Introduction

Hydropower projects are key in the world’s further development of renewable energy. They are hugely variable in ownership, size, complexity and cost, and require a wide variety of procurement routes and contracts for their successful execution.

The Employer will not always have a free hand in selecting the procurement route or the types of contract and/or particular terms. Any funders will have their say. There is likely to be a conflict between a desire for price and time certainty and the desirability of a balanced risk allocation, lowest cost, and/or the shortest time for construction.

There may be a desire to pass risk to the Contractor under a design and build contract or perhaps a design build and operate contract, but then a reluctance to allow the Contractor to carry out the work in the manner he has chosen and priced. Insurance, particularly for tunnelling works, may only be available if the Employer has followed best practice in the assessment and evaluation of ground conditions, and uses of a form of contract with proven suitability regarding the allocation of risks to the parties. There may also be a limit to the management resources that the employer can afford or may be willing to deploy for tender preparation and contract management.

Most contracts funded by International Funding Institutions (IFIs) have traditionally been carried out using the contracts recommended or required by them. These were typically FIDIC contracts and/or design and build contract forms specifically designed for mechanical and electrical works.

The NEC (formerly the New Engineering Contract) was drafted in the late 1980s in the UK with some international input from organisations and individuals involved in the power generation sector. It was sponsored and published by the UK’s Institution of Civil Engineers (ICE). The NEC forms of contract, specifically designed for clarity, flexibility and to stimulate good management are now extensively used for infrastructure in the UK and South Africa. Use is growing in New Zealand and in Hong Kong, where, after trial projects, the NEC is mandated for government construction projects in 2015. Some IFIs are now taking an interest in the NEC. NEC contracts have been used successfully for hydro contracts at least in the UK and New Zealand, including for maintenance and refurbishment works on existing plant.

This paper first describes the key features of hydropower projects and some of the key requirements for the contracts for those projects. It then uses the results of a survey to demonstrate what users of contracts in the hydropower sector want from their contracts and how NEC matches these requirements. The paper goes on to describes what makes NEC contracts different from FIDIC and other standard forms, how they can be used in the hydro sector and why they should be at least considered for any hydro project.

1. Key features of hydropower projects

Hydropower projects are subject to a range of challenges that in turn give rise to particular requirements of the contracts used to help deliver them. This section focuses on new hydropower projects but most of the characteristics also apply to maintenance and refurbishment works on existing plant and structures.
1.1 Nature of the work
Hydropower projects are bespoke. There is little replication and all need careful and individual planning. They tend to involve multimillion dollar contracts with high risks and potential rewards for contractors. They involve a wide range of infrastructure and are very much multidisciplinary. Projects are likely to include:

- dams
- tunnels
- power stations
- turbines
- generators
- switchyards
- transmission lines

and supporting
- roads
- buildings
- utilities
- control systems

1.2 Location and materials
Hydropower projects are usually in remote and mountainous locations requiring the provision of utilities and the establishment of significant office facilities and accommodation for staff and labour. Transportation links are often poor and need to be improved or sometimes created from scratch to provide access for people and materials. The scale of the projects is such that key materials usually have to be produced on site, requiring quarries, crushers, batching plants and delivery systems for concrete and processing and transport facilities for earth fill, rock fill and filter material. Construction equipment often has to be imported. Skilled labour often also has to be imported and local labour trained up to meet the requirements of the operations needed. This leads to risks for any contractor and difficulties in estimating the productivity of his labour and the level of supervision required.

1.3 Physical environment
Hydropower projects are often in harsh environments. The weather is often extreme and presents risks to the workforce, construction, maintenance and operation activities. Ice plants may be needed to keep concrete temperatures down. Poor weather will at least have significant impacts on productivity. Hydropower projects are also often in highly seismic areas. This presents difficult decisions in relation to the appropriate return period of earthquakes to be designed for and exactly how earthquake resistance can be achieved.

1.4 Geology
Hydropower projects almost always involve significant underground works for dam and power station excavation and for tunnels. The permanent excavation may be definable but it is typical to make the contractor responsible for the temporary excavation, dewatering and drainage. There is a potentially complex overlap between support requirements for the permanent situations and for the temporary works. The typical remoteness of the site makes quality site investigation expensive and clients are sometimes not able to (or choose not to) invest sufficient resources in such investigation. This applies to the site of the permanent works and particularly to potential quarry and borrow pits. In unpredictable conditions it is can be very difficult for bidders to plan construction equipment and to predict progress and productivity for excavation and tunnelling. On the other hand, for tunnelling in particular, insurers require that a thorough geotechnical baseline report (GBR) is carried out (Patterson and Essex, 2010).

1.5 Programme, seasonality and interfaces
Projects often need a cofferdam and temporary river diversion arrangements for dam construction. These are heavily subject to the variation in flows in the river and sometimes put significant limits on the available ‘windows’ for construction. The weather itself can do likewise. The timing of impoundment to allow commissioning and so
commercial operation is heavily dependent on the seasonality of river flows. The project will always be driven by the desire for power production and revenue. Attempts to protect the client from the effect of delays to that revenue can lead to the inclusion by clients of very high delay damages, adding further risk to any contractor. The timescale for the manufacture of the significant mechanical and electrical equipment and built-in parts also has significant programme implications. The dam has to be constructed and at least partially impounded and tunnels have to be completed in order to provide water to commission the turbines and generators. In the hydropower station the detailed interfaces for example between the civil and the mechanical and electrical works are critical and numerous.

1.6 Complexity of equipment specifications
The mechanical and electrical equipment required are subject to a number of requirements and constraints including:
- a growing size and installed capacity of units
- rapid start and stop requirements
- often a wide range of operating conditions (head and flow)
- high efficiency requirements (often backed up by performance damages)
- the need to design for ‘runaway’ conditions
- a requirement to resist erosion by sediment in the water.

The result is the need for very detailed specification of the requirements and constraints of the mechanical and electrical equipment.

1.7 Quality
The nature of hydropower projects presents particular challenges to the control of quality. Geographically dispersed sites makes supervision difficult, onsite materials production brings its own problems and the ‘one off’ workforce often needs extensive training to achieve the required quality. The off-site manufacture of equipment brings a need for factory visits and tests and inspections.

1.8 Health and safety, environmental and social
Hydropower projects are subject to most of the health and safety risks associated with any major construction project. They are subject to gradually increasing owner requirements for better attention to health and safety. This is sometimes driven and enforced by the requirements of any IFI supporting the project. This is also the case with environmental and social issues. Hydropower projects of course produce ‘green energy’ but always have many significant environmental impacts including large spoil disposal requirements, siltation from excavations, high traffic movements and changes to access routes in the area affected by the project. Often the required new or improved roads to the distant site bring major environmental and social impacts of their own. In particular hydropower projects often have requirements for relocation of local people and the large use of imported labour can have a number of social effects.

1.9 Country risks
The international nature of hydropower projects brings a number of ‘country’ challenges including:
- work permits and licenses
- local regulations
- import difficulties
- local legal issues
- language – for contracts, documents and communication.
- safety and security issues
2. Procurement options

The scale and nature of the civils and electrical and mechanical works in a hydropower project mean that very different organisations are normally appropriate to carry out each aspect. A key procurement decision is how to get those organisations in place on the project.

2.1 Split packages for the project

It is traditional, typical, but of course not essential, for the civil work to be primarily designed on behalf of the employer and let on a remeasurement basis to a contractor. If this is the case, the employer takes the risk of the quantities required. On the other hand the mechanical and electrical work is typically designed by a contractor to performance requirements in ‘design and build’ (D&B) contracts, sometimes referred to as ‘engineer, procure and construct’ (EPC) contracts. In many cases these contracts will include guaranteed efficiencies that may be backed up by pre-determined performance damages. Such contracts are very expensive to bid not least because of the need to carry out significant design to firm up what is typically a lump sum price required by the employer. If the employer chooses to split the work in this way he has to manage the physical and time interfaces between the contracts. These interfaces must be set out very clearly in all affected contracts.

2.2 Single contract for construction of the project

For some projects the employer may choose to pass on the interfacing risks and so increase his time and price certainty by employing a single EPC contractor for the project. If this is the case, the very different organisations required normally means that contractors will have to form a joint venture to bid for the project. Subcontractors for some of the smaller elements of the works will be appointed to bring into the ‘team’ organisations that are not able to share the risk of the joint venture. Such joint ventures are often led by a civil contractor with experience in coordinating the work of the other partner(s). But such joint ventures are difficult and risky as the partners often do not really understand each other’s risks and may need to set up side agreements to allocate the risks between the parties, despite the ‘joint and several’ liability always required by the EPC contract. This approach is not common in hydro simply because of the scale and risk of each of the civil and mechanical and electrical components.

2.3 Making the contractor responsible for operation

If the employer wants to make the contractor responsible for operating the hydropower project and so be incentivised properly to take into account the net present cost of construction and operation in his design, he could use a design build and operate (DBO) contract. Given that a hydropower project will bring in revenue above the operating costs, the contractor will want the employer to guarantee that he will take and pay for the power made available.

2.4 Design, build, finance and operation (DBFO)

Of course, the further shift of risk to the contractor is the DBFO arrangement where the contractor borrows from lenders to finance the construction and the employer pays for power only when delivered. This is often also known as a public private partnership (PPP) and has been used for a number of hydropower projects. In some cases this is taken further to a full ‘concession’ where the employer gives the contractor the right to use the site and construct the project: the contractor is then responsible for getting payment from a third party, normally the operator of the national grid network.

3. Features of contracts likely to be use for hydropower projects and how the NEC performs

The following features are needed to meet the requirements set out above. They were tested for importance with users in an online survey. Links to the survey were provided on the websites of the International Hydropower Association and Water Power and Dam Construction. 24 valid survey responses were received.

83% of respondents were involved in the procurement of contracts for hydropower, and 88% were involved in the delivery of projects in the hydropower industry. 75% had ten years or more of hydropower experience, 46% each were consultants or clients, with the remaining 8% being contractors or subcontractors.
3.1 Use of NEC forms

83% of survey respondents said they were aware of NEC, 32% have used it, and 38% have received some NEC training.

Respondents indicated they have used NEC primarily for hydropower contracts, with a small number using it for building, transport, civil works and heat pump projects.

Respondents were asked to consider the highest value project in which they had been involved using NEC. Works included major construction works, several small-scale hydro projects, turbine refurbishment, plant upgrade, and plant and facilities maintenance services, were all based in the UK or New Zealand and varied from less than £100k (Euro 140k) to more than NZ$10 million (Euro 5m). Clearly the particular respondents had not used NEC for very high value contracts.

The projects used a variety of NEC forms (See Table 2):

- 5 used the Engineering and Construction Contract (ECC) (NEC (2013a))
- 3 used the Engineering and Construction Short Contract (ECSC) (NEC (2013b))
- 2 used the Professional Services Contract (PSC) (NEC (2013d))
- 2 used the Professional Services Short Contract (PSSC) (NEC (2013e))
- 1 used the Engineering and Construction Subcontract (ECS) (NEC (2013b))
- 1 used the Engineering and Construction Short Subcontract (ECSS) (NEC (2013c))

Respondents were asked about the use of standard and bespoke forms. 46% use only standard forms and 54% use a combination of standard and bespoke forms.

50% of respondents agreed that the type of contract used within their organisations are determined are determined by third parties such as funders.

29% had a requirement for contracts in languages other than English. Four required Spanish, two required French and Chinese, with one each requiring Farsi, German, and Welsh.

3.2 Forms used in the last five years

Respondents were asked to consider their forms of contract used in the last five years.

3.2.1 For mechanical and electrical hydropower works:

- 13 used the FIDIC ‘Yellow Book’ (FIDIC (1999a))
- 9 used bespoke forms
- 7 used the FIDIC ‘Silver Book’ ((1999b))
- 6 used the FIDIC ‘Red Book’ ((1999c))
- 6 used World Bank standard forms
- 6 used the NEC
- 6 others used Asian Development Bank (ADB), International Chamber of Commerce (ICC), or national industry forms

3.2.2 For civil hydropower works:

- 12 used FIDIC Red Book
- 8 used bespoke forms
- 7 used FIDIC Silver Book
- 6 used World Bank standard forms
- 5 used NEC
- 4 used FIDIC Yellow Book
- 5 others used national industry forms or a licenced version of FIDIC Red Book

3.2.3 For projects combining civil, mechanical and electrical hydropower works in EPC or ‘turnkey’ contracts:

- 8 used bespoke forms
• 7 used FIDIC Silver Book
• 6 used World Bank standard forms
• 5 used FIDIC Red Book
• 5 used FIDIC Yellow Book
• 3 used NEC
• 2 others used an unidentified EPCM form or a national industry form

The survey showed there is a high level of awareness of NEC, and a third of respondents had used the forms for a variety of hydropower and other projects, and with a wide range of project values. The most common forms of contract used by respondents over the past five years are the FIDIC Red, Yellow and Silver Books and bespoke forms, but there has been significant use of NEC.

| Micro hydro installed under NEC ECC Option A (see Section 3.4.1) by Mott MacDonald’s design and build contractor, Mott MacDonald Bentley at Woodend. This was part of the Scottish Water Hydropower’s Difgen Programme to install hydropower in its water pipelines. | The 156 MW, US$250 million Song Bung 4 Hydropower Project in Vietnam. Mott MacDonald reviewed the design and supervised construction by Chinese contractor Sinohydro for the Song Bung 4 Hydropower Management Board. Part funded by the Asian Development Bank (ADB), the civils works used the FIDIC ‘Pink Book’ while mechanical works used the ADB’s preferred form of contract for Contractor design of mechanical and electrical work. The ADB has since shown an interest in NEC contracts. |
Hydro developer RWE Innogy uses the NEC ECC – mainly Option A- for UK hydro construction projects. Recent projects include the £11.8 million, 3MW run of the river hydro at Cia Aig near Fort William in Scotland. Mott MacDonald carried out design under the NEC PSC contract. The project used NEC ECC option A for separate civils and plant contracts. The project is near completion and RWE Innogy is very positive about the use of NEC. In mainland Europe RWE tends to use FIDIC, but is trying to adopt NEC.

3.3 Important factors in choosing forms, and levels of satisfaction with contract forms currently in use

Respondents were asked to consider the importance of factors when choosing a contract form for hydropower works, and to consider their levels of satisfaction with the contract forms they were currently using. Factors were split into pre-award and post-award contract management phases. The results are summarised in Table 1.

<table>
<thead>
<tr>
<th>Pre-award</th>
<th>Considered important or very important</th>
<th>Considered satisfied or very satisfied with current form</th>
</tr>
</thead>
<tbody>
<tr>
<td>The forms are flexible and so can be applied to different types and sizes of work</td>
<td>88%</td>
<td>71%</td>
</tr>
<tr>
<td>The form recognises that the extent of design required by the contractor may vary</td>
<td>92%</td>
<td>54%</td>
</tr>
<tr>
<td>The form allows the option of a target cost payment mechanism</td>
<td>54%</td>
<td>38%</td>
</tr>
<tr>
<td>The form allows flexibility with respect to risk allocation, but the allocation is clear</td>
<td>96%</td>
<td>42%</td>
</tr>
<tr>
<td>The form is well used and understood by potential bidders</td>
<td>88%</td>
<td>67%</td>
</tr>
<tr>
<td>The form has a history of use in the country of the project</td>
<td>67%</td>
<td>79%</td>
</tr>
<tr>
<td>The form is part of a suite of complementary contracts which can be used across all contracts required for the project</td>
<td>71%</td>
<td>63%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contract management</th>
<th>Considered important or very important</th>
<th>Considered satisfied or very satisfied with current form</th>
</tr>
</thead>
<tbody>
<tr>
<td>The form is written in simple language and can be understood by those for whom English is a foreign language</td>
<td>96%</td>
<td>63%</td>
</tr>
<tr>
<td>The form is published in a language other than English</td>
<td>25%</td>
<td>21%</td>
</tr>
<tr>
<td>The form helps the parties project manage the change inevitable in a project</td>
<td>96%</td>
<td>67%</td>
</tr>
<tr>
<td>The form does not require active project management</td>
<td>38%</td>
<td>17%</td>
</tr>
<tr>
<td>The form allows for ‘in the cloud’ management systems to help with contract management</td>
<td>38%</td>
<td>21%</td>
</tr>
<tr>
<td>The form does not require special training</td>
<td>54%</td>
<td>29%</td>
</tr>
<tr>
<td>The form stresses the importance of the programme (e.g. as interfacing between contracts is often critical)</td>
<td>83%</td>
<td>67%</td>
</tr>
<tr>
<td>The form allows for the possibility of joint incentives across separate contracts for the same project</td>
<td>50%</td>
<td>33%</td>
</tr>
</tbody>
</table>

Table 1. Important factors and satisfaction
3.4 Pre-award

3.4.1 The forms are flexible and so can be applied to different types and sizes of work

88% of respondents considered this important or very important. Hydropower contracts are clearly required for very different types of work and for different scale projects. It would be useful if the required contracts could use a similar form of contract so that staff get used to the processes in the contracts.

The NEC has developed into a family of contracts as set out in Table 2. Each of the contracts has a very similar structure and uses common language and common processes.

The most frequently used contract is likely to be the NEC Engineering and Construction Contract (ECC) (NEC 2013a). This is appropriate for any significant project relying on the use of any disciplines. Critically the ECC:

- allows the Contractor to be required to carry out any level of design and
- allows the choice of payment mechanism to be added to the ‘core clauses’ of the contract:
  - Option A Priced contract with activity schedule
  - Option B Priced contract with bill of quantities
  - Option C Target contract with activity schedule
  - Option D Target contract with bill of quantities
  - Option E Cost reimbursable contract
  - Option F Management contract

For the ‘normal’ split in hydropower projects (See section 2.1) if the civils work and electrical and mechanical work are in separate contracts:

- Option A or B with predominantly Employer design is likely to be appropriate for the civil works
- Option A with Contractor design to performance requirements is likely to be appropriate for contracts that are predominantly for electrical and mechanical works.

The ECC, because it is not discipline specific, is also appropriate for the single contract approach.

The NEC family includes the Engineering and Construction Subcontract (ECS) (NEC (2013b)) which allows the Contractor to pass on obligations and liabilities to his supply chain using a contract that is back to back with the ECC. The simpler Engineering and Construction Short Contract (ECSC) (NEC (2013c)) is available for simple priced subcontracts.

The professional services contract (PSC) (NEC (2013d)) can be used by the employer to engage his advisors and for the Contractor to pass on the design obligations in his main contract.

The NEC provides also the Term Service Contract (TSC) (NEC (2013f)), which is used to define and pay for a service.

3.4.2 The form recognises that the extent of design required by the Contractor may vary

92% of respondents considered this important or very important. Only 54% were satisfied or very satisfied with how their current forms dealt with the issues. Different types of work in hydropower projects may be designed by the employer and the contractor. These may be in the same contract.

The ECC provides for any level of Contractor design. It requires the employer to set out in the tender documents exactly what is to be designed by the contractor and any requirements and constraints that are to apply. This level of design can therefore be very different for different parts of the works. If required, there is a mechanism to include in the contract a stated level of tender design. The contractor is then required to implement this tender design, but the employer’s stated requirements take precedence over that tender design.

3.4.3 The form allows for the option of a target cost payment mechanism

54% of respondents considered this important or very important.

Many large infrastructure projects are now using target cost contracts that directly and commercially incentivise collaboration between Employer and Contractor.

The very flexible target contract (Options C and D, see Section 3.4.1) are available to put this into effect. These options require the employer to define a ‘share profile’ to set the rules on how any saving or underspend compared with the target is to be shared.
Flexible and clear risk allocation and management is a critical role of any contract, and 96% of respondents considered this important or very important.

The allocation of estimating and efficiency risk is set by the choice of main option as set out in section 3.4.1. There are then a series of secondary options, many of which have directly allocated a particular risk. These include Option X1, Price adjustment for inflation and Option X2, Change in law. With regard to specific risk events the contract is very clear. The contractor can receive compensation (in the form of a delay to the ‘Completion Date’ and/or an increase in the ‘Prices’ only if a stated ‘compensation event’ occurs. The majority of these compensation events are set out in one clear list. The most commonly used is a change to the employer’s requirements in the Works Information. This is a very good starting point for risk allocation, but if there is a requirement to change the risk allocation for a particular contract, this can be done simply by adding to the list or modifying or deleting particular standard compensation events. The flexible rules and mechanisms for dealing with compensation events are set out in one clear part of the contract and apply to all compensation events. (Patterson (2009a)).

Two critical risks for hydropower contracts are physical conditions and weather. The ECC includes a ‘Site Information’ document in which the employer can provide geotechnical and existing services data and which is used in assessing physical conditions. This is one thing required to be taken into account by the bidder when pricing the works. It is very difficult for a standard form to draw a clear line between employer’s and contractor’s risk when it comes to physical conditions. The wording in the ECC is similar to that in traditional contracts. The compensation event is physical conditions which ‘an experienced contractor would have judged at the ‘Contract Date’ to have such a small chance of occurring that it would have been unreasonable for him to have allowed for them.’ On a significant hydropower contract there is likely to be a geotechnical baseline report (GBR). (This is a pre-requisite of many insurers to get an insurance policy for tunnel construction). The risk allocation baselines in the GBR can be neatly included as compensation events in the contract (Patterson and Essex (2010)).

Most traditional forms of contract define the weather risk allocation in terms of ‘extremely adverse’ weather or similar. This can often lead to disputes. The ECC takes a different and more objective approach. A compensation occurs only if a stated ‘weather measurement’ exceeds the one in ten year level. Best practice is to state those one in ten year levels for each weather measurement directly in the contract.

The use of NEC internationally is growing. However, the NEC may be relatively new to many employers and bidders in the international hydropower market. If employers choose to use the NEC they will need to get themselves properly trained to understand it and in the first instance employ consultants with experience of preparing tender documents and of acting as the Project Manager and Supervisor, the two administration roles in the contract. In markets where NEC is new they would be well advised to help train their bidders.

The hydropower market is a very international business. Tender documents are drafted to attract international bidders and are often in English.

The NEC is widely used in the UK and in South Africa. In Hong Kong it is now mandatory for all government construction spend. Use is growing in New Zealand, where one of the leading early adopters is renewable energy company Meridian Energy. Meridian used NEC and FIDIC for two similar and parallel projects back in 2004 - 2007 (Wright and Fergusson, 2009). As a result Meridian moved most of its hydro-related procurement to NEC and has recently used the NEC also in Australia (NEC (2015a)). The NEC has been used for airports in India (NEC (2015b)) and is being used for the International Criminal Court in The Hague (NEC (2015c)).

The contract is specifically designed to be able to be used in any jurisdiction. His Honour Humphrey Lloyd QC, a former UK Technology and Construction Court judge stated that ‘In a nutshell, there are no real difficulties in using the NEC3 contract either inside or outside the UK. With a couple of exceptions, the core clauses of NEC3 do not contain any significant features that would make it unwise to use it abroad’. (Lloyd (2008) and Patterson (2009b)).

Minor secondary options are published for users in the UK and New Zealand to comply with specific laws. However, if used outside those countries a legal review should be carried out by a team with experience in NEC and the local law. Clearly using a contract for the first time in a given country will present its own risks.
3.4.7 The form is part of a suite of complementary contracts which can be used across all contracts required for the project

71% of respondents considered this important.

As demonstrated in section 3.4.1, the NEC is specifically designed as a separate but inter-related series of contracts that can be used alongside each other and along the supply chain.

3.5 Contract management

3.5.1 The form is written in simple language and can be understood by those for whom English is a foreign language

No less than 96% of respondents considered this important. Only 63% were satisfied or very satisfied with the language in their current form.

Hydropower contracts are needed all over the world and many people working internationally have English as a second language.

The ECC is a sophisticated contract for complex projects. It is designed as a series of processes with very clear actions required by each party, each within a defined period. One of the three guiding principles for drafting is ‘clarity and simplicity’. The contract is written in ‘plain English’ with short sentences and bullet points where appropriate. It is a refreshing change from the ‘legalese’ in most traditional contracts. As such, it can be understood – in principle at least - by those with a good grasp of English. However, to understand and use the NEC properly, training will be required.

3.5.2 The form is published in a language other than English

Only 25% of respondents considered this important.

At present the form is published only in English. English is the de facto international language of business and probably that most likely to be used for most international hydropower projects. If there is a significant demand, the NEC has stated that it will consider commissioning translations into other languages.

3.5.3 The form helps the parties project manage the change inevitable in a project

96% of respondents considered this important and 67% stated they were satisfied or very satisfied with their current form.

Despite best efforts to set out requirements clearly, hydropower contracts are often subject to change – and risks with the Employer do happen.

The NEC is a contract. But it is also a project management system. As noted, the only way for a supplier (contractor under ECC or consultant under PSC) to get a change to his ‘Prices’ (the lump sum or target) and/or the ‘Completion Date’ (the date when he is required to achieve ‘Completion’) is to show that a compensation event has occurred. This term covers changes to the ‘Works Information’1 (what is called a ‘variation’ in some other contracts), and other things that are at the risk of the employer. The process for managing those compensation events is set out in the core clauses of the contract. The rules for assessment are clearly set out:

- the change to the Prices2 is based on the actual cost of work already done and a forecast of the cost of the work not yet done
- the delay to the Completion Date3 is assessed using the last ‘Accepted Programme’, updated first for progress

The contracts have a clear process for notifying, quoting for and accepting quotations. All stages of the process have a defined time period in which each person has to respond. The process also has several degrees of flexibility for the Project Manager, the main employer side contract administration role. He or she can ask for a quotation for a proposed instruction, quotations for different ways of dealing with the event and can state assumptions for assessment. If the Project Manager has stated assumptions, the Employer holds the risk of those assumptions being incorrect. The NEC is sometimes criticised for being overly ‘administrative’. However, it is simply good project management to manage change actively: the NEC gives the processes for that to be done flexibly, professionally and within defined timescales: there is no ‘reasonable time’.

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1 Works Information is the ECC’s term for the document setting out the requirements for the works and the constraints on providing the works.
2 ECC Clause 63.1
3 ECC Clause 63.3
3.5.4 The form does not require active project management

Only 38% of respondents considered this important suggesting that respondents would be content with a form that did not require active project management.

Hydropower clients sometimes do not have the management resources to properly manage their own often complex contracts. Some may want a contract that is ‘left in the drawer’. If that is the case then the NEC is not for them. The NEC does need good systems to implement it and people with the skills, knowledge and mentality to use them. It does need both parties to commit to active management of their project, to address all issues as they occur – throughout the contract.

3.5.5 The form allows for ‘in the cloud’ management systems to help with contract management

Surprisingly only 38% of respondents considered this important.

As noted the NEC does require active project management and good systems to carry out that management. The contract is designed as a series of clear actions and responses by Contractor, the Employer and his Project Manager and Supervisor. Each action has a defined period within which a response is required. All the contracts are accompanied by clear flow charts that illustrate those processes. The way the contract is designed has allowed the development of several proprietary ‘in the cloud’ management systems to prompt, record and report on all the actions required by the contract. These are hugely beneficial on a significant contract.

3.5.6 The form does not require special training

54% of respondents considered this important.

Hydropower clients may want their people to be able to use their contracts with the minimum of effort. The contract is written in plain English, but it is for complex projects, it is very flexible and it does therefore need training if it is to be used properly. At the very least there is a need for a project start up workshop to ensure those charged with managing the contract have a clear understanding of how it is to be operated and the systems to be used. Because the NEC has been around since 1991, there are a number of established training providers and on-line learning is also widely available.

3.5.7 The form stresses the importance of the programme (e.g. as interfacing between contracts is often critical)

83% of respondents considered this important.

Hydropower projects are complex and, especially if the procurement route is to use more than one contract, there will be a number of contractual interfaces to be managed. For such projects monitoring of progress against programme is critical.

The NEC contracts have two options for setting out time requirements: completion and key dates. There is a secondary option that introduces sectional completion. Completion of the sections on time can be made subject to delay damages. The Employer is normally required to take over a section after its completion. The Employer can also set requirements for certain ‘conditions’ to be met by ‘key dates’. The Employer does not have to take over after the contractor has achieved the stated condition. If the condition is not met by the key date the contractor is required to pay the Project Manager’s assessment of the additional cost to the Employer either in carrying out work or by paying an additional amount to others to carry out work. The same options are available to the contractor in the ECS.

Most forms of contract require a programme, but the use of the programme in the contract is often limited. This is not the case in the NEC, which is, a contract for project management. The programme is used directly in the assessment of compensation events. Because of this, the ECC, ECS and PSC include detailed requirements for a resource loaded programme which is required to be accepted by the Project Manager. There are also detailed requirements for each revised programme so that, in effect, the ‘as-built’ programme is developed as the contract progresses. There are clear reasons for not accepting the programme.

The detailed requirements for the programme do mean that both the contractor and the project manager must have programme skills at their disposal.

3.5.8 The form allows for the possibility of joint incentives across separate contracts for the same project

50% of respondents considered this important.

The NEC has not yet developed an alliance agreement for a truly multi-party contract. (This is currently being developed). However, the ECC does have a secondary option to facilitate multi party partnering between different suppliers each working under a separate NEC contract on the same project. Option X12:

- sets up a ‘core group’ comprising representatives from the client and each of the contractors (and potentially subcontractors and consultants) in the arrangement
requires a common set of ‘Partnering Information’ (included in each contract) setting out how the partners will work collaboratively and, perhaps most importantly
allows for a schedule of incentives that can be developed to incentivise the client’s success factors for the whole project, rather than just the individual contract
The schedule of incentives can be used, for example, to help incentivise collaboration between a civil contractor and the electrical and mechanical contractors working alongside each other in a powerhouse.

4. What makes NEC contracts different from FIDIC and other standard forms
Most engineering contract forms have been developed by national organisations for use in their own particular legal jurisdiction, and often by industry or professional organisations for use in their own industry or engineering discipline. Contracts developed for international use or for multiple engineering disciplines are much less common. NEC and FIDIC have both been developed for international use, and have both been drafted with no reference to any specific country or legislation. FIDIC has long been a preferred form for international use, but NEC is gaining acceptance in a number of countries. However, the philosophies of the two forms are different. NEC was developed as a form of relationship contract, intended to promote collaboration between the parties, and to include a framework for sound project management principles and practice. FIDIC can be regarded as a traditional form of contract which focuses on the rights and obligations of the parties.
NEC offers a number of advantages over FIDIC, particularly in clarity, flexibility, explicit project management procedures, partnering and teamwork, risk management, objective measurements of weather and ground conditions risk, and variations (Besaiso, 2012). Each NEC contract is supported by associated guidance notes and flow charts, detailing exactly what procedures should be followed by whom and when.

Table 2 shows the suites of NEC and FIDIC contract forms and their counterparts. One of the authors provides a more detailed comparison of the two forms in a soon to be published book by the UK Institution of Civil Engineers (Fergusson, 2015).
<table>
<thead>
<tr>
<th>NEC3 Form</th>
<th>FIDIC Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEC3 Engineering and Construction Contract (ECC)</td>
<td>Conditions of Contract for Construction for Building and Engineering Works designed by the Employer (Red Book)</td>
</tr>
<tr>
<td></td>
<td>Conditions of Contract for Construction for Building and Engineering Works designed by the Employer; Multilateral Development Bank Harmonised Edition (Pink Book)</td>
</tr>
<tr>
<td></td>
<td>Conditions of Contract for Plant &amp; Design-Build for Electrical &amp; Mechanical Plant &amp; For Building &amp; Engineering Works designed by the Contractor (Yellow Book)</td>
</tr>
<tr>
<td></td>
<td>Conditions of Contract for EPC Turnkey Projects (Silver Book)</td>
</tr>
<tr>
<td>NEC3 Engineering and Construction Short Contract (ECSC)</td>
<td>Short Form of Contract (Green Book)</td>
</tr>
<tr>
<td>NEC3 Engineering and Construction Subcontract (ECS) NEC3 Engineering and Construction Short Subcontract (ECSS)</td>
<td>Conditions of Subcontract for Construction (no book colour) No equivalent</td>
</tr>
<tr>
<td></td>
<td>No direct NEC3 Form, but see Section 5 Conditions of Contract for Design, Build and Operate Projects (Gold Book)</td>
</tr>
<tr>
<td>NEC3 Professional Services Contract (PSC) NEC3 Professional Services Short Contract (PSSC)</td>
<td>Client/Consultant Model Services Agreement (White Book)</td>
</tr>
<tr>
<td>NEC3 Supply Contract (SC) NEC3 Supply Short Contract (SSC)</td>
<td>No equivalents</td>
</tr>
<tr>
<td>NEC3 Term Service Contract (TSC) NEC3 Term Service Short Contract (TSSC)</td>
<td>No equivalents</td>
</tr>
<tr>
<td>No equivalent</td>
<td>Contract for Dredging and Reclamation Works (Blue Book)</td>
</tr>
</tbody>
</table>

Table 2. Contract form counterparts

FIDIC publishes five main forms which provide for differing engineering disciplines, assignment of design responsibility, EPC arrangements and multi-lateral development bank financing. In contrast, the NEC ECC is a single flexible form which is designed to provide for all arrangements by means of a menu of options plus the employer’s specific requirements.

FIDIC uses differing editions of the contracts to allocate responsibility for design to the employer or the contractor, while the ECC provides for any level of design to be done by either party.

FIDIC and NEC both publish short forms of contract designed for use with projects which have technically straightforward work, present low risk to the owner and contractor, or the work is of low value. However both short form versions may be suitable for contracts of relatively high value where the work is simple or of short duration and does not include significant Contractor design.

Both publishers also provide sub-contract forms, designed to operate back-to-back with their respective main forms. NEC includes both a subcontract (ECS) a short subcontract (ECSS). FIDIC publishes a single construction subcontract.

**5. How the NEC contracts can be used in the hydro sector**

Section 3 has shown how NEC contracts meet the requirements of contracts as ‘requested’ by respondents to the survey. The contract’s design means that, if used properly the employer and the contractor can benefit from better
The detailed change control process means that both sides have better ‘incremental certainty’ on the end point in terms of time and money.

All but the smallest projects will require more than one contract, and NEC provides an interlocking suite of contracts that can be used to establish back-to-back terms and could be used on hydropower projects for:

- the employer’s consultants (PSC)
- civils contracts (ECC)
- electrical and mechanical contracts (ECC)
- a combined EPC contract for civil and electrical and mechanical works (ECC)
- all tiers of subcontracts (ECS and ECSC)
- the contractor’s designers (PSC)

If the Employer wants a design build operate (DBO) contract then he can combine the ECC for the design and build phase and the TSC for the operation and maintenance phase. How this can be done is set out in Patterson and Trebes (2013). The NEC has since developed a contract for DBO for the Adian Development Bank and will in time make it more available. (One of the authors was part of the team that carried out this work). The NEC has not yet been used for the project agreement in a DBFO contract, although contractors under DFBO contracts have used the flexible NEC to pass their risks on to their subcontracts using the NEC (Cole (2007)). However, one of the authors has investigated the concept of NEC for DBFO by examining what provisions are actually unique because of the financing (Patterson and Trebes (2015)). The paper argues that a DFBO ‘project agreement’ can be achieved using NEC contracts as a base.

Meridian Energy is New Zealand’s largest hydro generator, was an earlier adopter of NEC in New Zealand, and has used the various NEC forms more than 200 times. One of the authors published a case study which compared the use by Meridian of NEC and FIDIC contracts on the same 4-year $NZ100m hydro generation station electrical and mechanical refurbishment project for Meridian (Wright and Fergusson (2009)). That concluded the NEC ECC contract using a target payment option delivered the expected business benefits to the Employer in terms of project management, contract clarity and contract relationships. It was found the contract provided a forward-looking proactive environment to manage project time and cost, although in the case, the use of the target-sum payment option required additional time and cost for administration. The contract was also found to provide the unexpected benefit of added safety.

Meridian’s 800mW underground Manapouri hydropower station during the mechanical and electrical refurbishment programme. The NZ$30m mechanical refurbishment project was carried out using the NEC3 ECC with the target cost payment option.
The Waitaki power station is an historic part of New Zealand’s electricity network being almost 80 years old. Meridian is carrying out a range of work including earthquake strengthening and reinstating the site’s seventh generation unit, which hasn’t operated for a number of years. The work is using over 50 NEC3 contracts.

Pukaki canal intake repair. The unique aspect of this Meridian project was that all repairs were successfully completed during ‘62 hours on the slab’ before recommissioning the canal. The NEC3 ECC was used with the reimbursable payment option.

Meridian is currently investing more than NZ$40m on a 4 year project to refurbish the Waitaki dam, power station and surrounding infrastructure using over 50 NEC contracts. These include the Professional Services Contract (PSC), Engineering and Construction Contract (ECC), Supply Contract (SC) and associated short contracts (NEC (2015d)). By way of contrast, on a much smaller project Meridian used the ECC with the reimbursable payment option to carry out a $NZ1.8m urgent civil works project on the Pukaki canal intake (Damwatch Engineering (2009)).
6. Why NEC should be at least considered for any hydro project

NEC contracts are an option and deserve to be considered in the procurement and contract strategy for any hydropower project, including small and large maintenance projects on existing plant, and for new construction projects.

The success of NEC in the civil construction industry in the UK and other countries can be mirrored in hydropower. NEC contracts can, in principle, be used in any jurisdiction and support almost any procurement strategy.

Most hydropower projects include both electrical and mechanical works, and civil works. NEC can be used for all engineering disciplines and all stages in the project lifecycle, from planning, design and project management through to construction, maintenance and facilities management.

NEC contracts are very different from traditional contracts. They do encourage a collaborative working culture, and significant initial training will be required to realise the benefit of the contract. Any employer looking to use NEC – a modern form of contract – for the first time must recognise there is a lot to learn and that active management of the contract is essential to realise its advantages. This requires good systems, training and good people.

NEC will not be right for all clients. However, adopters in the hydropower sector can potentially gain a number of benefits from use of NEC:

- a comprehensive suite of contracts to procure works, services, maintenance and supply
- a range of procurement and payment options
- flexibility, clarity & simplicity providing a stimulus to good management
- fair and sensible allocation, management and awareness of risk
- opportunities for partnering
- flexibility of responsibility for design
- price changes based on quotations - fewer surprises and fewer post-completion disputes
- up-to-date realistic programme used in joint decision making
- improved incremental cost certainty for the parties.

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Warwick R. Fergusson holds an MBA in project management from Henley Business School, is a Member of the Australian Institute of Project Management (MAIPM), holds chartered membership of the NZ Institute of IT Professionals (CITPNZ), and was the first Chair of the NEC Australasian User Group. He has some fifteen years of project management experience in the electricity industry in Australia and New Zealand, primarily in hydro generation, as well as wind generation and SCADA projects. Warwick, has experience of drafting and using both NEC and FIDIC contracts, has delivered NEC training, and is a published author on NEC.