Comments on the TSLRIC Model for Declared Transmission Services

A report prepared
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1. Introduction

Marsden Jacob Associates (**MJA**) has been requested by the Competitive Carriers Coalition (**CCC**) to address the questions in the Australian Competition and Consumer Commission's (**ACCC**) discussion paper related to the Transmission Network Cost model developed by Gibson Quai AAS (**GQ-AAS**).

The comments and opinions expressed in this paper are those of MJA and do not necessarily reflect those of the CCC.

The questions/issues addressed in this report are:

Overview of model

- Do you agree with the architecture of the routes that are proposed to be modelled? If not, why not?
- Do you agree that the model allows for the appropriate transmission elements and services to be modelled? If not, why not?
- Do you consider the transmission between capital cities and regional centres should be modelled based on Telstra's current network architecture? If not, why not?
- In your opinion, to what extent will the cost of transmission differ on a particular route depending on the available bandwidth that is offered to an access seeker?

Input Parameters and Results Sheet

- Do you think that the specified mark-ups listed in Figure 3 are appropriate in a model used to estimate the costs of supplying transmission capacity services? Why or why not?
- In your opinion, what is the appropriate magnitude of any mark-ups for the purpose of estimating transmission costs? What evidence is there to support these magnitudes?
- In your opinion, what is the appropriate WACC value to apply when estimating the costs of providing transmission capacity services? To what extent can the WACC value be benchmarked against those applied for the provision of PSTN services? To what extent (if at all) should a different WACC estimate be used to estimate the costs of providing transmission capacity services on different capital regional routes?

Route Design Sheet

- Are the parameters specified to model the cost of transmission on a 'inter exchange' route appropriate? If not, why?
- Are the parameters specified to model the cost of transmission on a 'link' route appropriate? If not, why?
- Are the parameters specified to model the cost of transmission on a 'tail-end' transmission route appropriate? If not, why?

- Are the parameters specified to model the cost of transmission on a 'submarine route' appropriate? If not, why?
- Are the additional parameters specified to incorporate the 'additional length of optical fibre into each exchange', the 'optical fibres in exchange cable lead in' and the 'optical fibre cable joints' appropriate? If not, why?

Technology Selection

- Do you agree with the technology choices available in the model? If not, what is the 'best-in-use' technology?
- Are the assumptions in Technology selection sheet of the model reasonable?
- Are the parameters specified in the Technology selection sheet appropriate? If not, why?

The Transmission Demand Estimates

- Does the methodology employed in the Demand estimates sheet provide reliable and reasonable estimates of capacity demand?
- Are the assumptions in Demand estimates sheet of the model reasonable?
- Does the Demand estimates sheet assist with the selection of parameters which are consistent with an efficient network design?

Accommodation Cost Estimates

- Are the assumptions in the Accommodation cost estimates sheet of the model reasonable?
- Does the methodology employed in the Accommodation cost estimates sheet provide reliable and reasonable estimates of accommodation costs?

Annualised Cost Calculation

- To what extent are the initial investment costs for each network item a reasonable approximation of actual ~~price trends~~ investment costs?[1]
- To what extent are the price trends assumed for each network item a reasonable approximation of actual price trends?
- Is the conversion factor used to convert the 'total cost' of network items into an annualised cost into a 'year 0' tilted annuity value appropriate?
- Is it reasonable that the model should estimate costs for year 0 in a tilted annuity?

Trench and Optical Fibre Cable Calculation

- Are the assumptions in the Trench and Optical Fibre Cable sheet of the model reasonable?
- Do you consider distance to be the major driver of trench and optical fibre cable costs?

[1] We assume this revision reflects the intent of the question.

- Are the calculations performed to estimate Trench and Optical Fibre costs appropriate?

The Inter-exchange, link, tail and submarine model sheets

- Does the methodology employed in the inter-exchange, link, tail and submarine model sheets provide reliable and reasonable estimates of transmission costs?

2. Summary of key issues

One re-occurring critique of cost models in Australian regulatory proceedings (in particular the PIE II and more recently the WIK model) has been lack of transparency. This is not a feature of the model produced by GQ-AAS. It is clearly and transparently set-out with all key workings of the model readily accessible. That said, MJA has identified a number of shortcomings with the model.

First, the model contains no dimensioning algorithms. It is essentially a static model - equipment numbers are determined independent of demand. With a basic choice of structure, technology and configuration, it is MJA's opinion that the model should contain functionality to optimally dimension the transmission network. However, this analysis is off-line (i.e. separate from the model). Further, demand inputs suggested in the model to assist with this off-line analysis are averages or total values. Input values of this kind are inappropriate for dimensioning purposes. Ideally, traffic distributions in different parts of the transmission network (i.e. on different routes) should be used. This would allow for a more accurate dimensioning.

Second, little or no analysis is provided that can shed light on the optimality of the model. For example, a certain network configuration is simply assumed. There is no discussion of different options or the cost minimisation problem inherent in the TSLRIC concept. While scenario analysis need not be part of the model (although it would be advisable) there should be a minimum of discussion on the dimensioning choices and why the final outcome is cost efficient.

Third, and related to the above, it is unclear how the model can be updated over time. Clearly, demand on the modelled transmission routes will change over time leading to changes in cost.[2] In a recent press release on the potential to increase Telstra's 10Gbps Dense Wave Division Multiplexing transmission technology to 40Gbps, Dan Burns, Telstra Executive Managing Director, Network and Technology noted that the "*trial was commissioned as a part of Telstra's forward planning to meet expected growth on the inter-capital networks*". In MJA's view, traffic patterns and volumes may change significantly within the coming years. The model must contain a detailed analysis of forecast growth in order to inform on the appropriateness of equipment numbers and sizing over time.

Fourth, a key element of different transmission services is that they will share infrastructure and transmission elements with each other. Currently, it would appear that the approach used is to identify the type of route subject to costing and proceed with specific modelling of this type of route. The amount of sharing is in this case a largely arbitrary input. This is problematic and a significant shortcoming of the model as sharing can have a very substantial influence on transmission service costs. The model needs to consider not only the routes subject to declaration but also other (competitive) routes to accurately determine the amount of sharing. Indeed the conventional approach to TSLRIC modelling is not to

2 See http://media-newswire.com/release_1051211.html.

focus on a subset of an increment (in this case the transmission and infrastructure network) but to model a whole increment or sometimes even several additional increments to ensure the appropriate dimensioning and design of the network.

MJA submits that the model in its current form does not provide a robust basis for determining that cost of declared transmission services. However, MJA acknowledges the effort already put into building the model and does not believe a complete dismissal of it would be appropriate. It is therefore imperative that the model be substantially improved before it is used to inform decisions on transmission costs and prices.

3. Comments on questions

3.1. Overview of model

- Do you agree with the architecture of the routes that are proposed to be modelled? If not, why not?
- Do you agree that the model allows for the appropriate transmission elements and services to be modelled? If not, why not?
- Do you consider the transmission between capital cities and regional centres should be modelled based on Telstra's current network architecture? If not, why not?
- In your opinion, to what extent will the cost of transmission differ on a particular route depending on the available bandwidth that is offered to an access seeker?

In terms of the basic architecture, using fibre rings and best-in-use transmission electronics is an appropriate starting point for the transmission model. However, the way the model is currently structured it focuses narrowly on specific routes in the Telstra network. Instead it should take a more holistic approach. Although transmission routes may logically be separate they are often shared at a physical level. From an optimisation perspective it is therefore important to consider not only specific routes but several routes to ensure an accurate dimensioning.

More generally, MJA proposes the following minimum requirements of the optimisation process:

- the network must be dimensioned correctly. This requires detailed information on demand by route. Information of this kind is currently not used in the model. See section 3.5 for more discussion on this issue;
- the network must provide services with a quality of service equal to that which Telstra provides to interconnecting carriers. Basing the model architecture on that of Telstra assists in ensuring this. However, optimal departures from the Telstra network should be allowed;
- the network must meet the scorched node assumption. It is currently unclear whether the model meets this criterion. The conventional interpretation of the scorched node assumption implies that the location of the network nodes in Telstra's network should be taken as given. Our reading of the GQ-AAS model documentation suggests that this is the approach taken;
- the network must be technically feasible. This implies that the network must not be too theoretical or experimental, but should reflect the type of network that would be rolled out or developed by Telstra (or a competitive carrier) were it to build a network of similar size and scope today. Of particular importance in this case is also to consider the

evolution of Telstra's telecommunications networks. There is no consideration of these issues in the GQ-AAS model documentation;

- it must be able to carry the relevant services (see discussion above); and
- it must be cost effective. Cost optimisation and effectiveness is inherent in the TSLRIC cost concept. In order to adequately test the cost effectiveness of results generated by the model it is necessary to have a measure to evaluate it against. This is discussed in more detail in section 3.3.

One question related to the extent be which the cost of transmission will differ on a particular route depending on the available bandwidth that is offered to an access seeker; we note that this is a function of several factors. First, higher bandwidth requires greater capacity in the electronic equipment used and hence higher costs. Second, the nature of the bandwidth required will also influence cost. A guaranteed bandwidth of 100 Mbit/s will incur higher costs than one that is dynamically assigned within 100 Mbit/s. Third, the approach to cost allocation of infrastructure items will change the costing results. For example, trenching costs are driven by distance rather than traffic. Hence there is scope to employ allocation keys for trenching that reflect measures that are independent on bandwidth.

3.2. Input Parameters and Results Sheet

- Do you think that the specified mark-ups listed in Figure 3 are appropriate in a model used to estimate the costs of supplying transmission capacity services? Why or why not?
- In your opinion, what is the appropriate magnitude of any mark-ups for the purpose of estimating transmission costs? What evidence is there to support these magnitudes?
- In your opinion, what is the appropriate WACC value to apply when estimating the costs of providing transmission capacity services? To what extent can the WACC value be benchmarked against those applied for the provision of PSTN services? To what extent (if at all) should a different WACC estimate be used to estimate the costs of providing transmission capacity services on different capital regional routes?

3.2.1. The mark-up approach[3]

A single installation mark-up on capital costs is used to estimate the cost of installation for all equipment types (except for submarine costs). In MJA's view, this is a crude approach. Installation costs relative to capital costs may vary significantly depending on the specific equipment item being considered. In addition, it is MJA's experience that care must be taken in evaluating equipment costs as it is not uncommon to bundle some installation into purchasing contracts. We therefore suggest that the model allow the user to insert individual installation costs for each category of equipment.

3 According to the GQ-AAS model, the parameters used are test values only.

MJA notes that the model recognises that submarine cable installation costs will differ substantially from other costs. MJA supports this approach.

The model relies on a single mark-up for indirect capital costs, i.e., capital costs not otherwise captured in the model. While not uncommon in costing models and in some cases appropriate on aggregate, MJA suggests allowance be made for a more detailed modelling of indirect costs, by indicating which cost categories are included in the mark-up estimate (for example, PCs, equipment for network planning, network management and billing systems etc.). Without a more detailed understanding of the costs to be included in this category it is difficult to advise on specific parameters.

The model allows for three mark-ups for (direct) operating and maintenance (O&M): Trench and Conduit, Optical Fibre and Transmission Technology. In our view, this classification is too broad. In particular, O&M costs for transmission technology would be expected to differ by specific cost category. The aggregate approach also implicitly suggests that costs will not vary by type of region (for example CBD and rural areas).

The use of mark-ups for O&M costs is practical but not ideal. Ideally, O&M costs should be calculated from first principles and reconciled with operator practices and costs. Another approach is to calculate O&M costs as driven by the number of events per major cost component. Events could include:

- fault detection, monitoring and diagnosis;
- fault repair (different costs for different types of repair); and/or
- any routine maintenance / renewal of equipment.

The operating cost per event would take into account the total time spent dealing with the "event" and an average wage for the engineering or other personnel in charge of the "event". As an example of this approach, MJA refers to version 1.3 of the Danish hybrid model.[4]

The model has one mark-up for indirect O&M. Like direct operating costs, indirect operating costs are difficult to estimate in a 'pure' bottom-up manner. It is therefore not uncommon to use mark-ups sourced from operator accounts to estimate these costs. However, the GQ-AAS model provides no indication on the type of cost included as indirect. It is therefore difficult to provide additional comment on this category of cost.

Regardless of the potential inappropriateness of the mark-up approach to calculate direct operating and indirect capital and operating costs (and common costs), MJA submits that mark-ups offer one advantage in that they may allow comparisons with benchmarks on public record. Typically, MJA has seen estimates in the following ranges:

- Indirect network capital costs: 10-15% of direct capital costs;

4 Yet another approach that has been used in other jurisdictions is the so called Functional Area approach. This methodology was developed as an attempt to overcome some of the shortcomings of relying on mark-ups over equipment costs as an estimate of direct network O&M costs. However, for the purpose of the GQ-AAS model this approach is unlikely to be feasible as it would require detailed analysis of information from Telstra.

- Direct network operating costs: 3-15% of direct network capital costs. These will vary significantly by cost category, e.g., the cost of maintaining a trench as a proportion of the cost of laying the trench will be very minor, while the cost of maintaining transmission electronics as a proportion of their direct capital costs tends to be fairly large;
- Indirect network operating costs: 20-30% of direct network operating costs; and
- Common costs: 3-10% of direct capital costs.

Without a more detailed classification of the cost categories it is difficult to provide recommendations on specific values. In Appendix A we have provided some analysis of the mark-ups used in regulatory proceedings in Denmark and Sweden.

3.2.2. Working capital

MJA notes that the model contains no inputs related to working capital costs. When there is a delay between paying out cash for inputs and receiving cash for outputs, a stock of cash (working capital) is required at the beginning of trade to be able to cope with this delay from operations. Working capital may also include other items such as stock of network spare parts, other current assets and liabilities etc. Cash or working capital is tied up in the running of the business until trading ceases. Hence working capital imposes an opportunity cost.

While MJA would expect that the total working capital items of the various network elements and transmission services to be minimal[5], the cost of working capital is a legitimate cost item and should be included in the estimate of efficient forward-looking costs.

The prudent amount of working capital may be estimated using a bottom-up modelling technique. The required level of working capital may be calculated as:

$$\frac{DD \times sales}{days\,in\,a\,year} + cash - \frac{CD \times trade\,creditor\,related\,costs}{days\,in\,a\,year}, \qquad (1)$$

where

DD = debtor days; and

CD = creditor days.

In the formula above stock is assumed to be negligible and debtor days and creditor days refer to the weighted average. As stated above, only working capital which is related to the provider's network (wholesale), may be included.

Sales will be the sales revenue of network services. Here total annualised costs may be used as proxy, since they will equal the level of sales revenue if rates are set correctly.

5 TSLRIC models within telecommunications often assume that the cost of working capital is negligible or even zero.

Determining the prudent level of cash to be held as working capital will depend on attitudes to risk and the perceived cost to a telecommunications provider suffering a cash flow crisis. One simple way of accounting for cash is to estimate a percentage increase in net debtor days.[6]

Assuming total annualised costs are used as a proxy for total revenue and an increase in debtor days is used as a proxy for cash, the debtors and cash part of Formula (1) above may be rewritten:

$$\sum_{i=1}^{n} \frac{DD_{\mathbf{i}} \times DW_i}{365} \times TC \times (1+\Delta DD) \qquad (2)$$

where

DW_i = is the weight assigned to the debtor *i* (a percentage of total annualised costs); and

TC = total annualised costs.

MJA notes that some services paid for in advance (will have negative debtor days) and others are paid for in arrears (will be a positive number of days).

The total trade creditor related costs should include costs of wages, electricity and other payments to suppliers, such as support contracts and equipment suppliers. These creditor costs can be determined using the TSLRIC model, i.e., as the total costs of the business, when the cost of capital is set to zero.[7]

Applying these simplifications, creditor related costs may be written as:

$$\sum_{j=1}^{m} \frac{CD_j \times CW_j}{365} \times TC_{CoC=0} \qquad (3)$$

where

CW_j = is the weight assigned to creditor j; and

$TC_{CoC=0}$ = Total costs excluding a return on capital.

The bottom-up formula for calculating the required level of working capital can therefore be summarised as follows:

$$\sum_{i=1}^{n} \frac{D_{\mathbf{i}} \times DW_i}{365} \times TC \times (1+\Delta DD) - \sum_{j=1}^{m} \frac{C_j \times CW_j}{365} \times TC_{CoC=0} \qquad (4)$$

6 In the Oftel model this is referred to as a contingency requirement.

7 Since the equipment suppliers' costs (annual capital expenditure) are approximately equal to the depreciation and electricity, wages and other supplier costs may be regarded as related to operational cost, the total annual cost when cost of capital is set to zero may be used as a proxy for creditor costs.

The total working capital value is multiplied by the cost of capital to get the cost of working capital.

MJA submits that working capital may have a lower return than the return used for capital investment. This is possible since some of the working capital could be used to obtain a return from (say) short-term bank deposits. Hence applying the same return value for working and investment capital will potentially result in an over-estimate of the cost of working capital.

In terms of international experience MJA has surveyed a number of countries:

- *Denmark*: The Danish hybrid LRAIC model (version 1.3) does not explicitly contain working capital costs. However, these may be inferred from a description of common cost items in the model documentation. For core services, the working capital cost mark-up applied to service costs is 0.9%. For access services it is -1.6%.
- *Sweden*: Based on empirical evidence from TeliaSonera's top-down model the cost of working capital has been set to zero.
- *United Kingdom*: Oftel applied a working capital cost of 1.5% to network services in their 1997 estimate of the LRIC of interconnection services. The 1.5% was applied to annualised cost.

To summarise, experience in other jurisdictions suggests that working capital costs are likely to be minor. It also shows that it is important to recognise that different services will have differing working capital costs.

3.2.3. WACC

MJA supports the use of the Capital Asset Pricing Model (CAPM) for the estimation of the weighted average cost of capital (WACC). However, very little information is provided on the approach used in the GQ-AAS model documentation or the model itself. As with other parameters used in the model, MJA assumes that that those used for the WACC are only for testing purposes only.

Generally, a WACC estimate makes use of the following individual parameters:

- the risk-free rate;
- gearing;
- debt margin (incl. potential debt raising costs);
- market risk premium;
- tax rate;
- gamma; and
- beta.

None of these parameters are discussed the GQ-AAS report. It is outside the scope of our review to comment extensively on the different WACC parameters. Hence MJA has not recommended a specific WACC. However, in terms of benchmarking against the values used for the provision of PSTN services we believe this is a reasonable starting point, subject to the following comments:

- MJA believes there are arguments in favour of using a maturity period equal to the length of the regulatory period for the risk-free rate. To the extent that the regulatory period differs then the risk-free rate should be adjust accordingly.
- Historically, the ACCC has used a gearing ratio of 40% for Telstra's PSTN business. MJA considers that the gearing ratio (consistent with an efficient financing structure and which maximises the value of the business and minimises the WACC) would likely to lower for transmission services because of different risk characteristics.
- Financial theory asserts that rational, informed investors require higher returns from higher risk investment. This implies that the expected return for a higher risk investment exceeds that of a lower risk investment. Different parts of any regulated utility will face different risks, i.e. risks are not homogenous. The term 'beta' refers to the relative risk of a return producing asset such as a ratio of the covariance of income from the particular asset and a well-diversified portfolio and the variance of the income from the diversified portfolio.[8] Beta should therefore reflect the specific risk characteristics of the service that is subject to regulation. In most regulatory proceedings it is difficult to accurately assess beta for different business units or services. There are, however, several methodologies available including
  - management comparisons;
  - the pure-play approach;
  - residual beta;
  - multiple regression of weights;
  - beta panel data; and
  - accounting beta.

  Each methodology has its strengths and weaknesses. However, for transmission services a 'pure-play' approach is likely to be appropriate. It relies on identifying publicly traded companies similar to the business unit under consideration and using the beta values from these comparators as an estimate of the beta for transmission service.[9]

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8 In formal statistical terms, beta is defined as the covariance of returns to the particular asset and returns to the market portfolio divided by the variance of returns to the market portfolio.

9 The procedure may be summarised is as follows:

- o find a sample of publicly traded companies that are in a similar type of business to that of the division being evaluated;
- o for each firm find the betas of their stocks as well as their market value (debt/equity) ratios and determine the tax rules governing the business; and finally
- o calculate the unlevered (asset) betas to enable a comparison.

- In terms of further disaggregation of risk to look at costs of providing transmission capacity services on different capital regional routes, MJA does not believe this to be tractable nor practical.

3.3. Route Design Sheet

- Are the parameters specified to model the cost of transmission on a 'inter exchange' route appropriate? If not, why?
- Are the parameters specified to model the cost of transmission on a 'link' route appropriate? If not, why?
- Are the parameters specified to model the cost of transmission on a 'tail-end' transmission route appropriate? If not, why?
- Are the parameters specified to model the cost of transmission on a 'submarine route' appropriate? If not, why?
- Are the additional parameters specified to incorporate the 'additional length of optical fibre into each exchange', the 'optical fibres in exchange cable lead in' and the 'optical fibre cable joints' appropriate? If not, why?

The model contains four basic route designs. While MJA agrees with the basic designs of these routes and the number of network elements contained on each route, MJA has a number of concerns with the approach.

First, most routes are likely to share infrastructure and transmission elements with each other. In the GQ-AAS model it would appear that the approach used is to identify the type of route subject to costing and proceed with specific modelling of this type of route. This is problematic as dimensioning occurs in a standalone fashion. Without consideration of other routes there is a risk that the modelled network will not reflect costing realities. Indeed the conventional approach to TSLRIC modelling is not to focus on a subset of an increment (in this case the transmission and infrastructure network) but to model a whole increment or sometimes even several additional increments to ensure the appropriate dimensioning and design of the network. In other words, MJA submits it is necessary to model both declared and non-declared transmission services and based on this more complete modelling allocate costing to the specific transmission services in question.

Second, the designs appear to assume that the ring structure will cater for any security and or resilience issues. While this may be correct, there may cases where additional meshing between nodes may be appropriate to supplement the rings, giving further resilience to cable breaks.

MJA also submits:

- the approach assumes the distance between MTHs is the same regardless of the number;
- there are no cross-checks (sanity checks) of the input numbers, for example between number of nodes and number of links; and

- optical fibre cable lead-ins (assumed to be 24 pair) are not linked to the choice of fibre cable.

3.4. Technology Selection

- Do you agree with the technology choices available in the model? If not, what is the 'best-in-use' technology?
- Are the assumptions in Technology selection sheet of the model reasonable?
- Are the parameters specified in the Technology selection sheet appropriate? If not, why?

The technology selections available in the model are reflected in the following quotes from the model documentation:[10]

> *GQ-AAS's understanding is that best-in use technologies at this point in time, considering the required transmission volumes and deployment locations, will include Synchronous Digital Hierarchy (SDH) and or Wave Division Multiplexer (WDM) equipment on optical fibre routes. Ethernet aggregation equipment is to be included within the capability of the model; however this technology may not be regarded at this time as best-in-use technology for regional routes as to our knowledge it is not in use in these locations and the cost and capacity considerations are more than would be required for regional routes…*
>
> *Microwave technology which Telstra still uses to connect some exchanges, usually in more remote areas and for legacy reasons, is not considered as an appropriate technology for the purposes of this model.*

In the ACCC's general guide to access pricing principles it notes that:[11]

> *"TSLRIC is based on forward-looking costs. These are the on-going costs of providing the service in the future using the most efficient means possible and commercially available. In practice this often means basing costs on the best-in-use technology and production practices and valuing inputs using current prices."* [emphasis added]

It is not clear if "best-in-use" should be interpreted as the most efficient technology available or should be limited to comprise only technology that has been tested and implemented by operators in practice (i.e., best-in-commercial-use).

In MJA's view, the choice of technology should be that which an efficient operator would use if it were to build or upgrade the network today. An efficient operator would use the best productive technology available for its business. This entails finding the right balance between the technology that is proven and reliable and represents more or less the current

10 GQ (2007), p. 3

11 ACCC (1997), *Access Pricing Principles, Telecommunications – a Guide*, July, pp. 21-22

state of the art, and the technology that is new, promising cost savings, but has not yet demonstrated conclusively its strengths.

In terms of transmission equipment MJA submits that SDH fibre technology is appropriate and that some consideration also be given to newer alternatives like Ethernet over SDH. MJA is not convinced that it is appropriate to rule out microwave altogether. This could be tested within a fuller scenario based modelling framework.

Apart from being reflective of good modelling practice, the modelling of different costing scenarios provides a number of important benefits. Examples of different scenarios could include the Telstra transmission network as it is today and a number of scenarios that reflect slightly different technological solutions. The benefits of scenario analysis include:

- it is easier to optimise once you have a thorough understanding of the costs of the existing network architecture;
- it can provide confidence to the ACCC that the model is robust and reflective of efficient forward-looking costs within the constraints set out for the modelling work; and
- it could be used as a cross-check that the optimal network is one that can evolve from the existing network.

Different scenarios could be made part of the model as a way of conducting sensitivity analysis. There may also be trade-offs between cost reduction and certain aspects of network performance. Building in the capacity to run alternative scenarios would also allow the ACCC to estimate the trade-off between the different options.

The model assumes that the technology systems operate in series, i.e., in order to deliver a unit of capacity an SDH system is operating on top of a Dense Wavelength-division Multiplexing (**DWDM**) system. Engineering advice from the CCC suggests while all transmission systems are capable of delivering capacity directly to customers from each unit platform, it is not necessary to purchase a SDH platform to deliver, say, an STM16. This may be done directly from the DWDM layer. It may therefore be appropriate to derive capacity prices from each platform in the network.

3.5. The Transmission Demand Estimates

- Does the methodology employed in the Demand estimates sheet provide reliable and reasonable estimates of capacity demand?
- Are the assumptions in Demand estimates sheet of the model reasonable?
- Does the Demand estimates sheet assist with the selection of parameters which are consistent with an efficient network design?

The purpose of the Demand Estimates sheet is summarised by GQ-AAS as follows:[12]

> *The 'Transmission Demand Estimates' sheet is designed to inform the model user about the capacity that would typically be required to service the needs of all customers of the telecommunications network operator in a CCA….*
>
> *Decisions that flow from knowing the broad capacity requirements include for instance, whether Dense Wave Division Multiplexer (DWDM) equipment may be required, the likely capacity of an SDH system, the number of LTH that an SDH ring is likely to efficiently include, the number of overlayed rings that would typically require optical fibre pairs in the interconnecting optical fibre cables.*
>
> *The intent of this sheet is to provide information to the model user to assist with the selection of design parameters consistent with an efficient network design to meet the needs of the situation being modelled. Having a reasonable estimate of the total bandwidth needs is the basis for the subsequent network design decisions. <u>The sheets results are not directly linked to other calculations within the TSLRIC Model</u>* [emphasis added]

MJA has three major problems with this approach.

First, equipment numbers are independent of demand, i.e., are not linked to calculations within the model. Although the intention of the sheet is to assist in selecting design parameters to ensure an efficient network design, the type of demand information available in this sheet is far from satisfactory in this regard. With a basic choice of structure, technology and configuration the model should ideally dimension the transmission network on the basis of traffic distributions in different parts of the transmission network (i.e., on different routes) and equipment costs. Information on the distribution of the traffic in different parts of the transmission network would allow for a more accurate dimensioning than the use of averages or totals as shown in the GQ-AAS model, insofar as the cost minimisation problem is repeated for each set of routes of different size. The cost function to be minimised is a combination of the costs of the transmission equipment (line systems, multiplexors, etc.) and the costs of the fibre through which the signal travels. The modularity of equipment and circuit protection should also be taken into account.

12 GQ (2007) p. 23

Second, and related to the above, the model is static. Updating the model over time will require expert assistance in network dimensioning to ensure that it accurately reflects real world changes in demand. A good cost model should (within certain bounds) to able to adapt to changes over time.

Third, the model provides a range of inputs that appear to be based on residential services. These services are inadequate and do not reflect the full range of services that are drivers for the use of the transmission network. Accordingly, the demand sheet needs to be expanded to reflect all services using the network including, all business and government services.

3.6. Accommodation Cost Estimates

- Are the assumptions in the Accommodation cost estimates sheet of the model reasonable?
- Does the methodology employed in the Accommodation cost estimates sheet provide reliable and reasonable estimates of accommodation costs?

As a matter of principle MJA supports the current approach with a separate consideration of costs related to accommodation. However, we believe there is scope to improve the modelling of these costs. Although the GQ-AAS model considers these costs for individual network elements, the approach used is too high level to accurately capture the costs of accommodation.

While MJA concurs that a bottom-up approach would seek to estimate the space associated with the equipment modelled and use a market value per square metre to calculate the value of building (and land), there is also a need to carefully consider common building-related costs including site security, power supply units etc. More specifically, MJA submits the following:

- the footprint of a specific piece may in some cases be influenced by the type of rack used;
- there may be requirements for empty space to facilitate access (the utilisation factor in the model may be used to correct for this);
- power supply units and other auxiliary items also take up space; and
- air conditioning costs are not driven by the amount of square meters covered. Rather air conditioning costs are driven by the amount of heat generated by the equipment within the building and the need to cool equipment down.

There is also a need to specify what the square metre costs of the building cover. Buildings used for telecommunications purposes (in some cases, cabinets) are “made for purpose” and contain a number of specific elements including raised floors, storage, security systems etc. that are not commonly found in other buildings. When estimating the building costs per square metre it is necessary to take these common site costs into account. An alternative would be to rely on estimates based on containers (or technical house) that are purpose built for telecommunications equipment.

Finally, it should be ensured that any indirect costs calculated via mark-ups in the model do not include accommodation costs. Without a consistent approach there is a risk of double counting.

3.7. Annualised Cost Calculation

- To what extent are the initial investment costs for each network item a reasonable approximation of actual ~~price trends~~ investment costs?
- To what extent are the price trends assumed for each network item a reasonable approximation of actual price trends?
- Is the conversion factor used to convert the 'total cost' of network items into an annualised cost into a 'year 0' tilted annuity value appropriate?
- Is it reasonable that the model should estimate costs for year 0 in a tilted annuity?

MJA has reviewed the annualisation sheet and note that it would appear to function as specified. MJA would however, note the following:

- the model only allows three separate mark-ups for operating costs. More flexibility should be allowed in the selection of mark-up parameters;
- power consumption is input as a single figure for each major network element (where relevant). We believe a more detailed bottom-up approach that considers the annual power consumption and the cost of power would improve this aspect of the model;
- the price trend (or TECH factor as it is termed by GQ-AAS) is applied to a combination of installation costs and capital costs, however, the price trend for installation and equipment capital are likely to differ significantly. Historically, prices are fallen for telecommunications equipment while the cost of installation requiring skilled labour has increased; and
- the cost of the optical fibre cable joint is independent of the choice of fibre cable, i.e., we would expect the cost of the joint to increase with the size of the cable.

In MJA's opinion, the year 0 tilted annuity[13] is a reasonable approach for a bottom-up, fixed network model. However, the formula used does not take account properly of inflation.

13 A standard annuity calculates the charge that, after discounting, recovers the asset's purchase price and financing costs in equal annual sums. In the beginning of an asset's life, the annualisation charge consists of more capital charges and less depreciation charges. This reverses over time resulting in an upward sloping depreciation schedule. The increase in the depreciation charge over time exactly counterbalances the decrease in the capital charge, resulting in the annualisation charge being constant over time.

A tilted annuity takes account of price changes, creating front-loading if prices are expected to fall and back-loading if prices are expected to increase.

The formula used is:

$$\frac{(WACC - p - i)}{1 - \left(\frac{1 + p + i}{1 + WACC}\right)^{n}}, \quad (5)$$

Where:

p = price tilt

i = inflation

n = asset life

Inflation should be taken into account using the Fisher equation, leading to the following formula:

$$\frac{WACC - ((1 + p)(1 + i) - 1)}{1 - \left(\frac{(1 + p)(1 + i)}{1 + WACC}\right)^{n}} \quad (6)$$

A consequence of the tilted annuity approach is that any results will rely heavily on the appropriate specification of asset lives and price trends.

In order to assist the ACCC and GQ-AAS in populating the model with real data, MJA has reviewed publicly available information on the magnitude of price trends and asset lives primarily used in regulatory proceedings. The following tables summarise these findings.

Table 1: Nominal Price trends (annual percentage change in costs)

	Source:	*IRG*	*Europe Economics ABUM*	*Hybrid model*	*Analysys Municipal Duct model v1*	*Hybrid model*
	Country/region:	*France*	*Europe*	*Denmark*	*N/A*	*Sweden*
	Year:	*2001*	*2000*	*2005*	*2002*	*2004*
Major grouping	*Cost category*					
Trench	Trench in the access network	0%		3%	2%	2%
Trench	Trench in the core network	0%	1%	3%	2%	2%
Duct	Duct in access network	0%		3%	2%	2%
Duct	Duct in the core network	0%	1%	3%	2%	2%
Tie cable	Tie cables			0%		-2%
Fibre cable	Fibre cable (in the access network)			-5%		1%
Fibre cable	Fibre cable (in the core network)	-5%	-5%	-5%		0%
Cabinet/DP	Cabinets (including cabinet equipment)	0%		1%		2%
MDF	MDF	0%		-2%		0%
Switching	Tandem Switch switchblock unit	-5%	-6%	-6%		-4%
Switching	Tandem Switch processor unit		-6%	-6%		-5%
Switching	Tandem Switch software (unit)		-6%	-6%		-4%
Switching	Tandem Switch port unit		-6%	-6%		-3%
Transmission	STM multiplexers	-5%	-10%	0%		-5%
Transmission	STM cards		-10%	0%		-5%
Transmission	Cross-connects	-5%	-10%	0%		-4%
Transmission	Signalling points		-5%	-6%		-4%
Buildings	Buildings		-1%	2%		1%

Sources for Table 1 are analysis of:

- IRG–France: information received by ITST from the French regulator ART in relation to a data request sent out to members of the Independent Regulators Group (IRG) in connection with the Danish LRAIC process.
- Europe Economics ABUM—Adaptable Bottom-Up Model, Europe Economics: available at the EU.
- The Danish hybrid model — version 2.1 of the LRAIC model: used by the ITST to set the prices of access services, switched interconnection services, and co-location services.
- Analysys Municipal Duct model.
- The Swedish hybrid model: LRIC model used by the Swedish Regulator PTS to set the prices of access services, interconnection, and co-location services.

While Table 1 indicates there is some dispute on the price trend for fibre cable, it shows general agreement on a positive price trend in the benchmarked data for duct (conduit) and trench, and negative price trends for transmission and switching equipment. Our analysis suggests that the price trends are combined equipment and installation trends. This is confirmed by the observation from Table 4 that asset categories that contain a large labour component tend to have a more positive price trend. For example, trench and duct categories should have a large labour component.

Asset lives should correspond to the economic life of the assets considered. Tables 2 and 3 show publicly available information on the magnitude of economic asset lives used in regulatory proceedings.

Table 2: Asset lives—Part I

	Source	*IRG*	*IRG*	*IRG*	*IRG*	*IRG*	*IRG*	*Europe Economics ABUM*
	Country/region	*France*	*Switzerland*	*Spain*	*Austria*	*UK*	*Germany*	*Europe*
	Year	*2001*	*2001*	*2001*	*2001*	*2001*	*2001*	*1999*
Major grouping	*Cost category*							
Trench	Core trench	30.0	27.0	30.0	30.0		35.0	38.0
Duct	Core duct	30.0	27.0	30.0	30.0	42.0	35.0	38.0
Line card	Line cards		11.5					
Tie cable	Tie cables							
Fibre cable	Fibre cable (in the core network)	20.0	16.0		20.0	24.0	20.0	23.0
Cabinet/DP	Cabinets/distribution points	20.0		7.0			8.0	
Switching	Switchblock unit	12.0	14.0	5.7	10.0	14.0	10.0	13.0
Switching	Processor unit	12.0	11.5	5.7	10.0	14.0	10.0	11.0
Switching	Software		5.0		10.0		4.0	12.0
Switching	Port unit	12.0	11.5	5.7	10.0	14.0	10.0	11,5
Transmission	STM multiplexers	10.0	9.4		8.0	13.0	10.0	10.0
Transmission	STM cards		10.0			13.0	10.0	10.0
Transmission	Synchronisation		10.0		8.0	13.0	10.0	16.0
Transmission	Cross-connects	10.0	9.5		8.0	13.0	10.0	10.0
Transmission	Signalling points		10.0			13.0	10.0	16.0
Other	Power supply unit		10.0	15.0	5.0			
Other	Air conditioning unit		10.0	15.0	5.0			
Buildings	Buildings	30.0	30.0	24.2	40.0	42.0	35.0	37.0

Table 3: Asset lives—Part II

	Source	*HAI Model*	*NTT TD model*	*LRIC Study Group Model*	*Hybrid model*	*Hybrid model*	*C&W FLRLIC model*
	Country/region	*USA*	*Japan*	*Japan*	*Denmark*	*Sweden*	*Caribbean*
	Year	*1998*	*1998*	*1998*	*2005*	*2005*	*2006*
Major grouping	*Cost category*						
Trench	Core trench	51.1	27.0	27.0	40.0	40.0	20.0
Duct	Core duct	51.1	27.0	27.0	40.0	40.0	20.0
Tie cable	Tie cables	15.7			15.0	15.0	20.0
Fibre cable	Fibre cable (in the core network)	23.7	10.0	11.2	20.0	20.0	15.0
Cabinet/DP	Cabinets/distribution points	19.0			15.0	15.0	
Switching	Switchblock unit	16.4	6.0	11.9	10.0	10.0	
Switching	Processor unit	16.4	6.0	11.9	10.0	10.0	
Switching	Software	6.3	6.0	11.9	10.0	10.0	
Switching	Port unit	16.4	6.0	11.9	10.0	10.0	
Transmission	STM multiplexers	10.2			10.0	10.0	10.0
Transmission	STM cards	10.2			10.0	10.0	10.0
Transmission	Synchronisation	10.2			15.0	10.0	10.0
Transmission	Cross-connects	10.2			10.0	10.0	10.0
Transmission	Signalling points	10.2			10.0	10.0	
Other	Power supply unit				15.0	10.0	
Other	Air conditioning unit				15.0	10.0	
Buildings	Buildings	47.7	22.1	33.0	30.0	30.0	

Sources for Table 2 and Table 3 are the analysis of:

- IRG—different European countries: information received by ITST from a number of European regulators in the relation to a data request sent out to members of the IRG in connection with the Danish LRAIC process.
- Europe Economics ABUM—Adaptable Bottom-Up Model, Europe.
- HAI model: Appendix B—HAI Model Release 5.0a Inputs, Assumptions and Default Values, February 16, 1998.
- NTT TD model—Summary of Final Report of LRIC Study Group, 1998.
- LRIC Study group model—Summary of Final Report of LRIC Study Group, 1998.
- The Danish hybrid model (version 2.1 of LRAIC model): used by the ITST to set the prices of raw copper, switched interconnection services, and co-location services.
- The Swedish hybrid model (version 2.1 LRIC model): used by the Swedish regulator PTS to set the prices of access, interconnection, and co-location services.
- The C&W FLRIC model: used in Cayman Islands.

Although MJA acknowledges that the data in the current model are for testing purposes only, we would caution the application of asset lives or price trends at too granular a level. While a TSLRIC model may be accurate at estimating equipment numbers, and hence gross replacement costs, this is only one step in the modelling process. These costs need to be converted into annual costs as in the GQ-AAS model. Modelling the economic characteristics of the underlying assets at a detailed level is therefore important for an accurate outcome. Without sufficient detail in the application of asset lives and price trends any detailed modelling of the underlying equipment numbers is discounted. The same argument applies to the mark-up approach currently used in the GQ-AAS model.

3.8. Trench and Optical Fibre Cable Calculation

- Are the assumptions in the Trench and Optical Fibre Cable sheet of the model reasonable?
- Do you consider distance to be the major driver of trench and optical fibre cable costs?
- Are the calculations performed to estimate Trench and Optical Fibre costs appropriate?

The Trench and Optical Fibre Cable sheet allows for a fairly detailed individual modelling of specific transmission routes. However, as noted in section 3.3 many routes may share a single trench. If this is not taken into consideration, trench requirements may be significantly over-estimated. The total amount of existing trench by different network layers in the Telstra network may be used as a cross check, to ensure the modelled configuration bears some resemblance with the actual one.

The model has a rather curious approach to sharing. Each cost category within each major network element contains an option for sharing. The parameters currently used in the model vary between 1 and 3. A factor of 1 is equivalent to no sharing, while a factor of 2 is 50% sharing and a factor of 3 reduces costs to a third.

No rationale is provided for why sharing has been modelled in this way. Normally sharing will take on several forms: physical sharing between Telstra and third parties, trench sharing between different parts of the network (i.e., transmission network and access network) and cost sharing. The last refers to the allocation of costs where sharing takes place. It is common practice for costs to be shared equally where sharing occurs although it may in some cases be appropriate to depart from this assumption.

The way sharing works in the GQ-AAS model it is not possible to transparently take into account these different forms of sharing. For example, apart from trenches, buildings will be shared between services, certain transmission equipment may be shared with the PSTN traffic and auxiliary equipment like a reserve power supply may be dimensioned to cope with failures that are not only particular to the transmission network.

Without knowledge of the current sharing arrangements in the Telstra network it is difficult to provide accurate input of the appropriate level of sharing.[14] As a starting point it is worthwhile to consider the degree of sharing in Telstra's existing transmission network and take this as a lower bound of potential sharing and then consider how sharing may be increased and on which routes.

In terms of the percentages of trench by different segments in the GQ-AAS model, it is difficult to provide input on the specific percentages to use. However, to the extent that the model replicates the existing configuration of the Telstra network, then the mix of terrains (trench types) assumed could be taken as the existing one, otherwise input would need to sought by examination of maps and terrains.

It is unclear how the number of optical fibre cables per trench would be determined. This number would of course vary with the size of the cable assumed for the particular route. However, the model does not explicitly consider different cable sizes rather it considers different types where it is unclear whether cable size should be taken into consideration. Cable size requirements may be satisfied by different combinations of cables of different sizes. For example, if a route requires a 58 pair cable, this requirement may be satisfied by a combination of a 48 pair cable and a 12 pair cable as well as by a 96 pair cable. The cheaper of the two combinations should be chosen. In general, the need for different cable sizes should be determined taking into consideration the future demand to mirror the fact that digging of new cable represents a substantial cost. The need for excess capacity should therefore be based on rational economic considerations taking into account modularity and margins for growth.

Potential errors in the Trench and Optical Fibre Cable sheet:

- MTH to Mainland Landing Station Route 1 – distribution of trench types sum to 101%. The formula in E611 does not pick up the allocation in E556.

14 The key to understanding how much sharing should occur lies in the interpretation of "time" in the forward-looking concept. The forward-looking perspective can be interpreted as the costs of today looking forward, i.e. the cost of building the transmission network today taking account of future demand. This suggests that the transmission network is built over a very short period (some may even argue overnight). This is of course not practically possible and would for example give rise to problems in the choice of equipment price and labour costs and effectively result in zero trench sharing with third parties. For the purpose of modelling, it is therefore often assumed that the network from a technical perspective is built overnight (or instantaneously), but all input parameters (trench sharing, equipment prices, etc.) are verifiable and reflect the costs of actual networks built over time. This means that equipment prices may follow from normal operator purchases and sharing may reflect normal planning and construction activity where co-ordination of trench sharing and co-diggings may be planned years ahead with other operators and utilities.

- MTH to Mainland Landing Station Route 2 – distribution of trench types sum to 101%. The formula in E679 does not pick up the allocation in E624.
- Island LTH to Island Landing Station Route 1 – distribution of trench types sum to 101%. The formula in E747 does not pick up the allocation in E692.
- Island LTH to Island Landing Station Route 2 – distribution of trench types sum to 101%. The formula in E826 does not pick up the allocation in E771.

3.9. The Inter-exchange, link, tail and submarine model sheets

- Does the methodology employed in the inter-exchange, link, tail and submarine model sheets provide reliable and reasonable estimates of transmission costs?

Please refer to section 3.4 and 3.5.

Appendix A

The Danish Model v1.3

The Danish LRAIC model version 1.3 relies on a mark-up approach to calculating operating costs (direct and indirect), common costs and any additional costs that are not captured by the former.

In terms of direct operating costs IT- og Telestyrelsen, the Danish regulator, adopted two modelling approaches:

- Use of TDC's (the Danish incumbent) actual operating costs where adjustments are made to reflect TDC's relative level of efficiency and to reflect that the LRAIC model assumes new assets which should require less operating costs; and
- An event based system. The likelihood of an event occurring is estimated along with the estimated costs of such an event. This methodology is only used in the access network.

Remaining indirect costs (i.e. costs that are not allocated using mark-ups or as result of a direct modelling approach such as power and air conditioning) are added to final service costs using a mark-up approach. The model distinguishes between:

- Indirect mark-ups;
- Direct interconnection mark-ups; and
- Number portability (**NP**) / IN mark-ups.

Below, the mark-ups implied by the Danish model have been estimated.

Table 4: Implied mark-ups in the Danish LRAIC model

Cost Categories	*Values*	*Unit*
Direct costs		
Direct Switching Capex	1,499	mDKK
Direct Switching Opex	186	mDKK
Switching opex mark-up	*12.4%*	*% of direct switching capex*
Direct transmission Capex	707	mDKK
Direct transmission Opex	35	mDKK
Transmission opex mark-up	*4.9%*	*% of direct transmission capex*
Total Capex	2,206	mDKK
Total Opex	221	mDKK
Total network opex mark-up	*10.0%*	*% of direct capex*
Indirect costs		
Mark-up on core services	35.6%	% of annual costs.
Total annual core costs	620	mDKK
Implied indirect costs	221	mDKK
Indirect cost mark-up	*10.0%*	*% of direct capex*
Direct interconnection costs		
Mark-up on interconnection	28.1%	% of annual interconnection costs
Total annual interconnection costs	189.74	mDKK
Implied direct interconnection costs	53.32	mDKK
Interconnection specific mark-up	*2.4%*	*% of direct capex*
NP/IN costs allocated to interconnection		
NP/IN Mark-up	0.00145	DKK per call
Total annual NP/IN costs	3.36	mDKK
NP/IN mark-up	*0.2%*	*% of direct capex*

Source: MJA analysis of Danish Hybrid Model public version 1.3 (2005)

MJA notes the following to the table above:

- Capex refers to the capital expenditure related to the PSTN;
- Transmission includes cost categories related to infrastructure, e.g. duct and trench;
- The cost of working capital for core services of 0.9% has been excluded from the indirect cost mark-up;
- The indirect cost mark-up includes:
  - operating costs related to Network Management;
  - annualised capital costs related to synchronisation (excl. atomic clock); and
  - annualised capital costs related to network software and SDH management software;

  These cost categories amount to a mark-up of 19.3% (or 54% of the 35.6% mark-up). Excluding these cost categories from the estimate of the indirect mark-up in the table results in an indirect mark-up of 4.7% of direct capex (compared with 10.2%).

The remaining costs making up the 35.6% (i.e. a mark-up of 16.3%) include:

- operating costs relating to buildings (excluding rent and directly modelled operating expenses), motor vehicles, divisional overhead, corporate overhead and IT;
- annualised capital equipment costs, including other buildings, other property and IT cabling and PCs; and
- Building and land cost related to the mark-up in the previous section are included in the estimates above.

The Swedish Model v2.1

The approach to calculating operating costs in Sweden (direct and indirect operating costs and including indirect capital costs) is termed a Functional Area (FA) approach. This methodology was developed in response to industry consultation. The approach relies on the identification of a number of functional (or operational) areas of the telecommunications business, which is dimensioned in terms of personnel (pay costs) and non-pay costs. The annual cost of each area is allocated to network elements using disaggregated mark-ups as weights.

Table 5: Implied mark-ups in the Swedish LRIC model

Cost Categories	*Values*	*Unit*
Direct and Indirect costs		
Total switching FA costs	654	mSEK
Total switching FA costs excl. network management system	398	mSEK
Total transmission FA costs	278	mSEK
Total FA costs	932	mSEK
Total switching capex	3,804	mSEK
Total transmission capex	12,302	mSEK
Total capex	16,106	mSEK
Switching mark-up	*17.2%*	*% of direct capex*
Switching mark-up excl. network management system	*10.5%*	*% of direct capex*
Transmission mark-up	*2.3%*	*% of direct capex*
Total network mark-up	*5.8%*	*% of direct capex*
Total network mark-up excl. network management system	*4.2%*	*% of direct capex*
Other costs		
Common business costs	381	mSEK
Common business costs mark-up	*0.4%*	*% of direct capex*
Specific Interconnection costs	70	mSEK
Specific Interconnection cost mark-up	*0.4%*	*% of direct capex*

Source: MJA analysis of Swedish Hybrid Model public version 2.1

MJA notes the following to the table above:

- capex refers to the capital expenditure related to the PSTN. Likewise all FA costs and common business costs sourced from the Swedish model are those related to the PSTN. For example, the model has an input of mSEK 381 as a common business cost. This figure only relates to the PSTN. An operator providing other non-PSTN services will incur additional costs. However, these should not be allocated to the PSTN and hence not to interconnection;
- transmission refers to transmission and infrastructure equipment;
- costs identified as accommodation costs in the Swedish model (i.e. building costs, power supply unit costs, air-condition unit costs etc. allocated to each equipment based on their area of occupancy) are excluded in the mark-up calculations above; and
- the Swedish model also takes separate account of loss on debtors and additional costs related to transit interconnection services. These are not accounted for in the table above.

The outcome of this analysis shows that the direct and indirect operating costs and indirect capex in the Danish and Swedish models differ considerably on a per direct capex basis. The main reason for this difference is the relatively higher capital cost of transmission in Sweden compared with Denmark resulting in a different cost split between the two major cost categories transmission and switching: in the Swedish model transmission capex comprises 76% of total direct capex, the same figure in the Danish model is only 32%. Since direct operating costs as a percentage of direct capex in both models is higher for switching than transmission, the total mark-up in Sweden will therefore be lower because transmission operating costs are given more weight in the totals calculation.