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QUICK-AND-DIRTY PROJECT ECONOMICS

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Typically, a news report or press release about a proposed project will give rudimentary data: project size measured by plateau throughput (Mb/d, Bcm/y, Mt/y) and a cost figure perhaps broken out by chain segments. For example, the recent announcement by QP/ExxonMobil for a 15.6 Mt/y LNG project to the UK, reported a $12G total, while the cost data, including some EPC contract awards, appeared to break out: upstream $2.5 G, processing $4 G, shipping $1.8 G, and import terminal $1.1G, totaling $9.4 G. The unaccounted for 22% is probably made up of an allocation to the project of sponsors' costs for project formation, marketing, design and supervison, sponsors' fees to the project, plus financing fees, plus perhaps interest (but not equity finance) during construction.

By themselves, these data are meaningless. They must be put in a form that permits comparison of product output costs among projects and with product values delivered to markets, or netted back to supply points.

The basic output in this type of analysis is the *cost-of-service* (COS), defined as:

> the levelized real price per unit output (e. g., $/b or $/MBtu) that over the life of the project will provide (in present value) for recovery of operating expense, recovery of capital invested including a specified required rate of retrun, and payment of (grossed up) profit taxes and royalties that will be incurred.

In calculating the COS, in addition to reported data, sensible specifications must be made for construction expenditure profiles, production volume buildup, operating expense, losses, financing terms including required rates of return by segment, escalation of output prices and opex, and sovereign fiscal terms including tax rates and depreciation schedules. The methodology provides for simple representation of these data, but the data must come from an understanding of the engineering, economic, fiscal, and financial character of the project itself.

This paper has two sections: the first section develops the specification of COS scaled by the unit capital cost ($ per unit throughput capacity), and then organizes the COS into unit cost *recovery factors* for: capex, opex, profit tax, and royalty; the second section shows how

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to do economics for facility chains with losses, on both a *cost-forward* basis, and *netback* from market value basis. Example calculations are provided.

Cost-of-Service.

The analysis is scaled to unit output per period:

Q	plateau output per period,
$CAPEX$	capex in as-spent \$,
$K \; = \; CAPEX/Q$	unit capacity cost in \$ per (plateau output per period).

Expenditure parameters are:

$Leadtime \; (L)$	construction start lead,
$OPXfact$	opex annual share of CAPEX,
$VolProf_t$	volume buildup profile (reaches unity),
$OpxProf_t$	opex profile (typically unity).

Financial and price parameters are:

r	nominal req'd return,
g^{Rev}	output price growth rate,
g^{Opx}	opex growth rate,
$r^{Rev} \; = \; \dfrac{1+r}{1+g^{Rev}} - 1$	"real" rate-of-return for revenue,
$r^{Opx} \; = \; \dfrac{1+r}{1+g^{Opx}} - 1$	"real" rate-of-return for opex,
$FDCfact \; = \; (1+r)^{L/2}$	approximation to pre-startup FDC.

Tax parameters are:

τ	profit tax rate,
ρ	royalty rate,
$TaxProf_t$	tax depreciation schedule (sums to unity),
$Taxlife \; (TL)$	tax life.

Cashflow components per unit output are:

$RRev_t$	required revenue,
$Opex_t$	opex,
Tax_t	tax payed.

To solve for required revenue, let value of unit capex including finance during construction at time 0, V_0^K, equal the value of required unit net operating profit after tax at time 0, V_0^{NOPAT}.

$$\begin{aligned} V_0^K &= (1+r)^{L/2} \cdot K, \\ V_0^{NOPAT} &= \sum_{t=1}^{T} (1+r)^{-t+0.5} \ (\ RRev_t - Opex_t - Tax_t \ ). \end{aligned}$$

Partition the required revenue into required sponsors' revenue and sovereign tax revenue, so that:

$$\begin{aligned} \sum_{t=1}^{T} (1+r)^{-t+0.5} \ (\ RRev_t^S - Opex_t \ ) &= (1 \ + \ r)^{L/2} \cdot K, \\ \sum_{t=1}^{T} (1+r)^{-t+0.5} \ (\ RRev_t^\tau - Tax_t \ ) &= 0. \end{aligned}$$

Partition the cost of service , $COS = COS^S + COS^\tau$. Let:

$$\begin{aligned} RRev_t^i &= COS^i \cdot VolProf_t \cdot (1+g^{Rev})^{t-0.5}, \qquad t \in \{S, \tau\}, \\ Opex_t &= OPXfact \cdot K \cdot OpxProf_t \cdot (1+g^{Opx})^{t-0.5}, \\ Tax_t &= \tau \ (\ Rev_t - Opex_t - TaxProf_t \cdot K \ ). \end{aligned}$$

Now define the escalated profile values:[1]

$$\begin{aligned} V^{Rev} &= \sum_{t=1}^{T} (1+r^{Rev})^{-t+0.5} \cdot VolProf_t, \\ V^{Opx} &= \sum_{t=1}^{T} (1+r^{Opx})^{-t+0.5} \cdot OpxProf_t, \\ V^{Tax} &= \sum_{t=1}^{TL} (1+r)^{-t+0.5} \cdot TaxProf_t, \end{aligned}$$

and annuity and adjustment factors:

$$\begin{aligned} Ann^{Rev} &= 1/V^{Rev}, \\ Adj^{Opx} &= V^{Opx}/V^{Rev}, \\ Adj^{Tax} &= V^{Tax}/V^{Rev}. \end{aligned}$$

So:

$$\begin{aligned} COS^S \cdot V^{Rev} - OPXfact \cdot V^{Opx} &= FCFfact \cdot K, \\ COS^\tau \cdot V^{Rev} &= \tau \cdot (\ (\ COS^S + COS^\tau \ ) \cdot V^{Rev} - OPXfact \cdot V^{Opx} - K \cdot V^{tax} \ ), \end{aligned}$$

[1] Note that in terms of Excel functions, $V = NPV[\ r, profile\_range\ ] \cdot (1+r)^{0.5}$, and when the profile is a constant, say $1/TL$ for straight-line depreciation, $V = PV[\ r, TL, -1/TL\ ] \cdot (1+r)^{0.5}$.

and:

$$COS^S = K \cdot (\ FCFfact \cdot Ann^{Rev} + OPXfact \cdot Adj^{Opx}\ ),$$
$$COS^\tau = K \cdot \frac{\tau}{1-\tau} \cdot (\ FCFfact \cdot Ann^{Rev} - Adj^{Tax}\ ).$$

The total recovery factor, which gives COS when multiplied by K, is the sum of:

$$\begin{aligned} CpxRF &= FCFfact \cdot Ann^{Rev}, \\ OpxRF &= OPXfact \cdot Adj^{Opx}, \\ TaxRF &= \tau/(1-\tau) \cdot (\ CpxRF - Adj^{Tax}\ ), \\ RoyRF &= \rho/(1-\rho) \cdot (\ CpxRF + OpxRF + TaxRF\ ). \end{aligned}$$

The capex recovery factor is the annuitized value of unit initial capex including FDC. The opex recovery factor is the opex factor adjusted for differing escalation between revenue and opex. The profit tax recovery factor is the grossed-up tax on capex recovery minus the value of tax depreciation. And the royalty recovery factor is grossed-up royalty on the prior charges.

Chain economics with losses. A project typically comprises a chain of facilities each of which incurs processing losses. These losses can be evaluated on either a cost-forward or netback basis, depending on whether input supply cost or market value is the relevant opportunity cost.

Consider a chain of facilities, $i \in \{1 \dots n\}$, with segments' unit cost-of-service, $\{c_i\}$, measured in terms of segment outputs $\{q_i\}$, with initial chain input, q_0. Let h_i be the input loss factor, so that:

$$(1 - h_i) = q_i/q_{i-1}, \qquad \text{or} \qquad h_i = q_i/q_{i-1} - 1,$$

Let h_i^* be the output loss factor:

$$(1 + h_i^*) = q_{i-1}/q_i = 1/(1 - h_i) = 1 + h_i/(1 - h_i).$$

Let the value through the chain, $\{v_j\}$, $j \in \{0 \dots n\}$, be determined by:

$$v_j \cdot q_j = v_0 \cdot q_0 + \sum_{i=1}^{j} c_i \cdot q_i.$$

Then:

$$v_j = v_0 \cdot q_0/q_j + \sum_{i=1}^{j} c_i \cdot q_i/q_j,$$

so, for $j \in \{1 \dots n\}$:

$$\begin{aligned} v_j &= c_j + (1 + h_j^*) \cdot v_{j-1}, \\ &= c_j^* + v_{j-1}, \end{aligned}$$

where:

$$c_j^* \quad = \; c_j \; + \; h_j^* \cdot v_{j-1}.$$

The cost-forward value from delivery point 0 is determined by setting $v_0^F = 0$, so that:

$$v_j^F \quad = \; c_j \; + \; h_l^* \cdot v_{j-1}^F \; = \; \sum_{i=1}^{j} c_i^{*F},$$

where the losses are evaluated at the cost-forward values.

To calculate netback values through the chain given v_n^N, it is easiest to proceed recursively by deducting the loss from the subsequent segment, for $j \in \{n-1, \ldots, 0\}$:

$$v_{j-1}^N \; = \; (v_j^N \; - \; c_j) \cdot (1 - h_j).$$

Once the netback values are established, however, as above, for $j \in \{1 \ldots n\}$:

$$v_j^N \; = \; c_j \; + \; h_l^* \cdot v_{j-1}^N \; = \; \sum_{i=1}^{j} c_i^{*N},$$

where:

$$c_j^{*N} \; = \; c_j \; + \; h_j^* \cdot v_{j-1}^N.$$

Using the rough data from the ExxonMobil LNG to UK project together with rough estimates of the necessary parameters, spreadsheets are attached showing the calculation of recovery factors and COS by segment in terms of delivered quantities, chain cost-forward with losses, and netback values with losses.

QP/ExxonMobil LNG to UK

CRF PARAMETERS		*Prodn*	*Processing*	*Shipping*	*Import*
Construction/operation					
Leadtime	y	4	4	3	4
ProjLife	y	25	25	25	25
OpxFact	%	5%	2%	12%	3%
Vol discount	1	50%	50%	50%	50%
Finance/economic					
RRoR	%/y	12%	12%	10%	12%
Rev GR	%/y	2%	2%	2%	2%
Opx GR	%/y	1%	1%	1%	1%
Fiscal terms					
In/PSC tax rate	%	40%	35%	0%	35%
Royalty rate	%	10%	0%	0%	0%
Taxlife (st line)	y	7	12	0	20
Intermediate calculations					
FDCfact	%	125%	125%	115%	125%
Rrev	%/y	9.8%	9.8%	7.8%	9.8%
Ropx	%/y	10.9%	10.9%	8.9%	10.9%
Vrev	%	918%	918%	1075%	918%
Vopx	%	894%	894%	1033%	894%
Vtax	%	69%	55%	0%	40%
AnRev	%	10.9%	10.9%	9.3%	10.9%
AdjOpx	%	97.4%	97.4%	96.0%	97.4%
AdjTax	%	7.5%	6.0%	0.0%	4.3%
Recovery Factors (%/y)					
CpxRF		13.7%	13.7%	10.7%	13.7%
OpxRF		4.9%	1.9%	11.5%	2.9%
TaxRF		4.1%	4.2%	0.0%	5.0%
RoyRF		2.5%	0.0%	0.0%	0.0%
TotRF		25.1%	19.8%	22.2%	21.6%

QP/ExxonMobil LNG to UK

CRF PARAMETERS		*Prodn*	*Processing*	*Shipping*	*Import*	
Construction/operation						
Leadtime	y	4	4	3	4	
ProjLife	y	25	25	25	25	
OpxFact	%	5%	2%	12%	3%	
Vol discount	1	50%	50%	50%	50%	
Finance/economic						
RRoR	%/y	12%	12%	10%	12%	
Rev GR	%/y	2%	2%	2%	2%	
Opx GR	%/y	1%	1%	1%	1%	
Fiscal terms						
In/PSC tax rate	%	40%	35%	0%	35%	
Royalty rate	%	10%	0%	0%	0%	
Taxlife (st line)	y	7	12	0	20	
Recovery Factors (%/y)						
CpxRF		13.7%	13.7%	10.7%	13.7%	
OpxRF		4.9%	1.9%	11.5%	2.9%	
TaxRF		4.1%	4.2%	0.0%	5.0%	
RoyRF		2.5%	0.0%	0.0%	0.0%	
TotRF		25.1%	19.8%	22.2%	21.6%	
PROJECT PARAMETERS		*Prodn*	*Processing*	*Shipping*	*Import*	*Total*
Cost	M$	2,500	4,000	1,800	1,100	
Owners' cost	%	15%	15%	10%	15%	
Cost	M$	2,875	4,600	1,980	1,265	10,720
OpxFact	%	5%	2%	12%	3%	
Plateau volume	Mt/y	17.3	15.6	15.0	14.7	14.7
Loss	%		10%	4%	2%	
Conversion	MBtu/t	51.6	51.6	51.6	51.6	51.6
Plateau volume	TBtu/y	894	805	773	757	757
Unit capacity cost						
K $/(MBtu/y)-exchain		3.80	6.07	2.61	1.67	14.16
K $/(MBtu/y)-exsegment		3.21	5.71	2.56	1.67	
COS ($/MBtu-exchain)		*Prodn*	*Processing*	*Shipping*	*Import*	*Total*
Cpx recovery		0.52	0.83	0.28	0.23	1.86
Opx recovery		0.18	0.12	0.30	0.05	0.65
Tax		0.16	0.25	0.00	0.08	0.49
Royalty		0.10	0.00	0.00	0.00	0.10
Total		0.95	1.20	0.58	0.36	3.10
		Feedgas	*FOB*	*Exship*	*Inland*	
Cumulative		*0.95*	*2.16*	*2.74*	*3.10*	
COS ($/MBtu-exsegment)		*Prodn*	*Processing*	*Shipping*	*Import*	
Cpx recovery		0.44	0.78	0.27	0.23	
Opx recovery		0.16	0.11	0.30	0.05	
Tax		0.13	0.24	0.00	0.08	
Royalty		0.08	0.00	0.00	0.00	
Total		0.81	1.13	0.57	0.36	
Loss			0.09	0.08	0.05	
Total		0.81	1.22	0.65	0.42	
		Feedgas	*FOB*	*Exship*	*Inland*	
Cumulative		*0.81*	*2.03*	*2.68*	*3.10*	
Netback ($/MBtu)		*Prodn*	*Processing*	*Shipping*	*Import*	
Seg COS		0.81	1.13	0.57	0.36	
loss		0.00	0.27	0.16	0.09	
	Resource	*Feedgas*	*FOB*	*Exship*	*Inland*	
Value	*1.61*	*2.42*	*3.62*	*4.55*	*5.00*	