

1. General	
Project title	TKI Flexible end modular
Project leader(s)	Hugo Gelevert
Affiliation(s)	TNO
Researcher(s) employed	Mark Roelands, Rajat Bhardwaj, Karin van Kranenburg, Niels Jansen, Bart Devoldere
Roadmap(s)	
2. Financial report	<i>Please use the added format for a detailed financial account of the project</i>
Start date	1-11-2016
End date	31-3-2018
Total budget	290.250 euro
Realisation	298.507 euro
- Personnel	
- Materials	
- Equipment	
3. Project & results	<p>The TKI project Modular & Flexible production aimed to contribute to the adoption of flexible and modular technology in the chemical industry. The project was a close cooperation between Huntsman, Clariant, Bilfinger Tebodin, Zeton, Britest and TNO.</p> <p>Goal of the project was to gain insight in the economic potential of novel business models based on flexible production.</p> <p>The project delivered the following results:</p> <ul style="list-style-type: none"> • Two real-life cases were elaborated (Huntsman and Clariant), gaining many new insights in the technical, business and financial aspects of flexible modular production. • A generalized model that supports companies in constructing business cases for their own flexible modular cases. The resulting model is a breakthrough in calculating the business case for flexible and modular plants, including the future value of flexibility.
a) Aims and objectives of the research project	
b) New insights and remarkable scientific results, bottlenecks and setbacks	
c) Changes with respect to the original research plan	

3. Valorisation Importance of the results for the industrial partners and/or industry and/or society in general	During elaboration of the Huntsman and Clariant case, the following learnings were gained: <ul style="list-style-type: none"> • More responsiveness to customer demand – both in existing as in new markets – is an important driver for flexible production. Second driver is financial risk reduction. • Include both financial as other benefits (like better time to market, more resilience, etc.) in decision making. • Iteration in the process from first idea to final decision making is important. • The 0.6 rule, leading to high CAPEX for small modules appears difficult to overcome. This makes beating business as usual a challenge. Possible directions: <ul style="list-style-type: none"> • Use new technologies or production methods instead of just downsizing (e.g. electrolysis, from batch to continuous processing). • Produce equipment for shorter lifetimes (e.g. plastic skids). • Standardisation can reduce costs of smaller units significantly. • In a modular and flexible approach R&D has not yet ready-and-made answers.
4. Output a) Posters and presentations during congresses with reference to the Topsector Chemistry b) (Draft) publications c) (Draft) patent applications	The following project results were delivered and shared with the project partners: <ol style="list-style-type: none"> 1. Management summary TKI M&F.pdf 2. Final_Flexible business model archetypes TKI M&F.pdf 3. Final_General model TKI M&F.pdf 4. Final_M&F General Model - Empty Model - v1.0.xlsx 5. Final_M&F General Model - Fictional case capacity flexibility - v1.0.xlsx 6. How to Calculate the General Model.pdf <p>No posters, presentations, publications or patent applications were delivered.</p>
5. Follow-up a) career staff b) research	NA
6. Results for general public	<p><i>The TKI project Modular & Flexible production aimed to contribute to the adoption of flexible and modular technology in the chemical industry. The project was a close cooperation between Huntsman, Clariant, Bilfinger Tebodin, Zeton, Britest and TNO.</i></p> <p><i>Goal of the project was to gain insight in the economic potential of novel business models based on flexible production.</i></p> <p><i>The project delivered the following results:</i></p> <ul style="list-style-type: none"> - <i>Two real life cases were elaborated (Huntsman and Clariant), gaining many new insights in the technical, business and financial aspects of flexible modular production.</i> - <i>A generalized model that supports companies in constructing business cases for their own flexible modular cases. The resulting model is a breakthrough in calculating the business case for flexible and modular plants, including the future value of flexibility.</i> <p><i>Project learnings are:</i></p>

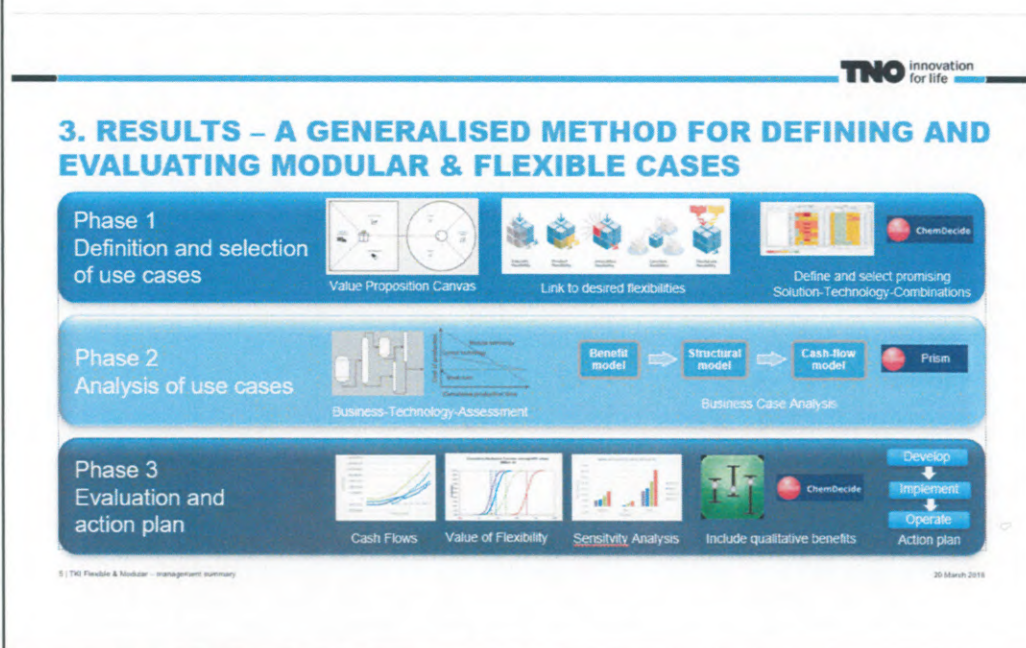
The generalized method and financial model make analysis and evaluation of flexible and modular solutions for capacity and product flexibility straightforward and include the future value of flexibility.

The 0.6 rule appears difficult to overcome. To make flexible solutions competitive, unconventional technical solutions are needed (e.g. electrolysis, continuous processing).

However flexible solutions can beat traditional large scale plants, by following market fluctuations more closely, resulting in higher NPVs and reducing financial risk.

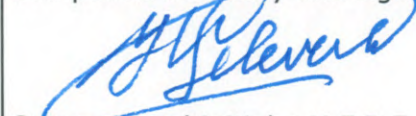
In the TKI Flexible & Modular production focus was on capacity flexibility. Location and feedstock flexibility are also very relevant to the chemical industry, e.g. in the transition to a circular economy.

7. Illustrations



8. Signature

Completed truthfully and signed:



Surname and initials: H.F.B.F. Gelevert

Date: ~~19 July 2019~~ 3 December 2019

Place: ~~Delft~~ Den Haag

Please send the completed form in **Word** format to tkichemie@tkichemie.nl.

