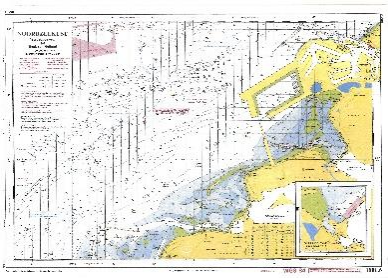
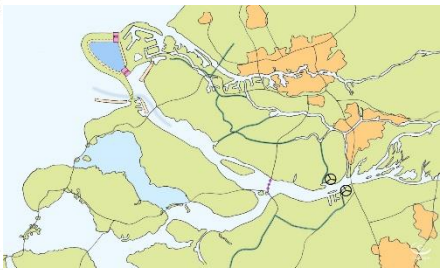
multiple MSc-graduate projects **DELTA FUTURES LAB**

An integrated plan for the redevelopment of the Haringvliet

Topics for a thesis (version 5th of September 2019)

Delta21 is a spatial plan for the redevelopment of a part of the Southwest Dutch delta. It is mainly located west of the Haringvliet and integrates several functions: flood protection, nature-conservation and restoration, water level regulation, generation and storage of renewable energy, fresh water buffer for the Rijnmond area and re-introduction saline tides in the Haringvliet.

The core of the Delta21 plan is flood protection in a highly flood sensitive area by means of a proven technology combination of dunes and pumps. The dunes form a reservoir, where energy can be stored and again generated with help of the same pumps and turbines. Optional, tidal turbines can be installed in the dunes generating energy using the tidal flows of the Haringvliet. Optionally floating solar panel parks, a n aqua battery park and wind farms can be implemented into the plan.

The gates of the Haringvliet sluices will remain open all the time, so the saline tide will be re-introduced in the Haringvliet, creating a saline and brackish water isotope. On the other hand, fresh water supply for Rotterdam and surroundings and Northwest Brabant will be provided as well, creating possibilities for aqua cultures in the entire saline water area. Fish migration between North Sea and Rhine and Meuse will be facilitated. The combination of all these functions will result in an attractive and healthy area for living and recreation.

MSc-thesis assignments

There are many elements to be be investigated in more detail to evaluate the feasibility of the Delta21 concept. Some students already selected and have already started with their thesis. Below a selection of topics that are suitable for an MSc-thesis are included. The subjects for the theses are mainly in the fields of Civil Engineering, Mechanical Engineering, Energy, Business Administration, Architecture and Nature Development/Fisheries. Several parties offered graduate positions for the Delta21 inspired theses and some of the students are stationed at their officers to carry out their investigations. More graduate positions have been offered by Royal Haskoning DHV, Pentair, Rijkswaterstaat, HKV, Ballast Nedam, Volker Wessels, DEME, VanOord, HZeeland, Volker Infra, SOLARFIELDS, Boskalis, Aqua Battery, Witteveen & Bos and others.

During the first phase of the graduate period, the problem will be explored in cooperation with other graduate students under the umbrella of Delta FUTURES Lab. From the 13th of September 2019 on every week the students will join and meet at the Bouwcampus, van der Burghweg 1, Delft.

Total List of topics per Sept. 5, 2019 (see appendix for descriptions of topics)

Civil Engineering topics:

A. Hydraulics

Topic 1: Flooding safety during severe storms and high river discharges
Topic 2: Salt-Fresh water development Haringvliet at open gates
Topic 3: River Flows at low discharges, due to new conditions created by Delta21
Topic 4: Water current changes and stratification along the North Sea coast
Topic 5: Changes of the current patterns, including density currents, sedimentation and erosion patterns within the Tidal Lake and the Haringvliet
Topic 6: Impact of Delta21 on the navigability/loading capacity of inland shipping during low river discharges along Waal and Rhine, between Nijmegen and the area of Ruhrort/Kaub, Germany

B. Design sandy beach and dune protection

Topic 7: Design and construction of the dune protection of the Energy Storage Lake
Topic 8: Design and construction of the dunes and access channel at the Tidal Lake

C. Fresh Water Supply

Topic 9: Investigate options to guarantee Freshwater supply to South Holland and Northwest Brabant during low river discharges and a sea level rise

D. Systems Engineering

Topic 10: Develop the Customer Requirements Specification (CSR), using SE for the Delta21 concept

E. Hydraulic concrete constructions

Topic 11: Design and construction of the spillway into the Energy Storage Lake
Topic 12: Design the options with and without of the tidal in- and outlet
Topic 13: Design of the navigation lock for recreation and fishing boat purposes

F. Planning of works

Topic 14: Planning for the execution of the works for the Energy Storage Lake and the Tidal Lake.
Topic 15: Nitrogen and Carbon Dioxide balances during execution, maintenance and demolishing Delta21

G. Soil Mechanics, Soil Water Mechanics and bottom stability

Topic 16: Bottom and Slope Stability, soil mechanics and groundwater flow
Topic 17: Effect of calculation rules on piping below river dikes

H. Risk Analysis Hydraulic Constructions

Topic 18: Investigation of failure mechanisms of the Maeslantkering with Delta21 and structural solutions to improve the safety of the barrier system

I. Coastal Morphology

Topic 19: Study of the morphological developments at the North Seaside of Delta21 between Hook of Holland and the Kwade Hoek
Topic 20: Study of the impact of Delta21 on the morphology along the coast between de Kwade Hoek and the head of Schouwen

Business Administration-Policy and Management topics:

J. Impact on the Electricity supply near the port of Rotterdam

Topic 21: Impact of electricity price development 2030-2050 on Delta21

Topic 22: Impact of Delta21 on netstability by Delta21 as a sustainable energy hub within the port of Rotterdam

K. Project Management and Policy

Topic 23: Delta21 as a sustainable energy hub within the port of Rotterdam

Topic 24: Development of organisation and contract structure for Delta21

Topic 25: Inventory and management of technical, & operational and financial risks of Delta21

Topic 26: Project comparison with Delta21 as an option

Topic 27: Options to Finance Delta21

Topic 28: Interdisciplinary and Integrated Infrastructure Design (IID) approach

Ecosystems, Natural Values and Fishery.

L. Ecosystems

Topic 29: Investigate development + restoration Fish Migration between Rhine/Meuse and North Sea

Topic 30: Investigate the possibilities for aquaculture within the Delta21 plan

Topic 31: Building with Nature Nature, Ecosystems, Natural Values

Topic 32:Impact of Delta21 on the function of the Biesbosch

Topic 33: Impact of Delta21 on European Framework Directive for Water values, on NATURA 2000 areas, etc.

Architecture

M. Landscape urban planning

Topic 34: Development of better integration offshore area of Delta21 in nature friendly landscape

Topic 35: Integration of coastal area of Voorne with Delta21 interventions

Topic 36: Integration of coastal area of Goeree Overflakkee with Delta21 interventions

Topic 37: Design alternatives of Tidal Lake and Energy Storage Basin

Topic 38: Design of an airstrip at Maasvlakte II, directly North of the Energy Storage Lake

Renewable Energy and Mechanical/Electrical Engineering

N. Renewable energy systems

Topic 39: Power Hydro Storage integration in network

Topic 40: Design Hydro Heat Storage Basin.

Topic 41: Design Wind Energy Park around Energy Storage Lake

Topic 42: Design Floating Solar Energy park in Energy Lake, Tidal Lake or Haringvliet

Topic 43: Design of sunken Brine Batteries-park in Energy Storage Basin

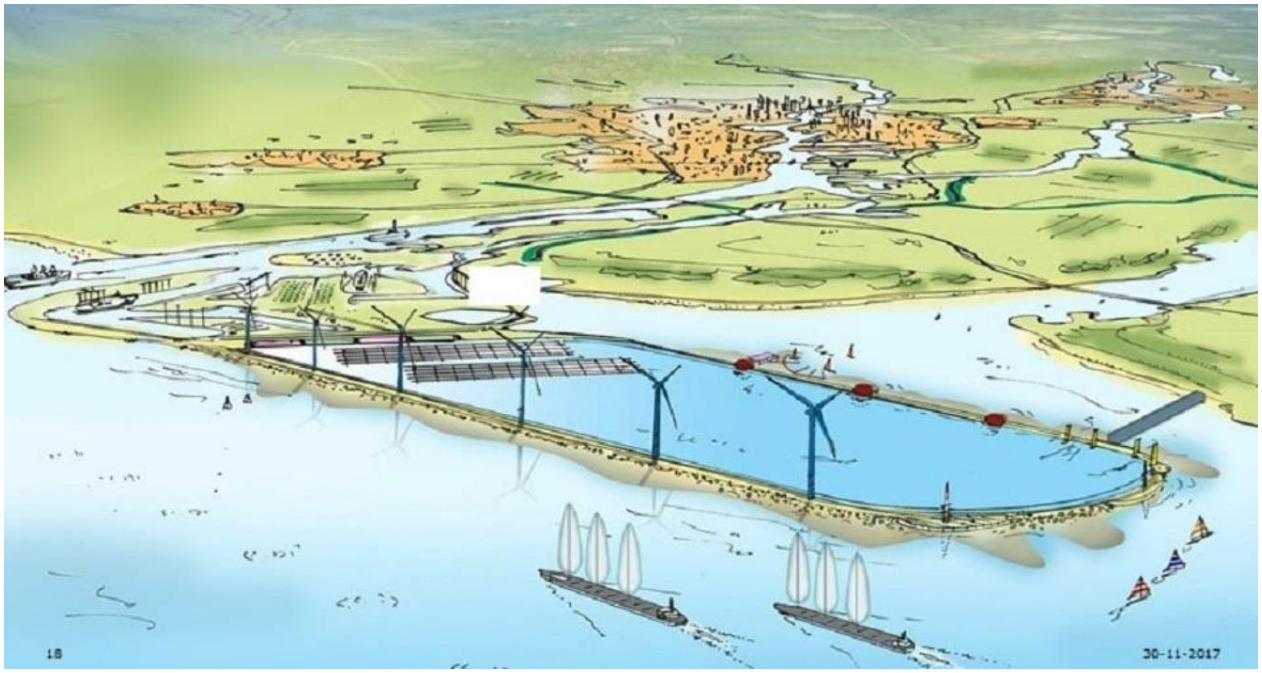
Topic 44: Design combination of floating Brine Batteries Park with sunpark in Energy Storage Basin

Topic 45: Design combination of Floating Solar Park in combination with aquaculture (e.g.algae)

Topic 46: Design an integrated H2-production plant

Topic 47: Optimize the design of the turbines/pumps of the Energy Storage Lake

Topic 48: Optimize the design of an efficient fish friendly pump/turbine



Programme: DELTA FUTURES LAB
Graduation professor Civil Engineering: prof.dr.ir. S.N. Jonkman, prof.dr.ir. M. Kok, prof. dr.ir. Z.B. Wang, or Prof.dr.ir. S.G.J. Aarninkhof
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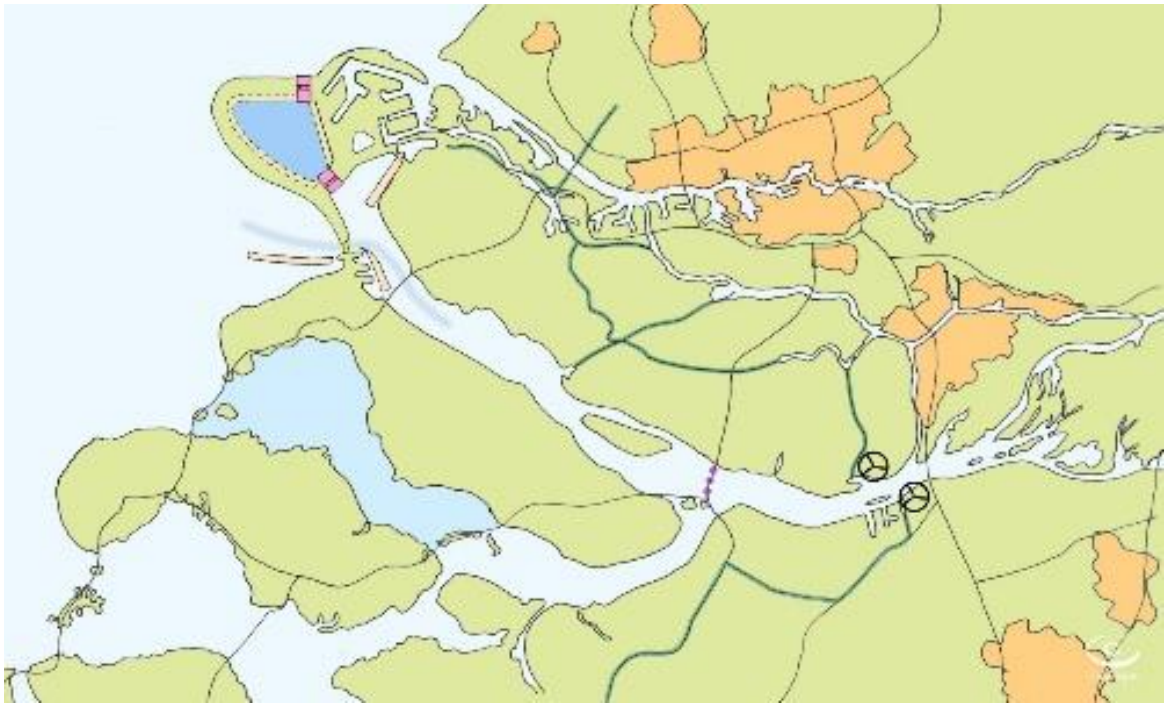
Architecture: dr. F.L. Hooimeijer
Solar energy: dr. Schreier



Appendix: Description of the DELTA21 Topics for DELTA FUTURES LAB

Civil Engineering

A. Hydraulics

Topic 1: Flooding safety during severe storms and high river discharges

Investigation of the effect of Delta21 on safety and safety conditions of the water system in the downstream area of Rhine and Meuse between the Maeslant barrier and Gorinchem during various severe and long lasting storms and various river discharges (between 5000-9000 m^3/s) taking into account the failure rate of safety systems involved. A model developed by HKV can be applied. This study involves the determination of water levels and discharges, also in case of failure of the Maeslant barrier. The flow model of the lower river areas includes the influence of the tide (HKV, Rijkswaterstaat).

Topic 2: Salt-Fresh water development Haringvliet at open gates

Investigate the development and stability of the fresh water current patterns and the salt tongue within the Haringvliet and Hollands Diep, at different discharges of the rivers Rhine and Meuse into the Haringvliet at open Haringvliet-locks as an option of Delta21, with fresh water intake measures in the Hollands Diep. The flow model includes the tidal influence via the Haringvlietlocks. A model developed by HKV can be applied (HKV, Rijkswaterstaat).

Topic 3: River Flows at low discharges, due to new conditions created by Delta21

Investigation of the impact of Delta21 on the water system in the downstream area of Rhine and Meuse between the Maeslant barrier and Gorinchem at open gates in the Haringvliet, during low river discharges of Rhine (below 2000 m3/s) and Meuse and assuming the realisation of the following works: Delta21 with open Haringvlietgates, POA (Permanent Eastern Supply) will transport fresh water from the Amsterdam-Rijnkanaal to South Holland. (A fresh water discharge via the Nieuwe Waterweg to reduce the salt tongue is not needed anymore, the fresh water flow via the Hollandse IJssel is not required anymore and the Volkerak Zoommeer contains salt water). These works will increase the freshwater discharge via the Haringvliet. Consider the location of the moving border between fresh and saltwater at different river discharges. A model developed by HKV can be applied (HKV, Rijkswaterstaat).

Topic 4: Water current changes and stratification along the North Sea coast

Study of the current changes along the coast of the North Sea in the area between Hook of Holland and the coast of Schouwen Duiveland, caused by the Delta21 interventions by modelling the area and taking into account the tidal effects, the river discharges and the currents from the Energy Storage Lake. Take also the differences of fresh and saltwater and its stratification into account.

Topic 5: Changes of the current patterns, including density currents, sedimentation and erosion patterns within the Tidal Lake and the Haringvliet

Study of the current changes within the Tidal Lake and the Haringvliet, caused by the Delta21 interventions by modelling the area and considering the tidal effects, the river discharges and the currents from the Energy Storage Lake. Take the differences of fresh and saltwater and its stratification into account. Determine the development of the sand and mud banks and the morphology in the the Tidal Lake. Determine the sedimentation and erosion patterns in these areas as a consequence and make an estimate of the required maintenance dredging cost.

Topic 6: Impact on the navigability/loading capacity of inland shipping

Investigate the impact of the Delta21 interventions on the navigability/loading capacity of inland shipping in the downstream area between Dordrecht and Gorinchem, along the Waal near Nijmegen and along the Rhine near Ruhrort/Kaub in Germany, at low river discharges, applying a river current model.

B. Design sandy beach and dune protection

Topic 7: Design and construction of the dune protection of the Energy Storage Lake

Design and construction method of the dune protection both at the seaside and at the inner tidal lake side, for the Energy Storage Lake within Delta21. The design includes dimensions of the cross sections of the dunes. For the construction mainly sand will be used, alternatives of hanging beach using rock or sandbags to be considered. Sand from the deepening of the Energy Storage Lake can be used.

Topic 8: Design and construction of the dunes and access channel at the Tidal Lake

Lay-out and cross-section design of the dune protection at the closure dam of the Tidal Lake, within Delta21, between the coastline of Goeree and the Energy Storage Lake. The dune is at one side connected with the sea and on the other side, part of the Tidal Lake. In the dam a lock for fishing vessels and recreational vessels can be considered as an option. The design should include the construction of a new and deepened access channel between the lock and the port of Stellendam.

C. Fresh Water Supply

Topic 9: Investigate options to guarantee Freshwater supply to South Holland during low river discharges and a sea level rise

Investigate several options within the Delta21 concept for a freshwater guarantee to South Holland during low river discharges and a sea level rise between 0,5 and 2 m. Consider POA as the main solution for the central Green Heart of South Holland. Consider the Nieuwe-Waterweg as not appropriate for freshwater intake during low river discharges. Investigate several options for the Delta21 concept around the Haringvliet and Hollands Diep to guarantee the fresh water supply for the Brielse Meer, Northwest Brabant and the islands around the Haringvliet.

D. Systems Engineering

Topic 10: Develop the Customer Requirements Specification (CSR), using SE for the Delta21 concept

Develop a Customer Requirements Specification (CRS) for the integral Delta21 concept, applying the Systems Engineering's approach. Safety against flooding in the downstream river basin of Rhine and Meuse, guarantee of fresh water supply during low river discharges, restoration of the brackish water biotope in the Haringvliet, restoration of fish migration between Rhine/Meuse, North Sea and Hydro Power Storage minimal economic damage, balancing of CO2 and NO emission, and nature preservation should be considered as the main requirements of the customers.

E. Hydraulic concrete constructions

Topic 11: Design and construction of the spillway

Design of the spillway between the tidal basin and the Energy Storage Lake, which will be opened and used once (1-2 days) every 5-20 years to allow an inflow of excessive river water into the Energy Storage Lake of about 10.000 m3/s. The design should include the bottom protection, the construction method and the construction cost.

Topic 12: Design of the tidal in- and outlet

Design of the in- and outlet structures of the tidal lake. The structures will be connected with the coastline by a dune construction and with the Energy Storage Lake on the other side. The tidal inlet will become the main defence barrier against flooding of the hinterland. The tidal inlet should be closed during heavy storms and corresponding expected seawater levels above about NAP + 2,5 m. The option of including a series of tidal energy turbines in the tidal in- and outlet should be considered. The design should include the bottom protection, the construction method and the construction cost.

Topic 13: Design of the navigation lock for recreation and fishing boat purposes

Design of the navigation lock for recreational vessels and fishing boats, including navigational aids and mooring facilities. This navigation lock is an option within the Delta21 plan, if the tidal turbines are built as

well. The navigation structures will be connected with the coastline with a dune construction. In this option a set of tidal energy turbines in the tidal in- and outlet should be taken into account. The design should include the construction method and the construction cost.

F. Planning of works

Topic 14: Planning for the execution of the works for the Energy Storage Lake and the Tidal Lake

Design a plan for the total construction planning for the offshore elements of Delta21 works. The works include mainly: Construction site, dredging of the access channel between Stellendam and the lock, dredging of the Energy Storage Lake, reclamation of the dunes around the lakes, rock constructions, concrete constructions for the in- and outlet of the Energy Storage Lake and installation of the turbines/pumps. The planning should include the construction methods, sequence of construction, equipment, permits, approvals and traffic planning, personnel involved, time planning, management, organization, construction cost and cash flow. For the study earlier carried out investigations and designs on Delta21 will be used.

Topic 15: Nitrogen and Carbon Dioxide balances during execution, maintenance and demolishing Delta21

Determine the Nitrogen and Carbon Dioxide balance during execution, maintenance and demolishing of the Delta21 project. Determine the emission of particulate matters and develop applications to reduce the emission amount as much as possible, e.g. by using GTL (gas-to-liquids or biofuel), avoiding running stationary during transports, or using sensors. Biofuel, on the other hand, can cause rust and bacteria formation etc. etc. Determine the additional cost and emission savings and develop a model to optimize the emission process. Compare these balances with the balances that would occur if the existing policy of dike strengthening would be continued.

G. Soil Mechanics, Soil Water Mechanics and bottom stability

Topic 16: Bottom and Slope Stability, soil mechanics and groundwater flow

Develop a groundwater model and determine the stability of the bottom and under water slopes of the Energy Storage Lake. Determine the groundwater flows during construction and during operations. Consider the application of vertical drainage to reduce the instability of the bottom and slopes of the Energy Storage Lake. Optimize the bottom depth of the Energy Storage Lake from the point of view of the geotechnical situation.

Topic 17: Effect of calculation rules on piping below river dikes

The huge impact of the dike strengthening on the Dutch landscape makes Delta21 an interesting and nature friendly alternative. This topics aims to quantify the impact of the new requirements on the cost of the dike strengthening program. The consequences of these new rules on the Dutch river landscape and on the design of about 700 km river dikes seems to be very high. About 60% of the dikes do not meet the stability requirements for piping, applying the new calculation rules for piping. With the new rules, piping becomes the most important failure mechanism for dikes, whereby water with sand particles flows under the dike. The water with the sand particles flow behind the dike create a channel (a 'pipe') under the dike and a well on the inside of the dike. This can weaken and destabilize the dike construction and eventually even create a collapse. Investigate, using the probabilistic approach for a standard dike, applying different calculation rules and determine the effect on the landscape and the construction cost per kilometre dike.

H. Risk Analysis Hydraulic Constructions

Topic 18: Investigation of failure mechanisms of the Maeslantkering with Delta21 and structural solutions to improve the safety of the barrier system

Investigate the possibilities to reduce the consequences of failure of the Maeslantkering and to increase its lifespan by implementing Delta21. Make an estimate of the effect of Delta21 on the probability of failure if

the moment of closing of the Maeslantkering would be later than it is now, if the closing time would be less and if floating of the barrier during LW would not be needed anymore. Consider the present situation with a sea level rise of 0,5 m, 1 m and 2 m.

I. Coastal Morphology

Topic 19: Study of the morphological developments at the North Seaside of Delta21

Study of the tidal currents, the wave activities and the morphological changes along the coast of the North Sea, caused by the Delta21 interventions between Hook of Holland, the entrance of the Nieuwe Waterweg and the Kwade Hoek at Goeree. An estimation of the possible areas and velocity of erosion and sedimentation to be included.

Topic 20: Study of the impact of Delta21 on the morphology along the coast between de Kwade Hoek and the head of Schouwen

Study of the morphological changes, both sand and mud, along the North Sea coast, the access channel between de Kwade Hoek at Goeree and the head of Schouwen, caused by the Delta21 interventions. An estimation of the development of the shallow environmental important sand and mud banks in the Voordelta to be included.

Business Administration-Policy and Management

J. Impact on the Electricity supply near the port of Rotterdam

Topic 21: Impact of electricity price development 2030-2050 on Delta21

Develop a model that predicts the daily price fluctuations over a whole year of electrical power for the years 2030, 2040 and 2050 and thereby determine the purchase and sale prices of the electrical power that is purchased and supplied for the Energy Storage Lake within the Delta21 concept. Take the options of a floating Sunpark of 1,2 GW, an Aqua Battery of 0,8 GW and a 3 GW Windpark into account.

Topic 22: Impact of Delta21 on net stability by Delta21 as a sustainable energy hub within the port of Rotterdam

Consider the present grid capacity and stability and the situation in 2030, especially during the moments of a surplus on wind and solar electricity supply and the moments of “dunkelflautes”, also taking the role of the BritNed cable into account. Consider the consequence of the Delta21 interventions on the grid. Determine the added value of the Energy Storage System in the Dutch grid at Maasvlakte and include the options of a floating Sunpark of 1,2 GW, an Aqua Battery plan of brine and fresh water of 0,8 GW and a 3 GW windpark.

K. Project Management and Policy

Topic 23: Delta21 as a sustainable energy hub within the port of Rotterdam

Consider the Energy Storage Lake as a new sustainable energy hub for the port of Rotterdam. Include the 1,8 GW day-night storage of the Lake and include the options of a floating Sunpark of 1,2 GW, an Aqua Battery plan of brine and fresh water of 0,8 GW, a seasonal warm water storage basin of 0,8 GW and a 3 GW windpark. Consider the impact of this sustainable energy hub on the transfer of the port into a port with a focus on circular economic activities.

Topic 24: Development of organisation and contract structure for Delta21

Develop a robust organisation and contract structure and format indicating the project owner, the contractors, concessionaires and the operators pre- and post- completion. Determine the various possibilities of contracts, advantages and disadvantages and give a recommendation. Specify the kind of contracts to be concluded and how these contracts are interrelated in terms of timing and performance;

specify all interfaces. Illustrate this by making a critical path analysis for the performance under each contract and an overall critical path analysis for the whole project. Also specify the qualification requirements to be met by each party in the project in order to limited as much as possible the change of underperformance.

Topic 25: Inventory and management of technical, & operational and financial risks of Delta21

Develop a risk assessment model for each part of the project and for the total project applying a system analyses approach. The model should include at least all technical and operational risks, risks of permits and licences, risks of change in law, water quality, soil composition, archaeological findings, and buried explosives. Also include into the model the risk of opposition from local authorities, NGO's and private parties and persons. Make a risk allocation to the parties that can/must control the risks and make an assessment of the possible costs involved in managing the risks.

Topic 26: Project comparison with Delta21 as an option

Compare the situation in which the Delta21 project is executed with the situation without Delta21; i.e. present existing programs on dike strengthening, transfer into a sustainable energy supply system and nature restoration of the Haringvliet will be executed. Analyse, complying a system analysis approach, at least the differences in costs, possible economic damage, nature conservation, energy transition, life environment, CO2 and NO emission, subsidence, tourism, aquaculture and fishery. Develop a decision model which determines which part(s) of the Delta21 project is essential for the wellbeing of future generations to be executed and which part(s) can be left out and/or replaced by existing scheme(s). In making the assessment also national and international treaties are to be considered. Assume different climate scenario's.

Topic 27: Options to Finance Delta21

Determine which part(s) of Delta21 is fit to be financed on a project finance, DBFMO, basis. Consider the different puroposes of the project: Flood safety, energy supply and natura restoration. Prepare, for each part of the project, a sound risk allocation between the concessionaire and the project owner as well as an effective penalty regime. Provide an indicative term sheet for each financing including at least the amount and term of the contract, specifying the phases to be financed, minimum equity ratio, other (default)ratio's, risk allocation between concessionaire and financial institution, guaranties favour the financial institutions, drawn down scheme, cash flow waterfall, insurances, and reserve accounts. Provide for each such financing the financial model covering the whole period of financing. Also indicate activities for which the financing may be enhanced by Delta21, such as seaweed farms, aquaculture, fishery, tourism. By doing so, take into account all subsidies that are already in existences for these kind of activities or is worthwhile to be made available by councils or other governmental institutions, taking into account European legislation.

Topic 28: Interdisciplinary and Integrated Infrastructure Design (IID) approach

A team of 3-6 students will explore and (re)define the design issue and objectives of Delta21 and investigate and analyse the environmental and societal stakeholder context for its possibilities, constraints and conditions. The students will work autonomously on different design-issues and in a team composed by different disciplinary backgrounds on basis of a project-plan. The stages of this approach are characterized by different processes and dynamics. The following stages are considered: Project-definition, Exploration & Analysis, Conceptualisation & Integration, Simulation & Verification, Evaluation & Decision

Ecosystems, Natural Values and Fishery

L. Ecosystems

Topic 29: Investigate development + restoration Fish Migration between Rhine/Meuse and North Sea

Investigate what ecological changes can be expected, in particularly on fish migration, in the Haringvliet as an effect of the implementation of the Delta21 plan. What is the expected change in vegetation and what abiotic and biotic changes are expected to take hold in the Haringvliet if the plan would be implemented? What is the expected change in presence of migratory fish in the estuary and brackish water area when Delta21 is implemented? Which species will be lost? Which species can recover or successfully be reintroduced and what is the expected time scale for each of the expected changes?

Topic 30: Investigate the possibilities for aquaculture within the Delta21 plan

Investigate the possibilities for the development of aquaculture, with an emphasis on mussel cultures, oyster cultures and seaweed in the Haringvliet, the Tidal Lake and the Energy Storage Lake after the construction of the works for DELTA21. Define the requirements for setting up potential aquaculture production systems and the suitable conditions for seaweed cultivation, mussels and oysters. Determine, in business perspective what is needed to establish good aquaculture production areas.
What quantity of seaweed, mussels and oysters can we expect? And in which timeframe. Special emphasis should be given to the risks of fresh water during high river discharges and salt-fresh water stratification..

Topic 31: Building with Nature, Ecosystems, Natural Values

Develop a layout that is as nature friendly as possible for the Tidal Lake, the Energy Storage Lake, the Haringvliet and Hollands Diep within the DELTA21 concept, both the dunes, the embankments and the water side. Consider that activities take place in part of the foreshore area. which belongs to one of the Nature 2000 areas. Consider the need and the possible contribution of aquaculture activities for the restoration and increase of the diversification of the natural values in the whole area, including the Haringvliet (recovery of salt tide, fish migration and recovery brackish water biotope) the Tidal Lake (improvement of water clarity, better access to nutrients, less silt in the water and nursery function). Focus the study on the desired natural development of the ESLake, the slopes and the dunes the bottom (green dunes, perhaps planting of helmets, biodiversity options, planting mangroves, plants grass etc.). Which saltwater / brackish water biotopes, plant or other species do we expect to develop within the ESLake, the Tidal Lake, Hollands Diep and the Haringvliet and Hollands Diep?

Topic 32: Impact of Delta21 on the function of the Biesbosch

Investigate the consequences of an open Haringvliet on the functions of the Biesbosch. The tidal influence in the Biesbosch will increase, the brackish water biotope in the Haringvliet and in the Hollands Diep will return, but not as far as in the Biesbosch. Investigate the consequences for the ecology, for fish and birds habitats, flora and fauna in general.

Topic 33: Impact of Delta21 on European Framework Directive for Water values, on NATURA 2000 areas, etc.

Determine the most relevant policy frameworks, in particularly the European Framework Directive for Water and apply the available tests to evaluate the impact of Delta21 on the nature values within the framework, including the water test, to ensure that the spatial planning is sufficiently balanced in terms of storage of land in the floodplain, good water quantity and water quality, but also the Environmental Impact Assessment, like the protection against floods, seepage of water, groundwater quality, surface water quality and wet nature. Determine the values from the European Water framework directive (WFD) en Natura 2000 for Delta21, to ensure the quality of the surface and the groundwater and the relationship between the PKB/MER and Space for the River for the river area. The spatial measures, like the reduction of

the flood plains, the construction of secondary channels and the removal of obstacles and determine the preferred alternative (basic package and alternatives) in the PKB.

Architecture

M. Landscape urban planning

Topic 34: Development of better integration offshore area of Delta21 in nature friendly landscape

Develop a nature-friendly lay out of Delta21, aiming to fit the offshore area around the tidal lake and the Energy Storage Lake in a better way into a landscape than has now been worked out in the plans. Include options for more recreational and urban development of the area, as living and recreation by the sea and on the water is very popular and as there is a great deal of pressure of inhabitants to live permanently along the coast and in the coastal areas.

Topic 35: Integration of the lake and coastal area of Voorne with Delta21 interventions

Design options for the restoration of the nature- and tourism- attractive coastal area between Kruiningergors and the Haringvlietlocks. Consider an open saltwater connection between the Oostvoorne's Meer and the Tidal Lake for nature and recreational developments and integrate the area with Oostvoorne's unique dune area. Consider the possibilities to remove the sedimentation along the beaches of Voorne and restore the original beaches without damaging the new nature values. Consider also the extension of shallow sand and mud banks within and just outside the Tidal Lake for the extension of valuable natural habitats.

Topic 36: Integration of coastal area of Goeree Overflakkee with Delta21 interventions

Prepare alternative nature-friendly designs for the development of the dunes and beaches around the Energy Stoarage Lake and the area along the coast of Goeree, between the port of Stellendam and Ouddorp. Leave the Northern area of the Kwade Hoek for nature development and include some options for more water-bound recreational and limited urban development in the more Southern area near the by Delta21 created dunes. There is a great deal of pressure on the coastal areas by the sea for living and recreational purposes. Allow the unique dune development in the Northern part to fulfil a nature attractive area and create a limited option for permanent living along the coastline in combination with sea sport recreation, like a small craft port.

Topic 37: Design alternatives of Tidal Lake and Energy Storage Basin

Develop, within the boundary conditions of the requirements for flood protection, nature restoration and energy storage, alternative lay out options for the location of the Tidal Lake and the Energy Storage Basin, considering a better integration of the surrounding landscape of the islands, with the natural areas, tourism and permanent living in the coastal areas of the islands of South Holland.

Topic 38: Design of an airstrip at Maasvlakte II, directly North of the Energy Storage Lake

Develop various options for the lay out and location of an airstrip at Maasvlakte II, directly North of the Energy Storage Lake. The airstrip aims to focus on cargo, it aims to replace the airport of Rotterdam/the Hague and optional, it could combine its civilian with a military function.

Renewable Energy and Mechanical/Electrical Engineering

N. Renewable energy systems

Topic 39: Power Hydro Storage integration in network

Investigate the possibilities and constraints of integrating the Energy Storage Lake of Delta21 into the existing electricity network. Develop a model for using the Energy Storage Lake during different circumstances of wind energy and sun-energy supply during the day and during the year. Develop a policy

to manage the ESL into the existing network. Consider the Energy Storage Lake as part of the new sustainable energy hub for the port of Rotterdam with a 1,8 GW storage of the Lake, a floating Sunpark of 1,2 GW, an Aqua Battery plant of 0,8 GW and a 3 GW windpark.

Topic 40: Seasonal Hydro Heat Storage

Investigate the possibilities of developing a large-scale seasonal storage basin with water temperatures up to 90 gr. Celsius next to the Energy Storage Lake. In the basin, warm cooling water from industry can be stored for use during wintertime for heating purposes of building and households. Investigate as well, the pipe network capacity required for the supply and trnsport of hot water. Consider the option of extracting electricity from the cooling water according to the C-TEC principle. Investigate to what extent this hot water concept can be combined with the electricity supply from the Energy Storage Lake. Investigate how distribution to the users should take place, with possible interim storage and transport conducts.

Topic 41: Design Wind Energy Park around Energy Storage Lake

Investigate the possibilities and chances to develop a large-scale offshore wind farm of more than 3 GW within the DELTA21 concept, located in, around and / or offshore from the Energy Storage Lake. Investigate to what extent this can be combined with the electricity supply from the Energy Storage Lake, the sunpark and the Aqua Battery park.

Topic 42: Design Floating Solar park in Energy Lake, Tidal Lake or Haringvliet

Investigate the possibilities of constructing a floating large-scale solar park in the Energy Storage Basin, Haringvliet or Tidal Lake and investigate the possibility of using alternating or direct current. Develop some alternatives for the floating substructure in a lake with 20 m water level difference. Solarfields Rotterdam and Groningen is one of the partners for the development.

Topic 43: Design Design of sunken Brine Batteries-park in Energy Storage Basin

Explore the possibilities within the Energy Storage Lake of the DELTA21 concept to develop the concept with thousands of brine water batteries together with AQUA BATTERY. The brinewater batteries consist of three sections with flexible walls. The middle part contains "brine" water. With electricity, it is split into acid and basic water, which is collected in separate compartments. This will "charge" the battery. The power is released again by combining both types of water. Investigate to what extent this can be combined with the electricity supply from the Energy Storage Basin.

Topic 44: Design combination of floating Brine Batteries Park with sunpark in Energy Storage Basin

Investigate the possibilities of constructing a floating large-scale solar park in the Energy Storage Basin, Haringvliet or Tidal Lake. The solar park will be combined with floating brine water battery bags as developed by AQUA BATTERY. The brinewater batteries consist of three sections with flexible walls. The middle part contains "brine" water. With electricity, it is split into acid and basic water, which is collected in separate compartments. This will "charge" the battery. The power is released again by combining both types of water. Develop some alternatives for the floating substructure for the combination of the bags and the solar panels. Aqua Battery and Solarfields are the partners for the development.

Topic 45: Design combination of Floating Solar Park in combination with aquaculture (e.g.algae)

Investigate the possibilities of constructing a floating large-scale solar park in the Energy Storage Basin, Haringvliet or Tidal Lake. The solar park will be combined with aquaculture systems, like algae, mussels and/oir oysters. Develop some alternatives for the floating substructure for the combination of the aquaculture products and the solar panels. An oyster/mussel or algae company and Solarfields are the partners for the development.

Topic 46: Design an integrated H2-production plant

Investigate the possibilities of constructing a H2-productionplant by the owner/concessionaire of the ESLake converting the energy produces by the ESLake into H2. Determine by the breakeven amount for the

investment in the concession in this respect. Consider the H2-plant and the Energy Storage Lake as part of the new sustainable energy hub for the port of Rotterdam with a 1,8 GW storage of the Lake, a floating Sunpark of 1,2 GW, an Aqua Battery plant of 0,8 GW and a 3 GW windpark.

Topic 47: Optimize the design of the turbines/pumps of the Energy Storage Lake

Optimize the design of the most efficient capacity of the turbines/pumps for the Energy Storage Lake in relation with the optimal length and cost of the concrete “housing” for the turbines/pumps. The length of the construction strongly depends on the designed turbine capacity. The pumps/turbines and the “turbine-housing” have to be considered as an integrated system, to be optimized. Make an evaluation of the total efficiency and construction and maintenance cost (Pentair)

Topic 48: Optimize the design of an efficient fish friendly pump/turbine

Optimize the design of an efficient fish friendly pump/turbine for Delta21 with a capacity of 5-50 MW and average level difference of 15 [m] for the Energy Storage Lake and compare the efficiency with a conventional pump/turbine , protected by meshes of various sizes to avoid bigger fishes to pass the turbines. Make an evaluation of the efficiency, fish friendliness and cost (CAPEX/OPEX).(Pentair)
