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Evaluating main order contract forms for Major Industrial Plant Projects (MIPP) with respect to completion and performance of design risk allocation

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Abstract

Contracts should be matched to the unique situation of a Major Industrial Plant Project (MIPP). However, in reality, oftentimes contract forms are chosen that do not fit participant's (owners', contractors') competences and risk capabilities.
In this paper, MIPP order contract forms are evaluated for the most common settings of owners and contractors with respect to allocation of completion and performance-of-design risks.
The research method takes a qualitative approach by using grounded theory and expert interviews. 39 interviews were conducted with a total of 48 interviewees – professionals from EPC and EPCM contractors, main technical component suppliers, consultants and representatives of owners.
Firstly, it is defined what a MIPP is – considering technical as well as monetary terms. Secondly, using concepts of New Institutional Economics (NIE), the international context and the MIPP network of contracts are studied. Based on Project Finance literature, the commercial risks involved in a MIPP are laid-out. Focusing on the main order contract, the involved parties are termed, introducing a "standard situation" with typical core competences of owners and contractors.
Finally, using results from the expert interviews, the core MIPP order contract forms - owner-managed, EPC, EPCM, and deviations thereof are evaluated, illustrated by examples.
Appropriate contractual risk allocation depends on the specific MIPP situation - to be understood by a thorough analysis of the owner's competences, capacities and experience in relation to the project.

JEL classification: L-14; G-32; L-24; L-70; L-74

Keywords: major industrial plant projects, construction, contracting out, investment, financing, contractual risk allocation, reputation, order contract forms, owner-managed, general contractor, EPC lump-sum turnkey, EPCM, EPC+, EP(CM), split EPC

Zusammenfassung

„Evaluierung von Werkvertragsformen im Großanlagenbau unter Bezugnahme auf die Allokation von Fertigstellungs- und Konstruktionsrisiken"

Das vorliegende Arbeitspapier untersucht die im internationalen Großanlagenbau verwendeten Vertragsstrukturen für den Hauptliefervertrag (Werkvertrag). Nach einer Definition des Begriffs „Großanlagenbauprojekt" (Major Industrial Plant Project, MIPP) werden mittels der Neuen Institutionenökonomik und Projektfinanzierungs-Literatur das internationale Umfeld, die Risiken und Vertragsparteien des Werkvertrags analysiert.
Unter Zuhilfenahme von Experteninterviews werden die Vertragsformen EPC, EPCM und owner-managed sowie einige Mischformen insbesondere in Bezug auf die Allokation von Fertigstellungs- und Konstruktionsrisiken evaluiert. – Eine Kernkompetenz-, Kapazitäts- und Erfahrungsanalyse des Bauherrn in der Planungsphase ist die entscheidende Grundlage für die Wahl der Vertragsform.

JEL Klassifikation: L-14; G-32; L-24; L-70; L-74

Schlagworte: major industrial plant projects, construction, contracting out, investment, financing, contractual risk allocation, reputation, order contract forms, owner-managed, general contractor, EPC lump-sum turnkey, EPCM, EPC+, EP(CM), split EPC

Abbreviations

bn	Billion
BoP	Balance of Plant
C	(Civil) Construction (company)
E	Erection (company)
ECA	Export Credit Agency
EPC	Engineering, Procurement, Construction
EPCM	Engineering, Procurement, Construction Management
EP(CM)	Engineering, Procurement and Management/Supervision of Construction
EPDM	ethylene propylene diene monomer
FEED	front-end engineering and design
GC	General Contractor
HBI	Hot-Briquetted Iron
IPA	Independent Project Analysis, Inc.
JV	joint venture
LSTK	lump-sum turnkey
MC	Managing Contractor
MIPP	Major Industrial Plant Project
NIE	New Institutional Economics
O	Owner
PAC	Preliminary Acceptance Certificate
PCI	problem-centered interview
PMC	Project Management Consultant
S	Subcontractor, Supplier
TIC	Total Investment Cost
tpy	tons per year
VDMA	Verband Deutscher Maschinen- und Anlagenbauer (German Engineering Federation)

1 Introduction

Why is contract structuring important, especially under risk allocation considerations?

Front-end engineering **of institutional arrangements and strategic systems** is a far greater determinant of the success or failure of large engineering projects than are the more tangible aspects of project engineering and management (Miller and Lessard 2000: 1).
Contract structuring – including risk allocation among the parties involved – constitutes a crucial task in the early phase of project shaping, creating the circumstances that will eventually determine success or failure of a major industrial project (Widmann 1977: 25; Brookes 2012: 604). Data collected by the Independent Project Analysis (IPA) confirm that, due to setting the wrong tracks during the early phases, many large industrial plant projects end up being disappointing to their owners (Merrow 2011: 12,19,23-27).

Failure due to misplanning does not only affect commercial/ private **Major Industrial Plant Projects (MIPP)**, which rarely become public knowledge, but also major construction ventures financed by the public – such as infrastructure projects.
In fact, there are similarities between major projects in infrastructure construction and plant engineering. Considering two current endeavors, parallels can be drawn between the International Airport Berlin (BER) development and ThyssenKrupp's integrated steel plant venture in Brazil. In both cases, during the early phases of the project, inappropriate contract structures were chosen and risks (if recognized at all)[1] allocated to parties unable to cope with it (Berg et al 2012; Flughafen Berlin-Brandenburg 2013; Märkische Allg. Zeitung 2013; Blasberg and Kotynek 2012: 1–5).

Focusing on MIPP, this research aims to support owner's decision making in contract structuring by providing an evaluation of main order contract forms for the most common settings of owners and contractors with respect to the allocation of key risks. The findings of this paper may be transferable to major projects other than MIPP.

2 Research Objectives and Method Justification

This paper consists of a definition and two research questions, whereby the first is preparatory to the second.

Definition – What is a Major Industrial Plant Project (MIPP)?

This will be answered in Chapter 3 by an evaluation of existing works (handbooks, engineering and project management literature) – filtering out a new tangible definition. This definition will serve as a precondition for answering the following two questions.

[1] Large public construction projects if managed by politicians are often subject to risk ignorance and what the World Bank calls "EGAP Mentality" (Rothengatter and Steeger 2012: 11–2).

1. Which risks are to be allocated to MIPP order contract parties?

In Chapter 4, Risks are identified by synthesizing Project Finance and New Institutional Economics (NIE) literature, providing a theoretical framework. Focusing on the main order contract, the involved parties and their risk capabilities are termed, introducing a "standard situation" with typical core competences of owners and contractors.

2. What are the advantages and disadvantages of different MIPP order contract forms with respect to completion and performance of design risk allocation?

This question is answered by an analysis and evaluation of MIPP contract forms with the help of expert peer interviews.
Meuser and Nagel (2005: 257ff.) mention the following problems with expert interviews:

1. the expert is not a real expert;
2. the expert talks more about internal matters and intrigues than about the interview topic;
3. he switches roles from expert to private person;
4. the expert gives a lecture rather than an interview.

The first concern was overcome by choosing interview partners with considerable work experience in the MIPP industry of minimum five and up to over 40 years.
Concerns 2.-4. were overcome by using a problem-centered interview (PCI) strategy. Witzel and Reiter (2012: 24–9) describe the PCI strategy by its orientation towards a problem (here: MIPP main order contract structures), by developing methods with regard to an object (risk allocation to contract parties), and by process orientation.

39 interviews were conducted by and on behalf of the author during the 15 months period starting February 2012, with a total of 48 interviewees – MIPP professionals from EPC and EPCM contractors, main technical component suppliers, construction firms, consultants and representatives of owners and financing organizations.
Of the interviewees, seven had MIPP work experience of minimum five years, seven individuals had experience of over ten years, 26 of over 20 years and five of over 30 and three of over 40 years of MIPP experience, respectively.
36 interviews were conducted individually and three in groups of four members each.

The process was as follows:
Firstly, the expert(s) were presented the concepts of main order contract forms including diagrams representing the forms (owner-managed, EPC, EPCM) generated from Project Finance and Management literature.
Secondly, the experts were asked about a) their consent with the diagrams, b) their experience regarding advantages and disadvantages of using each of the forms, c) any other experience with these or deviating forms of contract they had encountered.

During the interviews, notes were taken. Open coding, which allows identifying and noting concepts in interviews (c.f. Strauss and Corbin 1998: 101ff.), was completed during data evaluation. The results derived are presented in Chapter 5.

3 What is a Major Industrial Plant Project (MIPP)?

3.1 Industrial Plant Projects

The projects analyzed here are a subset of all projects: We are talking about complex, unique, i.e. tailor-made to customer's specifications, and interdisciplinary endeavors (Schelle et al. 2006: 25; Backhaus 2010: 325; Brookes 2012: 604).

Merrow defines an **industrial plant** as making a product for sale, including mining, natural gas and oil extraction (Merrow 2011: 13). Private, “for-profit” projects are also subject of this study.
However, deviating from Merrow, this research focuses solely on **process plants** that produce a tradable good (electricity, steel, aluminum, chemicals…) **by material conversion** (rather than extraction) out of a raw material (oil, gas, ores, …).

Examples of MIPP include fossil fuel-fired power plants, basic and advanced materials plant projects (chemical, metallurgical, pulp & paper, building materials plants). These types of industrial plants account for over 50% of the *global plant engineering industry*, the market volume of which, according to estimates by the Plant Engineering Council of the German Engineering Federation (VDMA) amounts to approximately EUR 250 billion (ManagementEngineers and VDMA 2011: 2–4).

So, unlike civil and infrastructure construction endeavors, a MIPP comprises **process engineering** design tasks & **equipment** (including auxiliaries) of at **least 50% of Total Investment Cost** (TIC).[2]

3.2 What makes an industrial plant project a major one?

The average contract size of Miller and Lessard’s study of large engineering projects around the world amounts to USD 985 million (Miller and Lessard 2000: 9).

Merrow defines “a **megaproject** as any project with a total capital cost of more than USD 1 billion… as measured on January 1, 2003” (Merrow 2011: 15), while Brooks terms megaprojects as "projects with a delivered value of greater than $0.5 billion" (Brookes 2012: 603).

The Engineering News Record published a list of 178 **large-scale construction projects**, which comprises 11 process plant projects of an average size of USD 596 million (ENR 2000: 45–52).

VDMA defines **large industrial plant constructors**[3] to be firms which have the capability to engineer and construct, on the basis of their know-how of process engineering technology, industrial plants tailor-made to customer requirements of a value of at least EUR 25 million, once or several times per year (VDMA 2012: 5).

[2] For a Chemical plant (Fluids Process Type) process engineering equipment accounts for over 70% of total physical plant cost, incl. equipment erection and auxiliaries, excluding indirect cost (Sinnott 2005: 252). For a definition of TIC, see below.
[3] German: *Großanlagenbauer.*

Various other opinions and guidelines for the size of an industrial plant engineering project exist.[4]

For the purpose of this research, a major industrial plant project (MIPP) is defined to require a **Total Investment Cost (TIC) of minimum USD 100 million**.[5]
TIC comprises the costs for engineering, procurement and construction (EPC) of the plant as well as owner's cost (including project development, site acquisition & preparation, financing & insurance, permits, owner's consultant engineer and any other owner's cost).

The table below serves as a guideline for industrial plant project size categories by monetary value. The ones marked in grey are subject of this research.

Size category	**Total Investment Cost, TIC** (USD millions)
small industrial plant project	<25
medium industrial plant project	25 to <100
large (major) industrial plant project, **MIPP**	100 to 1,000
industrial megaproject	>1,000

Table 1: **Guideline for Industrial Plant Project Size Categories by TIC**

Further, to be classified as a MIPP for the purpose of this study, a project involves:

- minimum a 100 suppliers/ subcontractors
- duration of the project development phase of min. 6 months (12-24 months on average)[6]
- duration of project execution phase of min. 12 Months (2-5 years on average)

In addition, the projects focused on are **new developments**, i.e. no replacement, repair or extension projects (several similar plants in one location can be included).

[4] For example, Helmus defines small plants as "plants with a production volume of up to €500,000", medium-sized plants as „plants with order volumes of single or double digit amounts in millions" and large-scale plants' order volumes of „approximately a billion". He neither defines what "order volume" includes, nor how he would categorize plants between EUR 100-999 million (Helmus 2008: 3–6).
[5] We use this monetary figure as a guideline, rather than a definition *in sensu stricto*. As the **time value of money** is concerned, we do not fix the USD value to a certain date, meaning USD as of today, i.e. any day in 2013 and the years to follow. Merrow (2011: 15) notes that monetary definition is arbitrary as well as simplistic since it disregards the effects of complexity (however measured).
It might be possible to use **installed capacity** of an industrial plant as a measure of size, and thus complexity, but since we are looking at different industrial plants, the most practicable and easily applied solution may still be the monetary value (albeit arbitrary and simplistic).
On another note, it could be interesting to study large projects built in the past, for example in the Soviet Union, like the Bratsk primary aluminum plant of 1,000,000 tpy of capacity installed, erected from 1955-60. It will be very hard to find out about this project's investment cost at all and if found, to convert Soviet rubles of the 1950s to today's (or 2003) US dollars. However, judging from comparable present projects in the Middle East (TechnicalReview Middle East 2013), we may assume that an aluminum plant of this installed capacity would cost more than USD 5 bn if built today. Thus, the Bratsk aluminum smelter project could be categorized as a MIPP, and even a megaproject by Merrow's definition.
[6] Some planning activities run in parallel to project execution, e.g. detail engineering is still executed while site preparation and laying foundations has already commenced.

Notwithstanding industry differences, a MIPP generally includes the following units and tasks (Widmann 1977: 20–4):

- Process engineering unit (core equipment)
- Utilities & disposal unit
- Storage & materials handling unit
- Foundations & Buildings
- Integrated planning (engineering design, financing and other planning tasks)
- Realization (procurement, supply and erection of equipment plus civil construction[7])
- Testing & Commissioning
- (Preliminary & Final) Acceptance.[8]

The diagram below shows a MIPP's general structure with its units and tasks.

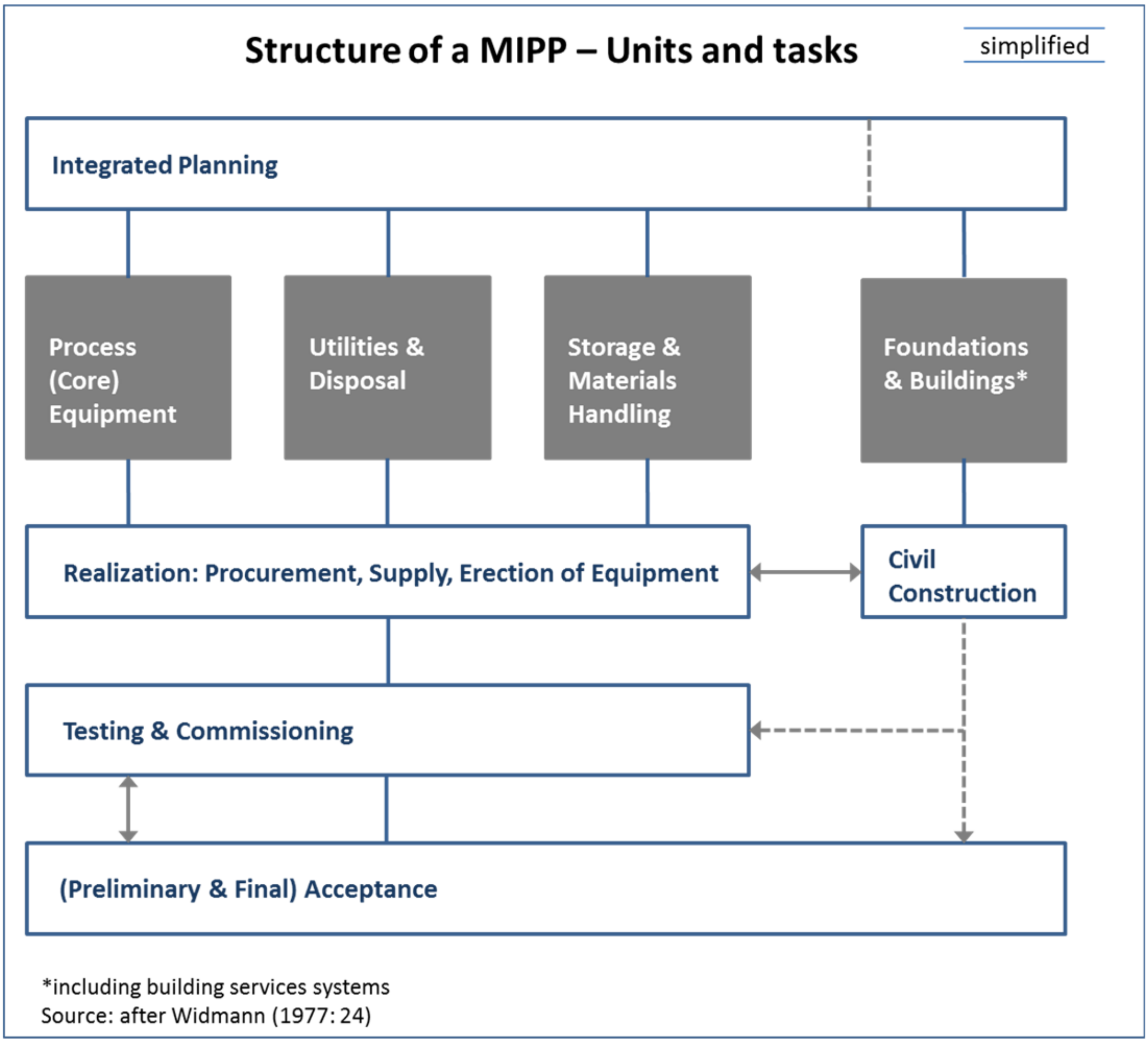

Figure 1: **Structure of a MIPP by units & tasks, simplified**

[7] Including site preparation.
[8] Assuming that the plant is accepted, and design performs as planned, preliminary acceptance, as documented in the PAC, marks the end of an MIPP. The subsequent operational phase of the plant, which can last for 20, 40 or even 60 and more years (as in case of some Soviet industrial plants), is not considered to be a part of the project, since risks now turn from project risks into operational risks.

3.3 Summarizing Key Features – Defining a MIPP

To be considered a MIPP for the purpose of this research, a project combines the following features:

1. Unique (tailor-made), complex and interdisciplinary
2. Private, "for-profit" (commercial)
3. Planning and realizing (but not operating) an **industrial process plant** that produces a **tradable good** by **material conversion** out of a raw material
4. Comprises process engineering design tasks & equipment (including auxiliaries) of at least 50% of Total Investment Cost (TIC)
5. TIC amounts to minimum USD 100 million
6. Involves minimum a 100 suppliers/ subcontractors
7. Duration of the project development phase of min. 6 months (12-24 months on average)
8. Duration of project execution phase of min. 12 Months (2-5 years on average)
9. **New** developments.

Examples of MIPPs include:

- Fossil (or biomass equivalent) fuel-fired power plant projects, basic and advanced materials plant projects (chemical, metallurgical, pulp & paper, building materials plants)

Projects which are **not** considered a MIPP for the purpose of this research include:

- Mining, natural gas and oil extraction
- Civil and infrastructure (buildings, roads, tunnels, bridges, railways, airports, sea ports etc.)
- power plants which convert energy from one form into another without material conversion (hydroelectric plants, tidal, solar and geothermal power plants, wind farms)
- Liquefaction of gases, cooling, regasification, and compressor plants (LNG Terminals, gas compressor stations)
- Military & defense, aerospace, shipbuilding
- Not-for profit, e.g. scientific megaprojects such as the multi-billion USD research facility "CERN" in Switzerland
- Replacement, repair and extension projects.

4 MIPP Risks and Order Contract Parties

4.1 The International Context of a MIPP

Today, established plant builders from industrialized nations - Western Europe, USA, Japan – (still) account for 70% of market volume of the plant engineering industry (ManagementEngineers and VDMA 2011: 2). Due to global cost competition, process industries seeking lower-cost feedstock often have to (re)locate production facilities to the source of the feedstock, in particular energy, to make the project viable (Merrow 2011: 12).
The common situation found for today's MIPPs is that at least one of the parties is contracting outside its home country, and plants are being built from equipment imported into the host country oftentimes an Emerging Market (Buckingham 2007: 711).

4.2 Risks in a MIPP

Risk analysis is the basis for risk management, which identifies strategies to reduce risks, including how to allocate them to the parties involved (Flyvbjerg et al. 2002: 73).
Following the principle of **balanced risk sharing**[9], risk should be distributed among the parties involved by means of considering their **core competences**.
Yescombe (2002: 137) differentiates three main categories of risks, which will be met in a MIPP:

- **Commercial risks** (also known as project risks) are those inherent in the project itself, or the market in which it operates.
- **Macro-economic risks** relate to external economic effects not directly related to the project (e.g., inflation, interest rates, and currency exchange rates).
- **Political risks** (also known as country risks) relate to the effects of government action or political force majeure events such as war and civil disturbance (especially, but not exclusively, where the project involves cross-border financing or investment).

The focus here is on **commercial risks**, i.e. the ones inherent in the project. Key questions considered in the commercial risk analysis process include, but are not limited to[10]:

1 – Commercial viability/ business case: Does the project make overall sense?

2 – Revenue/ offtake risks: Will operating revenues be as projected?

3 – Input/ supply risks: Can feedstocks and energy be obtained at the projected cost?

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[9] In their Introductory Note to the First Edition of the Conditions of Contracts for EPC/Turnkey Projects, the International Federation of Consulting Engineers (FIDIC) stresses their traditional principle of balanced risk sharing (International Federation of Consulting Engineers 1999).
[10] For a detailed analysis, cf. Yescombe 2002: 139-182; for a checklist for a successful project financing see Nevitt/Fabozzi 2000: 2-3.

4 – Environmental risks: Does the project face any environmental constraints in construction or operation?

5 – Sponsor support: Is there a need for more recourse to the sponsors?

6 – Force Majeure risks: How can the project cope with *force majeure* events?

7 – Contract mismatch: do the project contracts fit together properly?

8 – Completion risks: Can the project be completed on time and in budget?

9 – Performance of design risks: Is the plant capable of operating at the projected performance level?

The top three causes for project failure of MIPP are a **delay in completion** (with consequential increase in the interest expense on construction financing and delay in the contemplated revenue flow), followed by a capital cost overrun and technical failure, i.e. **performance of (process) design failure** (Nevitt and Fabozzi 2000: 2).

Consequently, **<u>risk no. 8 and 9</u>** are the crucial ones to be allocated to the appropriate contract party to contribute to project success.

4.3 Core Competence Considerations of Parties Involved in a MIPP Order Contract

Using New Institutional Economics (NIE) terminology, the shaping of a MIPP can be described as laying the basis for founding a new institution consisting of a network of contracts (Erlei et al. 2007: 65).

Complex project contracts are unavoidably incomplete (Williamson 2008: 46; Schuhmann 2013: 25), underlining the importance of allocating tasks and the corresponding risks to contract parties according to their core competences and experience.

Every situation for shaping a MIPP is unique, and so are its participants. For purposes of simplification, a “standard situation” is defined where the parties involved are equipped with the following core competencies:

Order contract party	Core competences	Allocated risk, No.
Owner (O)	Main investor and sponsor of the project. Will be operating the plant. Competent to make the business case for the project, including supply, offtake, and financing. Has local know-how, including experience with local construction & erection firms.	1,2,3,4,5, *6 (partially)*[11]
Suppliers (S) of (Main) Equipment	Process, Utilities & Disposal, Storage & Materials Handling equipment, BoP supply	*6 (partially),* 8,9 (for their scope)
Construction & Erection companies (C), (E),	Knowledge of local construction standards, experience in erection/ repair of process plants	*6 (partially),* 8,9 (for their scope)
General Contractor (GC)	Engineering, procurement and construction services experience, including services for supervision, commissioning and start-up. Project development, management and, ideally, financing know-how, reputation and experience. Financial strength to assume liability for the performance of the plant.	***6 (partially),* 7,8,9**

Table 2: **Core competences of order contract parties in a MIPP "standard situation"**

4.4 Make or Buy (Contracting Out) Decisions for MIPP

MIPP - like any project business - is characterized by a high degree of discontinuity in economic relations between the supplier (GC) and the customer (O). A customer from a developing nation who wants to be equipped, for instance, with a power plant or a refinery will not buy the same type of equipment for many years (or even decades) to come (Cova et al. 2002: 20).

Walker and Weber found that for production, comparative production costs in conjunction with buyer production experience are the strongest predictor of make-or-buy decisions (Walker and Weber 1984: 373). This can also be applied to a MIPP, where, unlike the GC, the owner has typically limited MIPP experience, ordering a major industrial plant only very rarely. Consequently, the owner has no or limited incentive to build up own GC capabilities.

[11] For suggestions on how to define and deal with *force majeure (a concept similar to that of 'frustration' in English law)*, see, for example, FIDIC Conditions of Contracts for EPC/Turnkey Projects: pp. 50-52.

4.5 Order Contract Forms for MIPP - Overview

To shape and realize a MIPP involves various national and international parties, drawing up numerous, partially interrelated contracts and agreements (Brockmann 2009: 189; Widmann 1977: 22; Yescombe 2002: 105ff.).

This research is focused on the main **order contract**[12] for a MIPP, which, in simplified terms, involves the following **parties**:

- **Owner (O)** – main investor and sponsor of the project. Will be operating the plant.[13]
- **Suppliers (S)** of Main Equipment – Process, Utilities & Disposal, Storage & Materials Handling
- **Construction & Erection companies (C), (E),** and - as applicable - a
- **General Contractor (GC)** or a **Managing Contractor (MC).**

The following order contract forms are relevant to a MIPP as defined above:

I. **Owner-managed:**
   a. By units: on av. 3-5 units/packages
   b. By lots: >100 (sub)suppliers
   c. Combined units and lots.[14]

II. **Managed on behalf of the Owner (EPCM):**
   a. By units: on av. 3-5 units/packages
   b. By lots: >100 (sub)suppliers
   c. Combined units and lots.

III. **Using a General Contractor (EPC):**
   a. EPC – Engineering, Procurement, Construction Contract
      I. Lump-sum Turnkey (Fixed-Price)
      II. Reimbursable
   b. EP(CM)– Engineering, Procurement, and Management/ Supervision of Construction.

In practice (unique tailor-made solutions), there are deviations and combinations of these forms, e.g. „**EPC+**“ (EPC plus equity participation by the General Contractor), and various mixed forms.

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[12] The order contract is also known as the *construction contract* or the *EPC contract* (cf. Yescombe 2002), however naming it *order contract* opens our views to its different forms.
[13] Using this assumption, BOT, BOOT and similar arrangements – which, for major industrial projects, rarely function as advertised – are being excluded from the analysis (c.f. Flyvbjerg et al. 2002: 93–5; Merrow 2011: 20).
[14] For example, the owner procures packages of main equipment, but takes care of BoP himself.

"The process of contracting needs to be studied in a real-world setting." (Coase 2008: 38)

5 Order Contract Forms for MIPP – Evaluation

5.1 Owner-Managed

The Owner prepares the engineering design package using either in-house resources or an external engineering firm[15] and takes care of the project's financing. The owner then divides the project into separate tasks and identifies subcontractors for each task.

This can be done by subcontracting plant units (e.g. 3-5 units plus BoP), lots (over 100 suppliers) or combining units and lots. The owner hires all subcontractors separately and directly on his own behalf and at his own risk.

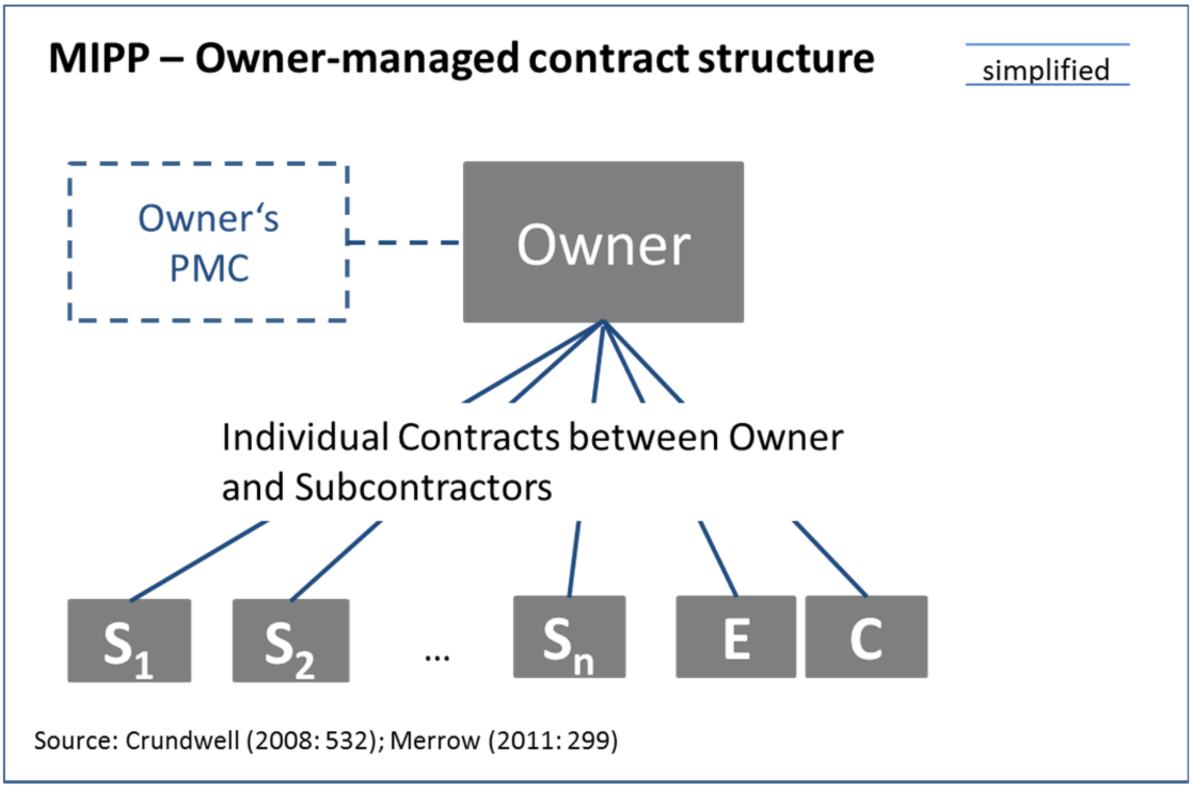

Figure 2: **MIPP Owner-managed Contract Structure**

Advantages of this approach include

- Owner is directly involved in the realization of the project, manages the tasks of coordination and supervision of subcontractors himself (PMC may support)
- Owner-managed approach can save cost **if owner has experience in and capacities for managing such projects**

[15] E.g., a PMC… Project Management Consultant - the owner's design (and management) function, or a FEED (Front End Engineering Design) contractor.

Disadvantages include

- Owner has contractual relationships with many subcontractors, assuming responsibility for the work of contractors until completion and carrying the risk for the performance of design
- Owner carries supply chain solvency risk - one failing subcontractor may result in a domino effect, jeopardizing the execution and completion of the project on time and in budget
- Owner bears interface/ coordination risk: technology of different suppliers may not fit together or even harm each other
- Owner must possess extensive know-how , expertise and capacity in full-scale MIPP realization
- Additional costs may occur (e.g. owner's contingencies, insurance)
- Limited financing options (lack of a neutral due diligence)

Completion and performance of design risks remain with the **Owner.**

Examples of successful use

The owner-managed contract form should be used if (and only if) the owner has extensive experience in managing MIPP as well as the financial strength to finance it. Ideally, the owner will have own resources to design the plant and established relationships to key component suppliers. Another advantage would be if the MIPP would be located in the owner's home market.

Captive fossil-fuelled power plants of major German utilities (**E.ON, RWE**) built in Western Europe are examples. Both E.ON and RWE possess own engineering divisions with the ability to design coal-, oil- or gas-fired power plants in-house. Both have several decades of experience in managing power plant construction projects[16] including long-term relationships with suppliers of core components like large gas and steam turbines.

[16] An overview of E.ON's existing power stations, upgrading projects and new construction projects can be found on http://www.eon-kraftwerke.com/pages/ekw_en/E.ON_Kraftwerke/Locations/index.htm; an overview of RWE's references on https://www.rwe.com/web/cms/en/1790996/rwe-technology-the-power-plant-specialist-in-the-rwe-group/construction-projects/new-build-projects/references/.

5.2 General Contractor: EPC, lump-sum turnkey

The Owner hires a General Contractor to provide all engineering, procurement and construction services including services for supervision, commissioning and start-up. The EPC-Contract is often concluded on turnkey and lump sum basis, meaning the GC is responsible for the construction of the MIPP until start-up and including performance test**.**

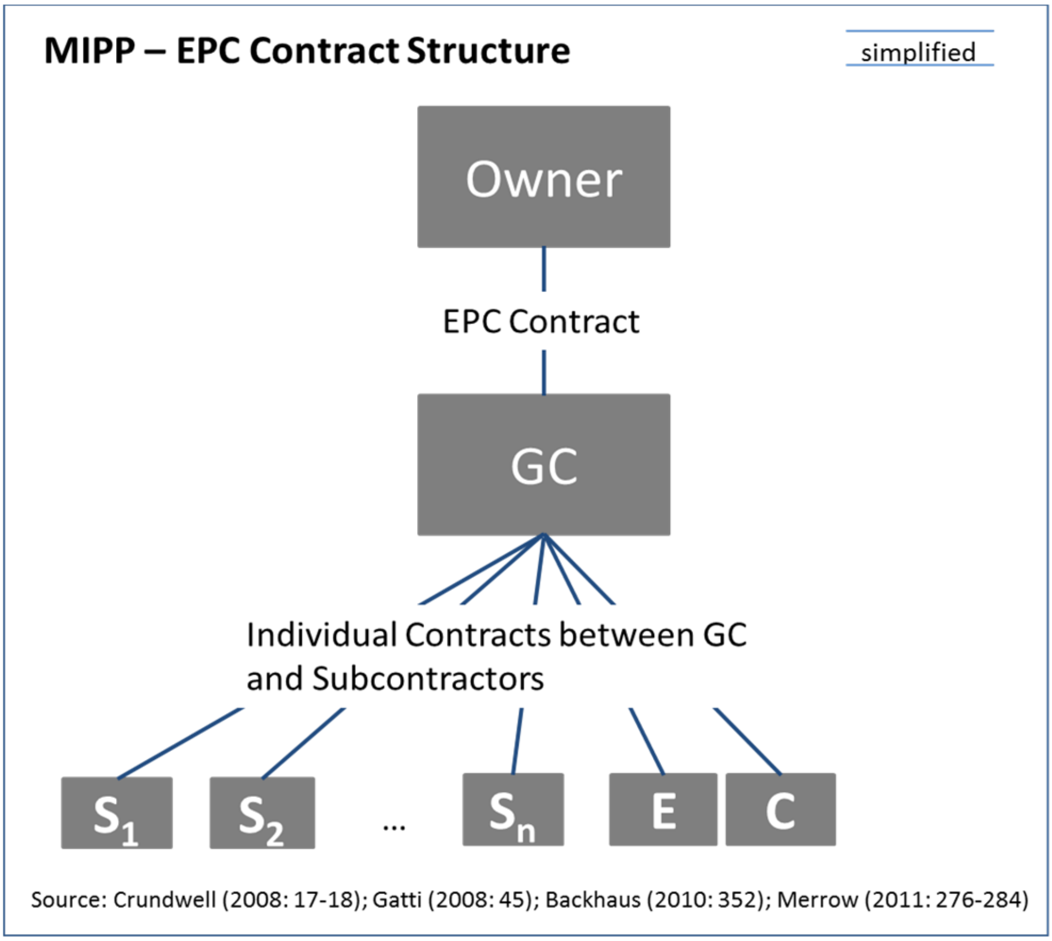

Figure 3: **MIPP EPC Contract Structure**

Advantages of this approach include

- GC offers a “one-stop-shop”/ a single contact point to the Owner
- Owner has only one direct contractual relationship, avoiding many possible disputing conflicts with various subcontractors
- Using EPC LSTK, GC bears the risks for completion and performance-of-design meaning:
    - GC guarantees total price, start-up date, quality and operability
    - GC bears supply chain solvency risk
- EPC typically is a precondition for project financing (most “bankable” approach)
- Standardized documentation/ low administrative burdens for Owner
- Owner can focus on his core business

Disadvantages may include

- Only a limited number of firms possess the required financial strength, know-how and experience to provide EPC services
- Owner does not have contractual relationships with sub-contractors, meaning:
- Owner is not involved in full details during the realization phase
- Cost - Owner has to pay an EPC-fee[17]
- Owner's dependence on EPC-contractor; Inflexibility.

Completion and performance of design risks are transferred to the **GC.[18]**

Examples of successful use

The **EPC lump-sum turnkey** contract with an experienced and reliable contractor is the preferred option for project financiers and lenders (Nevitt and Fabozzi 2000: 17; Gatti 2008: 45–48). IPA data show that EPC lump-sum is the most frequently used contract type for industrial megaprojects and its success rate is above average, second only to what Merrow calls "mixed contracting" (Merrow 2011: 258–60).

EPC lump-sum is also the one most frequently used form for MIPP according to VDMA estimates (Gottwald 02/15/2013).

There are many successful examples for the use of this contract structure. The following two are mentioned for the reason of their special features.

For the 1,200 MW combined-cycle power plant in Ribatejo, Portugal, a **GC was formed by a consortium** consisting of **Siemens** (supplier of core power train equipment) and **Ferrostaal** (an experienced EPC contractor). The state-of-the-art natural gas-fired power plant has been in operation since 2006 (Ferrostaal GmbH 6/2012: 13).

A second example, using the special contract form **EPC+** is the M5000 Methanol Plant in Trinidad. It is the success story of a winning team: in the 1980s, Lawrence Duprey, today CEO of Methanol Holdings Trinidad Limited (MHTL) had the idea of setting up the first privately owned methanol plant in Trinidad. To put this idea into reality, he had to find a GC who could undertake two key functions: the project development and management for the construction and financing of this MIPP.
Together, MHTL and Ferrostaal developed an innovative financing model and a business concept that changed the traditional role of the GC in a MIPP. This concept provided not only for the transfer of the turnkey plant to the owner, but involved Ferrostaal as investor and shareholder[19], accompanying the plant's economical operations over its whole lifetime. The plant, producing 5,000 metric tons of Methanol per day, has been operated by MHTL since 2005. (Ferrostaal References, 2 May 2013)

[17] The EPC fee typically consists of a overhead fee plus a contingency fee for the risk plus a profit margin for the GC. By sharing some of the cost estimate risk with the owner, the risk contingency and thus the EPC fee may be lowered (Schuhmann 2013: 26).
[18] This is the intention of using a fixed-price LSTK contract.
[19] Since 1992, Ferrostaal has acted as a GC and co-investor in seven major chemical plants in Trinidad (Ferrostaal GmbH 6/2012: 12).

5.3 Managed on behalf of the Owner: EPCM

EPCM stands for Engineering, Procurement and Construction Management.
Like for the owner-managed approach, the plant is designed by the Owner. The Owner hires a managing contractor (MC) on the basis of an EPCM contract. The MC manages the realization of the project on behalf of the owner.

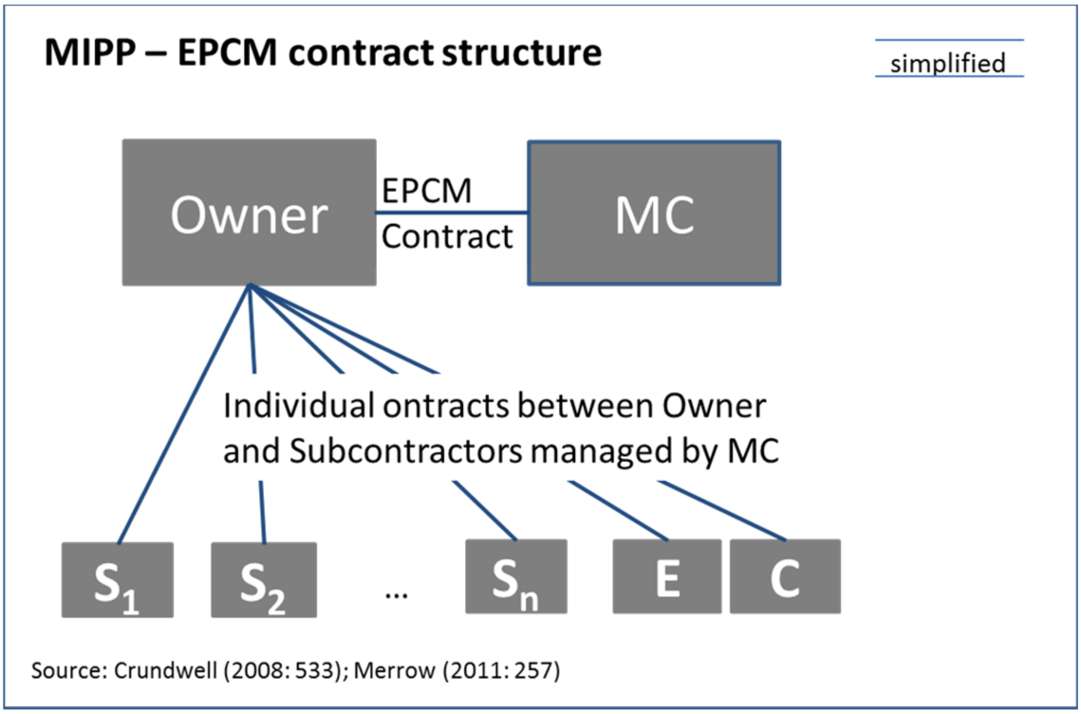

Figure 4: **MIPP EPCM Contract Structure**

Advantages of this approach include

- MC unburdens Owner of tasks of coordination and management of subcontractors
- Owner is directly involved in the realization of the project and assumes responsibility thereof
- EPCM can save cost vs. EPC approach (smaller fee)
- Flexibility – design changes can be accommodated more quickly

Disadvantages include

- Owner has contractual relationships with many subcontractors, assuming responsibility for the work of contractors until completion and carrying the risk for the performance of design
- No or limited liability of the MC for work of subcontractors or interface risk (any financial remedies are limited by the EPCM fee)
- Owner carries supply chain solvency risk - one failing subcontractor may result in a domino effect, jeopardizing the execution and completion of the project on time and in budget

- Owner should possess skills and resources of MIPP realization
- Complex documentation, limited financing options
- Additional costs may occur (e.g. owner's contingencies, insurance)

Completion and performance of design risks remain with the **Owner.**

Examples of successful use

Due to the fact that in an EPCM contract, no risk is actually passed from the Owner to the contractor (MC), EPCM contracts are often carried out on the basis of long-term relationships between the Owner and the contractor, based on the reputation and experience of the MC. EPCM is common practice for the major North American engineering contractors[20] and used in the Americas, as well as many parts of the Middle East and Asia.

Foster Wheeler was awarded an EPCM contract for the World's largest EPDM rubber facility in November 2012. The new facility is designed to produce 160,000 tpy of ethylene propylene diene monomer (EPDM) rubber. The plant is expected to start up in 2015. LANXESS, a leading Chemicals company headquartered in Germany, states that this new plant, which it describes as the largest EPDM rubber facility in the world, is its largest investment in China to date. "Foster Wheeler is working as the EPCM contractor on three of LANXESS' major projects in Asia." (Foster Wheeler 2012) "We are pleased to **strengthen the successful relationship** with Foster Wheeler in order to continue to jointly and safely implement the LANXESS growth strategy in the Asia Pacific region," said Carsten Kopke, project director, LANXESS Asia Pacific. (BusinessWire October 12, 2012)

In September 2012, Fluor Corp. was awarded an EPCM contract by the Dow Chemical Company for a propylene production asset project in Freeport, Texas. Fluor successfully completed the front-end engineering and design (FEED) contract thereby setting the stage for this next-phase EPCM project award. "Fluor is excited to be the EPCM contractor for the successful execution and completion of this project," said Peter Oosterveer, president of Fluor's Energy & Chemicals Group. "The U.S. is experiencing a significant rebound in the petrochemical sector due to the attractive price of shale gas and we look forward to helping our **long-time customer** Dow realize this important project." The project is under way with estimated mechanical completion by 2015. Earlier in 2012, Fluor and Dow signed a Strategic Global EPC and Construction Management Agreement in support of Dow's global capital projects program. This includes potential new project work spanning across the globe. (Fluor Corp. 14 September 2012)

[20] E.g., Bechtel, Fluor, Foster Wheeler, Jacobs Engineering, KBR, SNC-Lavalin.

5.4 Deviating Forms

5.4.1 General Contractor: EP(CM) or split EPC

Asked about deviating forms, 23 experts mentioned the EP(CM) contract structure. This contract is a combination of the EPC and owner-managed approaches. The Owner hires a GC to provide engineering, procurement on a lump sum fixed price basis including management and **supervision services** for construction & erection plus commissioning and start-up.

Onshore civil and erection companies are contracted by the Owner but managed by the GC on the Owner's behalf. By choosing the EP(CM) contract form, the GC can avoid liability for the particularly high-risk onshore civil construction (Jacob et al. 2011: 344-45; 358-61) and erection works in Emerging Markets.

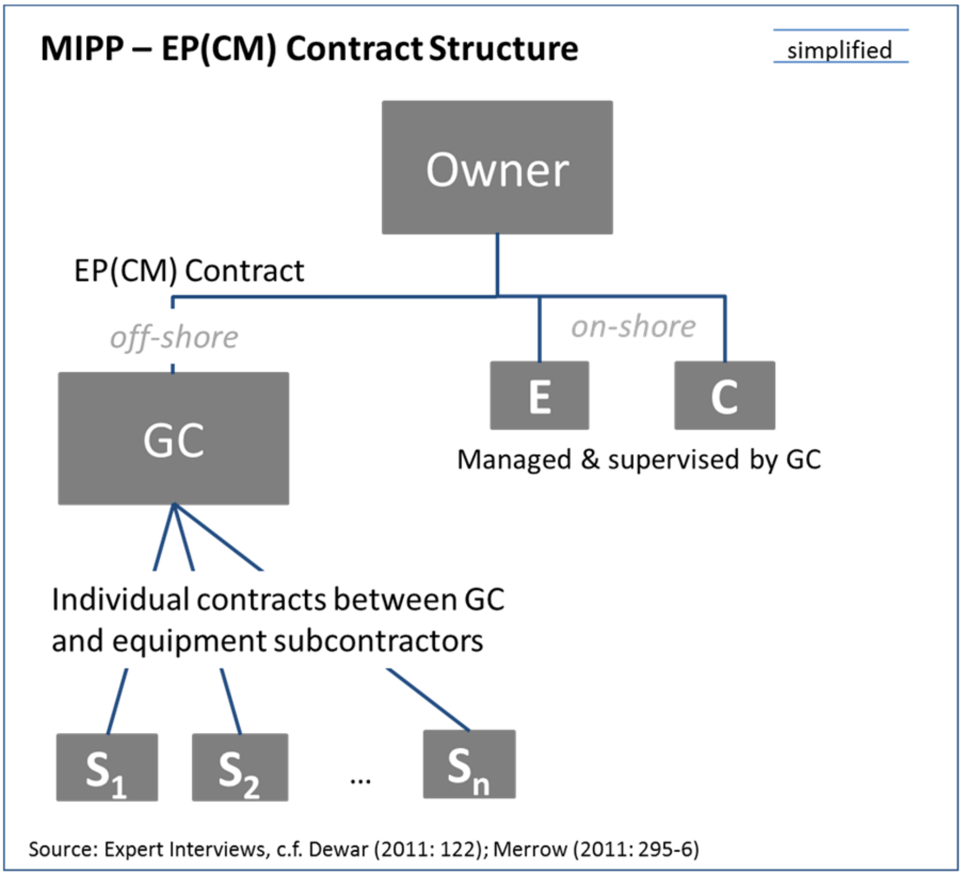

Figure 5: **MIPP EP(CM) Contract Structure**

A comparable approach, mentioned by 27 of the interviewed experts, and described in the Project Finance literature (e.g. Dewar) is the **split EPC** structure. It comprises three separate contracts: (1) **onshore** contract for local services and material (usually civil construction & erection plus some local procurement), (2) **offshore** contract (planning incl. financing, basic and detailed engineering design, procurement & supply of main process equipment), and a (3) **coordination**

agreement, which secures full responsibility for the entire EPC package (Dewar 2011: 122).[21]

Advantages of the EP(CM) approach include

- EP(CM)-Contractor (GC) manages the offshore part and Owner manages the local part with support of the GC, creating a working partnership
- Owner has only two or three contractual relationships with contractors
- Owner is involved in the implementation of the project to a certain extent (onshore, Construction & Erection)
- Owner can handle the local contractors better than the GC
- EP(CM)/ split EPC can save cost versus EPC (smaller fee)

Disadvantages include

- Completion risk for Construction & Erection remains with the owner
- Owner has to possess Construction & Erection competence and capabilities, ideally a captive construction company
- Owner gets involved in the project's realization

Completion and performance of design risks are transferred to the **GC** for the offshore (Engineering, Procurement) part while the onshore risks of Construction and Erection remain with the **Owner.**

Examples of successful use

EP(CM) or split EPC is used for MIPP with the intention that the onshore contractor(s) (for EP(CM): managed by the Owner) and the offshore contractor (the GC) will together be liable on the same basis as if there had been no split of the contractual arrangements (Dewar 2011: 121–2). Thus, a close working relationship is established between the Owner and the GC.
IPA data show that mixed contracting, which may be described as an in-sequence form of EP(CM), has the highest success rate of contract forms for industrial megaprojects (Merrow 2011: 260).

The realization of Europe's first hot-briquetted iron (HBI) plant, LebGOK-I located in Western Russia, is an example for a working partnership between a German GC (consortium) and a Russian construction and erection company (Rudstroy, design by Tsentrogiproruda). German and Russian engineers closely cooperated already in the engineering design phase. The GC took care of the offshore equipment supply, employing HYL technology, and ECA (Hermes) covered financing, while the Owner, LebGOK, took on the onshore (i.e. local construction & erection) tasks. The plant, with an installed capacity of 1 million tpy of HBI, went into full operation in 2001. (Ten 2007: 44–5)

[21] Merrow terms an in-sequence-subform of EP(CM) as "Mixed Contracting". It involves separate contracting of engineering and procurement services on a reimbursable basis followed by lump-sum civil & erection works with a construction organization. It is employed most frequently in petroleum development and Chemicals. In Mixed Contracting, construction management must stand alone and not be subsumed by the engineering contract (Merrow 2011: 295–6).

5.4.2 Mixed Forms

Particularly large, multi-billion Dollar TIC MIPP, which can be classified as industrial mega projects may require mixed forms of contract. Two examples are mentioned below.

I. Owner-managed, EPC and other contract forms - Yanbu Export Refinery Project (YERP).

This USD 8.5-10 bn project is jointly owned by Saudi Aramco and Sinopec of China, two major oil corporations, forming the Owner "Yanbu Aramco Sinopec Refining Co. Ltd." (Dow Jones Newswires 14 January 2012).
In January 2006, the base configuration and preliminary engineering began together with the initiation of the selection process for the contractor and process technology licensors. The FEED Contract was awarded to KBR (Houston).

The Owner awarded the following EPC contracts for the major process units:

EPC Contractor	Process Unit
Tecnicas Reunidas	Coker Package
Saudi Services	High Voltage Electrical Package
SK Engineering and Construction Co.	Crude Package
Dayim Punj Lloyd	Offsite Pipelines Package
Daelim	Gasoline Package
Daelim	Hydrocracker Package
Rajeh H. Al-Marri	Onsite Pipeline Relocation Package
ENPPI	Tank Farm Package

***Table 3:* EPC contract awards by Yanbu Aramco Sinopec Refining Co. Ltd.**
Source: EPCengineer

The site preparation contract was awarded to Abdulrahman Al-Shalawi Establishment. Other packages awarded at a later date included the Solids Handling package awarded to Techint and the Jetty package awarded to China Harbour (EPCengineer 24 September 2012).

II. Owner-managed, EPCM and other contract forms- Sadara.

Sadara Chemical Co. (the Owner), a JV between Saudi Arabian Oil Co. Aramco) and Dow Chemical Co., is a USD 12.4 bn Chemical plant project being constructed in Jubail Industrial City in Saudi Arabia (Bloomberg News 31 May 2012).

Construction work on the project has started by end-2012 and is scheduled to be completed by early 2015. The fully integrated complex is planned to consist of 26 chemical manufacturing units and will be one of the largest of its kind in the world. Sadara will produce polyeurethanes, propylene oxide, propylene glycol, elastomers, linear low-density polyethylene, low density polyethylene, glycol ethers and amines (EPCengineer 05 November 2012).

The Owner's awarded contracts include but are not limited to:

Type of Contract	Contractor	Plant Unit
EPCM	Fluor Corp.	utilities and offsites
EPCM	Jacobs Engineering Group Inc.	Chem-I
EPCM	Foster Wheeler AG	propylene oxide (PO) unit
EPCM	Jacobs Engineering Group Inc.	three polyethylene trains
EPC LSTK	Maire Tecnimont S.p.A.	manufacturing plant
EP	Foster Wheeler AG	Packaging center
EPC	Técnicas Reunidas	Chem-III (plants for six different products)

***Table 4:* Contract awards by Sadara Chemical Co.**
Source: EPCengineer

Although both of the above-mentioned mega projects use various forms of contract, the original form can be understood as owner-managed.

6 Discussion and Critical Reflection

MIPP uniqueness and differing legal systems

The uniqueness of each major industrial plant project and differing legal systems around the world make it difficult to give generally and globally valid statements on MIPP order contract structures. This research provides a high-level strategic view aiming to omit juridical details, be it general or particular contract conditions.

Majority consensus/ European bias

In this research, expert interviews were conducted in a streamlined and process-oriented way as described in Chapter 2. Nonetheless, MIPP experts came up with approving to the larger picture as well as divergent opinions for details of the given concepts, the advantages and disadvantages of certain contract structures. Consequently, the results presented in this research represent a **majority consensus.**
The interviews were conducted among MIPP industry experts located in Western Europe/ Continental Europe. Although the majority of the corporations are active internationally, the results of the interviews may be **biased towards a Continental European point of view**.

Reimbursable vs fixed price, and incentive schemes

The above evaluation of EPC and EP(CM) contracts, stating that risks are transferred from the Owner to the GC is assuming a **fixed-price**, i.e. lump-sum turnkey (LSTK) approach. Payment is received either when the GC has substantially completed the works or by installments according to a payment schedule (Jaeger and Hök 2009: 72).
Under a **reimbursable** scheme, the GC is reimbursed based on the quantity of services and materials provided. Some reimbursable contracts include **incentive schemes** like Guaranteed Maximum Price (GMP) and Target Cost Contracts (TCC) aiming to allow the Owner to share losses and gains with contractor(s) (IChemE 2007: 2; Chan et al. 2012: 6). Chan, Lam et al indicate that these schemes may bring benefits for certain civil construction projects (Chan et al. 2012: 11–8). However, for industrial megaprojects, and MIPP alike, incentive schemes have made projects harder - rather than easier - to execute (c.f. Merrow 2011: 285-288).

In any case, payment and incentive schemes have not been covered in this research which is focused solely on main order contract forms.

Contract structuring vs contract implementation

Finally, an important issue not considered in this research is the **implementation of the contract**. For instance, if an Owner chooses an EPC LSTK contract, and the GC goes bankrupt during the execution of the project, risk transfer may not be realized as intended in the contract.

7 Conclusion

In this research, a major industrial plant project (MIPP) is defined as a larger than USD 100 million process plant(s) endeavor with more than 50% of Total Investment Cost (TIC) attributable to engineering and process equipment, including over 100 suppliers taking min. 1 year to plan and 2-5 years to execute. The main order contract for a MIPP involves the owner, different kinds of contractor(s) and suppliers as applicable. The key risks for a MIPP are completion and performance of design risks.

"It is obviously desirable that [property] rights should be assigned to those who can use them most productively and with incentives that lead them to do so..." (Coase 2008: 37).

The same is true for allocating the tasks and associated risks to the MIPP order contract parties: In the planning phase of the project, a thorough analysis of the owner’s competences and experience helps to match the order contract to the specific MIPP situation.

If the “standard situation” occurs, where the owner has no or limited experience in planning and executing a MIPP, completion and performance of design risks should be allocated to an experienced and reliable general contractor (GC) under a LSTK **EPC** contract. The GC may act as a co-investor in the project (**EPC+** contract), giving him even more incentive to make the MIPP a success.[22]

EPC is the preferred contract approach for project financiers.

If no adequate GC is available on the market, a managing contractor (MC) can be hired under an **EPCM contract**. Since typically no risk is actually passed from the Owner to the contractor, EPCM contracting is often used on the basis of a long-term relationship with a reputable contractor.

In case the Owner possesses own construction & erection know-how and experience, these local (onshore) services can be excluded from the general contract on the basis of a **EP(CM)** or *split EPC* contract. Completion and performance of design risks are transferred to the GC for the offshore (Engineering, Procurement) part while the onshore risks of Construction and Erection remain with the Owner.

If and only if the Owner possesses MIPP planning and execution competences, experience and capabilities, the pure **owner-managed** approach should be used.

Multi-billion dollar industrial mega projects may require mixed forms of contract, e.g. a mixture or sequence of owner-managed, EPC and other contract forms, by which the project is divided into manageable packages. These mixed forms may be classified as sub forms of the owner-managed approach.

[22] It is also possible to form a GC of two or more firms, which will jointly be able to guarantee the MIPP’s performance, e.g. by joint and several liability for completion and performance of design risks for the project.

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