dutch North Sea. Covering 344 km², it was the first designated renewable energy zone under Dutch policy and a cornerstone of national plans to expand offshore wind capacity from 1,000 MW to 4,500 MW by 2023. Divided into five areas - Borssele I to V - and developed in phases, the zone will generate approximately 1,400 MW, enough to supply electricity to around one million households. The project, coordinated by the Ministry of Economic Affairs and supported by the Netherlands Enterprise Agency, involves major public-private partnerships, including energy firms such as Ørsted, Shell, and Eneco. Supporting infrastructure includes offshore transformer platforms, subsea high-voltage cables, and an onshore grid connection operated by TenneT (Timetric, 2017).

With the opening of the wind farm areas in 2021, Vlissingen seized the opportunity to position itself as a renewable energy hub. Ørsted's SeaH2Land project became a major milestone, aiming to build a large-scale green hydrogen facility powered by offshore wind to supply industries across the North Sea Port cluster from a base in Vlissingen (Ørsted, 2021). Alongside this, other energy ventures emerged: VoltH2 began developing a hydrogen plant; EvoTerminals invested in sustainable fuel infrastructure; and Lion Storage advanced a large-scale battery energy storage system to support grid integration (Oerlemans, 2024; Prevljak, 2024; Eneco, 2025). These projects closely aligned with earlier municipal goals for sustainable growth and innovation, reinforcing Vlissingen's long-term strategy to become a key node in the energy transition (Energy Port Zeeland, 2023).

Since the commissioning of the Borssele wind farms, the effects on the city have been modest but perceptible. Vlissingen's population has begun to grow again - though largely due to migration, rather than renewed industrial employment (van de Heijden, 2025). Meanwhile, unemployment in Zeeland, and

particularly in Vlissingen, has continued to rise (Klerks, 2025), likely linked to an aging population and shifts in the regional labour market. While the full impact of these developments may take time to materialise, Vlissingen's stagnation, first set in motion during the 1990s, remains a visible part of its urban condition.

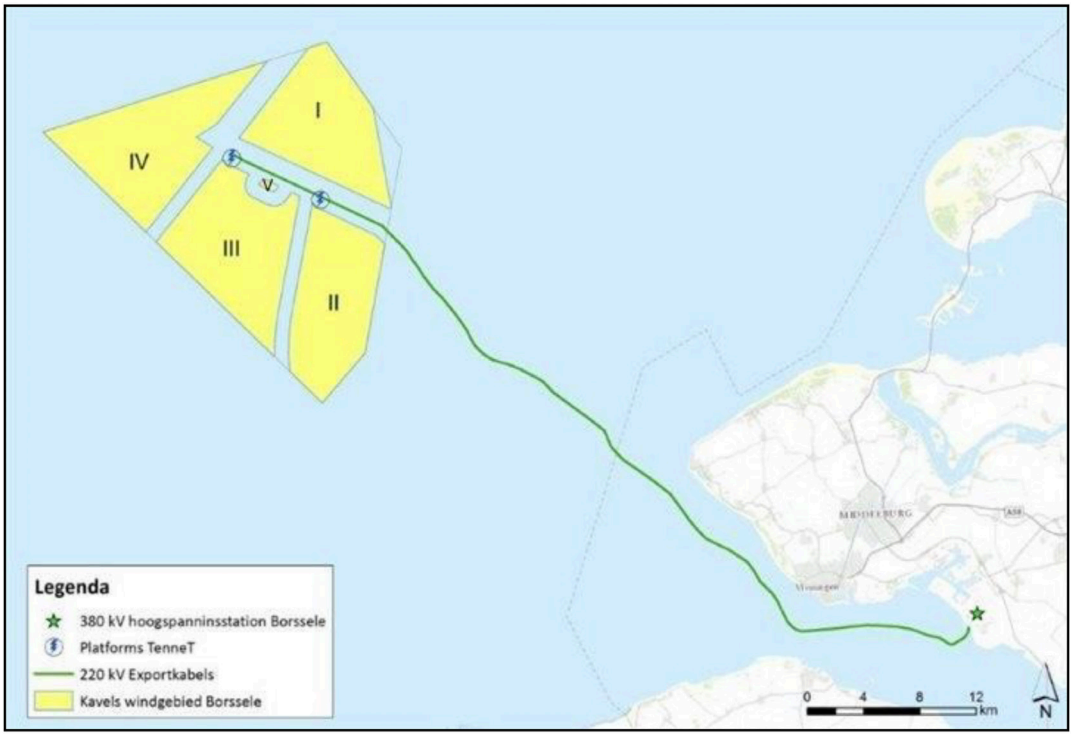

Figure 13: Borssele Wind Farm parcel layout. Courtesy of Noordzeeloket.nl.

4. Conclusion

Over the course of several decades, Vlissingen has undergone a series of spatial and economic transformations tied directly to the development of energy infrastructure. This study set out to answer the central question: How does energy infrastructure development shape port cities in housing, land use, and economics? By tracing the emergence of three key projects - Centrale Zeeland, the Borssele nuclear plant, and the Borssele wind farms - the analysis has shown that energy infrastructure has not only supported the city's growth, but has also actively shaped its function, form, and strategic positioning within the Netherlands.

Although the analysis focused on Vlissingen, it is important to acknowledge the dominant role of the Port of Rotterdam. Its growth began well before the North Sea became a direct resource frontier. Rotterdam's position as the primary port and gateway to the Rhine Delta enabled it to establish itself as the logistical heart of the Dutch economy. As offshore oil and gas exploration in the North Sea intensified, Rotterdam functioned as a central storage and distribution hub for these resources. This development reinforced the city's infrastructural centrality, while Vlissingen remained in its shadow. The early influence of the North Sea thus stimulated growth primarily in the Randstad, and only indirectly shaped Vlissingen by reinforcing its strategic importance in the broader spatial order.

It is in this indirect dynamic that Vlissingen first began to accrue new relevance. As industrial decentralisation policies pushed activities beyond the Randstad, and as maritime exploitation gained strategic urgency, Zeeland emerged as a territory of interest. Multiple forces came together: the presence of De Schelde, the spillover of Rotterdam's industrial saturation, the ambitions of national planning through the Delta Works, and the arrival of the chemical industry. These were the structural conditions under which Zeeland - and more specifically Vlissingen - was drawn into the national industrial project. The North Sea, while not yet directly exploited by Vlissingen itself until later, nonetheless played a formative role by shifting the industrial geography of the Netherlands.

The construction of Centrale Zeeland was emblematic of this first phase. Built largely in response to acute energy demand following World War II, the plant was driven by necessity. However, its impact on the city was relatively modest. It did not produce surplus energy, nor did it enable expansive industrial growth. In fact, demand consistently outpaced capacity. The plant was thus primarily a tool of postwar reconstruction, supporting local stability rather than enabling regional transformation. While it drew on the North Sea as a logistical corridor for supply, it was not positioned to leverage the sea's resource potential. In this early stage, Vlissingen remained connected to the sea, but not yet of it.

This shifted with the construction of the Borssele nuclear plant. Unlike its predecessor, this project was not reactive but speculative. It was designed to attract and retain high-energy industries, and in doing so, to assert Vlissingen-Oost as a centre of economic gravity. Crucially, it anticipated the long-term needs of firms such as Péchiney and Hoechst, whose settlement reinforced the city's industrial base. The nuclear plant marked a turning point: energy infrastructure was no longer simply supporting urban development - it was actively directing it. New infrastructure such as highways was developed, the population surged, and urban expansion followed. For the first time, Vlissingen began to exert agency in shaping its own future within the national system.

The arrival of offshore wind infrastructure in the 2010s opened a new chapter. For the first time, Vlissingen was directly involved in the extraction and conversion of marine energy resources. As part of the Dutch state's broader green

energy transition, the city was designated as a hub for logistics, maintenance, and innovation related to offshore wind. Yet so far, the socio-spatial impacts of these developments have remained limited. While companies such as Ørsted, VoltH2, and EvoTerminals have made large investments in hydrogen, battery storage, and sustainable fuels, this new wave of infrastructure has not yet reversed Vlissingen's economic stagnation. Unemployment remains high, and population growth is driven more by migration than by local opportunity. Yet Vlissingen's strategic location - along the Scheldt estuary with direct maritime access to the North Sea - remains a fundamental asset. It is this positioning that made the city suitable for both historical and contemporary infrastructural investments, from heavy industry to offshore renewables. Nevertheless, the full effects of these projects may take time to materialise. The case of the wind farms reminds us that infrastructure can be transformative - but not always immediately, and not always predictably.

In conclusion, Vlissingen's development has been deeply shaped by its evolving relationship with the North Sea. Initially peripheral and reactive, the city gradually became integrated into the logics of national energy policy. Each phase of infrastructural investment - from the coal-fired plant to nuclear expansion and renewable transition - redefined its spatial identity and economic positioning. Yet Vlissingen's role has always been, in part, defined by its proximity to Rotterdam. The larger port's capacity to concentrate capital, logistics, and policy attention has long influenced how Vlissingen-Oost developed and what it could become. For much of its history, Vlissingen has stood in the shadow of a more dominant centre - only recently beginning to emerge as a site of independent infrastructural importance.

What this study ultimately shows is that infrastructure does not just serve urban growth - it orchestrates it. But the effects are uneven, mediated by state policy, industrial interest, and regional hierarchy. Vlissingen's case demonstrates both the possibilities and the limits of infrastructure-led development. As the energy transition unfolds, the city may yet find itself at the forefront of a new spatial paradigm - one where the North Sea is no longer just a frontier, but a centre. In this shifting geography, energy infrastructure has become the coastal catalyst: activating spatial change, drawing new economic functions to the periphery, and giving Vlissingen a renewed - if uncertain - position within the Dutch energy landscape.

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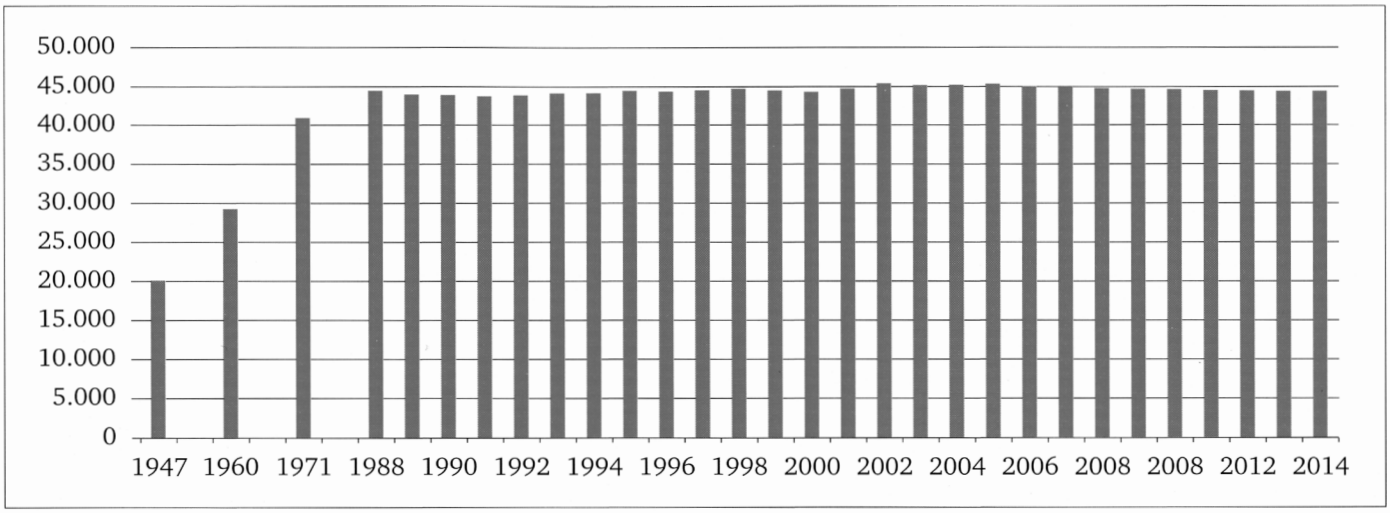
Appendix

A

Population of Vlissingen in the period of 1947, 1960, 1971 and 1988-2014; CBS, Statline

Found in Dreunen P. (2014)



B

Percentages of two age groups: under 20 years (grey) and over 65 years (dark grey) in the age composition of the total population of Vlissingen during the period 1988–2014; CBS, Statline

Found in Dreunen P. (2014)