

Exploring the Dynamics of an Energy Service Venture for Energy Efficiency Policy. Paper presented at the 35th International Conference of the System Dynamics Society, Cambridge, Massachusetts, USA.

## Appendix

### Model Documentation

The assumptions, parameters, and correspondent Powersim equations, units, type of variable, and documentation are listed below in alphabetical order. Most of the parameters were estimated using empirical data collected from an ESCO business venture during the period 2009 to 2014.

Acc Net Earnings = INTEGRATE(Net Earnings)

Units: K Eur

Variable type: auxiliary

Documentation: Accumulated net earnings of the ESCO

Adopt Audit = Audits Offered \* Fraction of Audit Adoption

Units: Clients/year

Variable type: auxiliary

Documentation: The rate of persuading interested prospects to purchase and adopt the energy audit from ESCO

Adopt Demo EPC = MIN(Demo Projects/Time to Develop EPC, Total EPC Developed)

Units: Cli/yr

Variable type: auxiliary

Documentation: The rate of performing energy audit, developing project, and agreeing EPC with clients involved in the demonstration programme.

Adopt EPC = EPC Developed\*Fraction of EPC Adoption

Units: Cli/yr

Variable type: auxiliary

Documentation: The rate in which the ESCO agrees EPC with clients.

Adopt PP Audit = MIN(Public Projects/Time to Adopt Audit, Total Audits Offered)

Units: Cli/yr

Variable type: auxiliary

Documentation: The rate in which public entities purchase and adopt the energy audit from ESCO.

Audit Subsidy Effect = (base case = 0; reference value = 1.3; min = 1.2; max = 1.5)

Units: Dimensionless

Variable type: constant

Documentation: This parameter represents the effect of partly subsidizing the audit cost on the fraction of audit adoption.

Source: Perception of ESCO professionals. From case study "Galp Energy Solutions".

Audits in Progress =  $dt * (\text{Adopt Audit} + \text{Adopt PP}) - dt * (\text{Adopt EPC} + \text{Reject EPC})$

Units: Cli

Variable type: level

Documentation: Clients with energy audit in progress.

Audits Offered = Total Audits Offered-Adopt PP Audit

Units: Cli/yr

Variable type: auxiliary

Documentation: Number of Audits that can be sold per year to interested prospects

Average Experience of New HR = 300

Units: Whr/ Emp

Variable type: constant

Documentation: Average experience of new project managers.

Source: Perception of ESCO professionals. From case study "Galp Energy Solutions".

Average HR Experience = HR Experience/HR

Units: Whr/Emp

Variable type: auxiliary

Documentation: Average HR (project managers) experience

Average Time to Hire and Train = 1

Units: yr

Variable type: constant

Documentation: Average time to hire and train new project managers

Source: Perception of ESCO professionals. From case study "Galp Energy Solutions".

Average Time to Learn from EPC = 2

Units: yr

Variable type: constant

Documentation: Average time to learn from EPC project implementation and exploitation.

Source: Perception of ESCO professionals. From case study "Galp Energy Solutions".

Become Informed by HR effort = HR Effort Assigned for Informing Prospects/HR Effort per Prospect

Units: Cli/yr

Variable type: auxiliary

Documentation: The rate in which potential clients become aware and interested prospects from ESCO communication.

Become Interested = Become Interested by WOM + Become Informed by HR effort \* Fraction of Interested

Units: Cli/yr

Variable type: auxiliary

Documentation: The rate in which potential clients become interested prospects. Interested prospects are aware and interested in applying EPC in partnership with the ESCO

Source: The effect of WOM is modelled according to Sterman (2000, p333) and Morecroft (2007, pp166-174).

Become Interested by WOM = Total EPC Adopters \* WOM Contact Rate \* (Potential/Total Potential Market)

Units: Cli/yr

Variable type: auxiliary

Documentation: The rate in which potential adopters become interested prospects from word-of-mouth.

Source: The effect of WOM is modelled according to Sterman (2000, p333) and Morecroft (2007, pp166-174).

Borrowing = Borrowing Cash

Units: K Eur/da

Variable type: auxiliary

Documentation: Amount of cash borrowed per day.

Borrowing Cash = MAX((Minimum cash level-Cash)/TIMESTEP - Incoming Cash + Out-flowing Cash, 0)

Units: K Eur/da

Variable type: auxiliary

Documentation: This is cash flowing into the firm via funds borrowed from debt holders.

$$\text{Capital Charge} = \text{Capital Employed} * \text{WACC}$$

Units: K Eur/yr

Variable type: auxiliary

Documentation: Capital charge is the cost of having the capital charged to the ESCO for use of the capital. The cost of capital is calculated as the weighted average cost of capital (WACC), averaged to a daily rate.

$$\text{Capital Employed} = \text{Cash} + \text{Capital in Projects}$$

Units: K Eur

Variable type: auxiliary

Documentation: ESCO total capital employed

$$\text{Capital in Projects} = dt * (\text{Investing in Projects}) - dt * (\text{Depreciating Projects})$$

Units: K Eur

Variable type: level

Documentation: Capital in Projects represents the net capital employed in EPC projects

$$\text{Cash} = \text{Initial Cash} + dt * (\text{Incoming Cash} + \text{Borrowing Cash}) - dt * \text{Outflowing Cash}$$

Units: K Eur

Variable type: level

Documentation: Cash available for the ESCO

$$\text{Cost of Debt} = \text{IF}(\text{TIME} < (\text{STARTTIME} + \text{Term of Interest Rate Subsidy}), \text{Interest Rate Subsidy}, \text{Market Cost of Debt})$$

Units: %/yr

Variable type: auxiliary

Documentation: Interest rate on debt

$$\text{Cost of Equity} = 15\%$$

Units: %/yr

Variable type: constant

Documentation: Rate of return required by equity holders

Source: Case study of "Galp Energy Solutions" venture

$$\text{Debt} = \text{Initial Debt} + dt * (\text{Borrowing}) - dt * (\text{Repaying})$$

Units: K Eur

Variable type: level

Documentation: The amount of ESCO debt

$$\text{Debt Ratio} = \text{Debt} / (\text{Debt} + \text{Equity})$$

Units: Dimensionless

Variable type: Auxiliary

Documentation: Debt ratio of the ESCO.

$$\text{Demo Programme Term} = 3$$

Units: yr

Variable type: constant

Documentation: Term of the demonstration projects programme

$$\text{Demo Projects} = dt * (\text{Adopt Demo EPC}) - dt * (\text{DP Calling Rate})$$

Units: Cli

Variable type: level

Documentation: These are firms with buildings selected for EPC demonstration projects. They will be submitted to project development and EPC agreeing. It is assumed that the number of demo projects will be available to the startup firm.

$$\text{Depreciating Projects} = \text{Capital in Projects} / \text{Projects Depreciation Time}$$

Units: K Eur/da

Variable type: auxiliary

Documentation: This is depreciation (and accounting) rate (on daily basis) of the project assets.

Desired Rate for Developing EPC = (Audits in Progress+Demo Projects)/Time to Develop EPC

Units: Cli/yr

Variable type: auxiliary

Documentation: Desired number of EPCs to be developed per year

Desired Rate for Implementing EPC = Projects in Progress/Time to Implement Project

Units: Cli/yr

Variable type: auxiliary

Documentation: Desired number of EPC projects to be implemented per year

Desired Rate for Informing Prospects = Potential/Time to Inform Prospects

Units: Cli/yr    auxiliary

Documentation: Desired number of prospects to be informed per year

Desired Rate for Selling Audits = (Interested + Public Projects)/Time to Adopt Audit

Units: Cli/yr

Variable type: auxiliary

Documentation: Desired number of Audits to be sold per year

DP Call = (base case = 0; reference value = 2; min = 1; max = 3)

Units: Cli/yr

Variable type: constant

Documentation: The calling rate for EPC demonstration projects. These are firms with buildings selected for EPC demonstration projects. They will be submitted to project development, and EPC agreeing. It is assumed that that rate of demo projects will be available to the startup firm.

Source: Discussion with ESCO professionals.

DP Calling Rate = IF(TIME < (STARTTIME+Demo Programme Term), DP Call, 0)

Units: Cli/yr

Variable type: auxiliary

Documentation: The calling rate for EPC demonstration projects.

EBIT = Revenues -Operating Expenses

Units: K Eur/yr

Variable type: auxiliary

Documentation: Yearly earnings before interest and taxes (EBIT) of the ESCO

End EPC = EPC Adopters/EPC Term

Units: Cli/da

Variable type: auxiliary

Documentation: The rate in which EPC agreements terminate.

EPC Adopters =  $dt * (\text{Implement EPC}) - dt * (\text{End EPC})$

Units: Cli

Variable type: level

Documentation: Clients that are benefitting from energy efficiency projects implemented by ESCO under an EPC agreement.

EPC Developed = Total EPC Developed-Adopt Demo EPC

Units: Cli/yr

Variable type: auxiliary

Documentation: Number of energy audits (and EPC design) performed per year from prospect base.

EPC Net Saving =  $dt * (\text{Saving Variation from EPC adoption}) - dt * (\text{Saving Variation from EPC Ending})$

Units: K Eur/yr

Variable type: level

Documentation: This stock represents the yearly net revenues produced by EPC projects.

EPC Term = 10

Units: yr

Variable type: constant

Documentation: Average term of EPC

Equity = Initial Equity +  $dt * (\text{Equity Var})$

Units: K Eur

Variable type: level

Documentation: The amount of ESCO equity

Equity Var = Net Earnings

Units: K Eur/yr

Variable type: auxiliary

Documentation: Amount of equity variation per day.

EVA = NOPLAT - (WACC  $\times$  Capital in Projects)

Units: K Eur/yr

Variable type: auxiliary

Documentation: Yearly EVA of the ESCO. EVA is the economic value added every time period which calculates the value created from the revenues after all costs, including capital charges, have been removed.

Expenses per Employee = 50

Units: K Eur/Emp/yr

Variable type: constant

Documentation: The yearly salary (and other related expenses) paid to the average employee (project manager)

Experience from EPC Adoption =  $\text{DELAYINF}(\text{Implement EPC, Average Time to Learn from EPC, 1, 0}) * \text{Experience Gain per EPC Adoption} / 2$

Units: Whr/da

Variable type: auxiliary

Documentation: Amount of experience provided by definition, implementation and exploitation of EPC projects.

Experience from Hiring = Average Experience of New HR  $\times$  HR Hiring Rate

Units: Whr/yr

Variable type: auxiliary

Documentation: Experience from Hiring new project managers

Experience Gain per EPC Adoption = 900

Units: Whr/ Cli

Variable type: constant

Documentation: Amount of experience provided by the definition, implementation and exploitation of each EPC project.

Source: Perception of ESCO professionals. From case study "Galp Energy Solutions" and discussion with ESCO professionals.

Fraction of Audit Adoption = Normal Fraction of Audit Adoption  $\times$  Learning Effects Factor  $\times$

$\text{IF}(\text{TIME} < (\text{STARTTIME} + \text{Term of Audit Subsidy}), \text{Audit Subsidy Effect}, 1)$

Units: %

Variable type: auxiliary

Documentation: Fraction of interested prospects that purchase the energy audit.

Fraction of EPC Adoption = Normal Fraction of EPC Audit Adoption \* Learning Effects Factor

Units: %

Variable type: auxiliary

Documentation: Fraction of clients that decide to adopt EPC and implement the energy efficiency project with the ESCO.

Fraction of Interested = Normal Fraction of Interested \* Learning Effects Factor

Units: %

Variable type: auxiliary

Documentation: Fraction of potential prospects that become interested prospects. Interested prospects are aware and interested in applying EPC in partnership with the ESCO

HR = Minimum HR Desired +  $dt$  \* (HR Hiring Rate) -  $dt$  \* (HR Leaving Rate)

Units: Emp

Variable type: level

Documentation: Project Managers

HR Attrition Rate = 10

Units: %/yr

Variable type: constant

Documentation: The percentage of employees that leave ESCOs each year.

HR Effort Assigned for Developing EPC = MIN(1, Total HR Effort Available/Total HR Effort Desired for EPC) \* HR Effort Desired For Developing EPC

Units: Whr/mo

Variable type: auxiliary

Documentation: The number of person-hours of effort per month assigned for Developing and Selling EPC

HR Effort Assigned for Implementing EPC = MIN(1, Total HR Effort Available/Total HR Effort Desired for EPC) \* HR Effort Desired For Implementing EPC

Units: Whr/mo

Variable type: auxiliary

Documentation: The number of person-hours of effort per month assigned for implementing EPC projects

HR Effort Assigned for Informing Prospects = MIN(HR Effort Available For Informing Prospects, HR Effort Desired for Informing Prospects)

Units: Whr/mo

Variable type: auxiliary

Documentation: The number of person-hours of effort per month assigned for Informing and Persuading Prospects about EPC

HR Effort Assigned for Running EPC = MIN(1, Total HR Effort Available/Total HR Effort Desired for EPC)\*HR Effort Desired For Running EPC

Units: Whr/mo

Variable type: auxiliary

Documentation: The number of person-hours of effort per month assigned for managing all the running EPC projects

HR Effort Assigned For Selling Audits = MIN(HR Effort Available For Selling Audits, HR Effort Desired for Selling Audits)

Units: Whr/mo

Variable type: auxiliary

Documentation: The number of person-hours of effort per month assigned for selling energy audits

HR Effort Available For Informing Prospects = Effort Available For Selling Audits-HR Effort Assigned For Selling Audits

Units: Whr/mo

Variable type: auxiliary

Documentation: The number of person-hours of effort per month available for informing prospects HR

HR Effort Available For Selling Audits = Total HR Effort Available-Total HR Effort Assigned For EPC

Units: Whr/mo

Variable type: auxiliary

Documentation: The number of person-hours of effort per day available for selling energy audits

HR Effort Desired For Developing EPC = Desired Rate for Developing EPC\*HR Effort per EPC Developed

Units: Whr/mo

Variable type: auxiliary

Documentation: The number of person-hours of effort desired per month for developing and selling EPC

HR Effort Desired For Implementing EPC = Desired Rate for Implementing EPC\*HR Effort per Implemented EPC

Units: Whr/mo

Variable type: auxiliary

Documentation: The number of person-hours of effort desired per month for implementing EPC projects

HR Effort Desired for Informing Prospects = Desired Rate for Informing Prospects\*HR Effort per Prospect

Units: Whr/mo

Variable type: auxiliary

Documentation: The number of person-hours of effort desired per month for informing prospects.

HR Effort Desired For Running EPC = EPC Adopters \* HR Effort per Running EPC

Units: Whr/mo

Variable type: auxiliary

Documentation: The number of person-hours of effort that are desired per month for managing all the running EPC projects.

HR Effort Desired for Selling Audits = Desired Rate for Selling Audits\*HR Effort per Audit Offered

Units: Whr/mo

Variable type: auxiliary

Documentation: The number of person-hours of effort desired per month for selling energy audits

HR Effort per Audit Offered = Normal HR Effort per Audit Offered/Learning Effects Factor

Units: Whr/ Cli

Variable type: auxiliary

Documentation: Number of person-hours that are needed for selling an energy audit

HR Effort per EPC Developed = Normal HR Effort per EPC Developed/ Learning Effects Factor

Units: Whr/ Cli

Variable type: auxiliary

Documentation: Number of person-hours that are needed for performing each energy audit (including EPC developing, and selling)

HR Effort per Implemented EPC = Normal HR Effort per Implemented EPC/Learning Effects Factor

Units: Whr/ Cli

Variable type: auxiliary

Documentation: Number of person-hours that are needed for implementing each EPC project

HR Effort per Prospect = Normal HR Effort per Prospect/Learning Effects Factor

Units: Whr/Cli

Variable type: auxiliary

Documentation: The number of person-hours of effort needed per prospect

HR Effort per Running EPC = Normal HR Effort per Running EPC/Learning Effects Factor

Units: Whr/yr/Cli

Variable type: auxiliary

Documentation: Number of person-hours per year that are needed for managing each running EPC project

HR Expenses = (Expenses per Employee) \* HR

Units: K Eur/da

Variable type: auxiliary

Documentation: Salaries and other related expenses paid per day to employees (project managers)

HR Experience = Minimum HR Desired \* Average Experience of New HR +  $dt$  \* (Increase HR Experience) –  $dt$  \* (Loss of HR Experience)

Units: Whr

Variable type: level

Documentation: Cumulative project management, engineering and sales experience of ESCO in terms of number of person-hours

HR Experience Reference = 900

Units: Whr/ Emp

Variable type: constant

Documentation: Amount of HR experience that will produce normal productivity in all activities

Source: Perception of ESCO professionals. From case study "Galp Energy Solutions" and discussion with ESCO professionals.

HR Fractional Experience Decay Rate = 10

Units: %/yr

Variable type: constant

Documentation: Fractional experience decay rate in terms of %/year. It represents the loss of effective experience. Employee knowledge and experience become obsolete because of technological changes.

Source: Literature review, case study of "Galp Energy Solutions" venture, and discussion with ESCO professionals.

HR Hiring Rate = HR to Hire/ Average Time to Hire and Train

Units: Emp/yr

Variable type: auxiliary

Documentation: Hire HR based on how many persons are needed and the average time to get and train them.

HR Leaving Rate = HR Attrition Rate\*HR

Variable type: auxiliary

Documentation: The number of employees that leave ESCO each day as a result of attrition.

Hire = IF(MIN(MAX(Minimum HR Desired, Minimum HR Needed), Maximum HR Desired) - HR > 0, MIN(MAX(Minimum HR Desired, Minimum HR Needed), Maximum HR Desired) - HR, 0)

Variable type: auxiliary

Documentation: The number of persons to hire

Percent EPC = HR Effort Assigned for Implementing EPC/ HR Effort per Implemented EPC

Variable type: auxiliary

Documentation: The rate of project completion.

Incoming Cash = Revenues

Variable type: auxiliary

Documentation: This is cash flowing into the ESCO via revenues from clients.

$$\text{Increase HR Experience} = \text{Experience from EPC Adoption} + \text{Experience from Hiring}$$

Variable type: auxiliary

Documentation: ESCO employees learn from time spent working with EPC based projects

$$\text{Increase in Potential Market} = \text{Yearly Increase in Potential Market} * \text{Total Potential Market}$$

Variable type: auxiliary

Documentation: The rate in which potential market (potential adopters) is increased.

$$\text{Initial Cash} = \text{Initial Debt} + \text{Initial Equity}$$

Variable type: constant

### Documentation: Initial debt of the ESCO

Initial Debt = 0

Variable type: constant

### Documentation: Initial debt of the ESCO

Source: Case study of "Galp Energy Solutions" venture

Initial Equity = 1,000

Variable type: constant

Documentation: Initial equity of the ESCO

Source: Case study of "Galp Energy Solutions" venture

Initial Market = 600

Variable type: constant

Documentation: Initial number of potential EPC adopters

Source: ADENE - National Energy Agency

$$\text{Interest Expense} = \text{Debt} * \text{Cost of Debt}$$

Variable type: auxiliary

Documentation: Interest expense on debt

Interest Rate Subsidy = (base case = 0; reference value = 2.5; min = 0; max = 5)

Units: %/yr

Variable type: constant

Documentation: This is the subsidized value of the interest rate on debt.

Source: Discussion with ESCO professionals.

Interested =  $dt * (\text{Become Interested}) - dt * (\text{Adopt Audit} + \text{Reject Audit})$

Units: Cli

Variable type: level

Documentation: Number of firms with buildings capable (legal, economically and technically) of adopting EPC that are aware and interested in applying EPC in partnership with the ESCO.

Investing in Projects = Investment per EPC\*Implement EPC

Units: K Eur/da

Variable type: auxiliary

Documentation: This is the financial investment rate (on daily basis) for the energy efficiency projects.

Investment per EPC = 450

Units: K Eur/Cli

Variable type: constant

Documentation: This is the average investment per EPC project.

Source: Case study of "Galp Energy Solutions" venture

Learning Effects Factor =  $(\text{MIN}(\text{Average HR Experience}/\text{HR Experience Reference}, 1))^{\text{LN}(1+\text{Productivity Factor Change per Double Experience})/\text{LN}(2)}$

Units: Dimensionless

Variable type: auxiliary

Documentation: This variable represents the learning curve for productivity from experience

Source: Formula 12-61 presented in section 12.2 of Sterman (2000, p507).

Loss of HR Experience = HR Leaving Rate\*Average HR Experience + HR Experience \* HR Fractional Experience Decay Rate

Units: Whr/da

Variable type: auxiliary

Documentation: This rate represents the loss of employee experience from attrition and knowledge obsolescence.

Lost Prospects =  $dt * (\text{Total Lost Prospects}) - dt * (\text{Regain Potential})$

Units: Cli

Variable type: level

Documentation: Potential prospects that are not interested in EPC and decide to implement in house energy efficiency projects.

Market Cost of Debt =  $\text{GRAPHCURVE}(\text{Debt Ratio}, 0, 0.05, \{0.065, 0.065, 0.065, 0.065, 0.065, 0.065, 0.065, 0.065, 0.065, 0.065, 0.065, 0.07, 0.085, 0.10, 0.12, 0.14, 0.16, 0.18, 0.195, 0.2, 0.2//\text{Min:0;Max:0.3//}\}) * 100$

Units: %/yr     auxiliary

Documentation: A graphical function of the debt interest rate.

Maximum Cash Level = 200

Units: K Eur

Variable type: constant

Documentation: Maximum cash availability in the ESCO

Maximum HR Desired = 30

Units: Emp

Variable type: constant

Documentation: Maximum number of employees (project managers)

Source: Case study of "Galp Energy Solutions" venture

Minimum cash level = 100

Units: K Eur

Variable type: constant

Documentation: Minimum cash availability in the ESCO

Minimum HR Desired = 5

Units: Emp

Variable type: constant

Documentation: Minimum number of employees (project managers)

Source: Case study of "Galp Energy Solutions" venture

Minimum HR Needed = (Total HR Effort Desired for EPC+HR Effort Desired for Selling Audits)/Work Hours per Month

Units: Emp

Variable type: auxiliary

Documentation: The number of employees (project managers) needed to perform total work effort

MVA = NPV(EVA\*TIMESTEP, WACC)

Units: K Eur

Variable type: auxiliary

Documentation: MVA (market value added) is the present value of futures EVAs and is estimated by summing the discounted economic value added (EVA)

Net Earnings = EBIT-Interest Expense-Taxes

Units: K Eur/yr

Variable type: auxiliary

Documentation: Yearly net earnings of the ESCO

Net Saving per EPC = Normal Net Saving per EPC\*Learning Effects Factor

Units: K Eur/yr/Cli

Variable type: auxiliary

Documentation: This variable represents the yearly net revenues produced by a new EPC project

No Interested = Become Informed by HR effort\*(1-Fraction of Interested)

Units: Cli/yr

Variable type: auxiliary

Documentation: The rate in which potential prospects become no potential prospects as they are no more capable (legal, economically and technically) of adopting EPC, or they are not interested in EPC and decide to implement in house energy efficiency projects.

NOPLAT = EBIT \* (1-Tax Rate)

Units: K Eur/yr

Variable type: auxiliary

Documentation: Yearly net operating profit less amortizations and taxes (NOPLAT) of the ESCO

Normal Fraction of Audit Adoption = 40

Units: %

Variable type: constant

Documentation: Normal fraction of interested prospects that purchase the energy audit.

Source: Sales reports from "Galp Energy Solutions"

Normal Fraction of EPC Audit Adoption = 50

Units: % Variable type: constant

Documentation: Normal fraction of clients that decide to adopt EPC.

Source: Sales reports from "Galp Energy Solutions"

Normal Fraction of Interested = 30

Units: % Variable type: constant

Documentation: Normal fraction of potential prospects that become interested prospects.

Source: Sales reports from "Galp Energy Solutions"

Normal HR Effort per Audit Offered = 70

Units: Whr/ Cli      Variable type: constant

Documentation: Normal number of person-hours that are needed for selling an energy audit

Source: Sales reports and time sheets from "Galp Energy Solutions"

Normal HR Effort per EPC Developed = 300

Units: Whr/ Cli      Variable type: constant

Documentation: Normal number of person-hours that are needed for performing one energy audit (including EPC developing, and selling)

Source: Sales reports and time sheets from "Galp Energy Solutions"

Normal HR Effort per Implemented EPC = 600

Units: Whr/ Cli      Variable type: constant

Documentation: Normal number of person-hours that are needed for implementing each EPC project

Source: Sales reports and time sheets from "Galp Energy Solutions"

Normal HR Effort per Prospect = 21

Units: Whr/Cli      Variable type: constant

Documentation: The normal number of person-hours of effort needed per prospect

Source: Sales reports and time sheets from "Galp Energy Solutions"

Normal HR Effort per Running EPC = 250

Units: Whr/yr/Cli Variable type: constant

Documentation: Normal number of person-hours per year that are needed for managing each running EPC project

Source: Sales reports and time sheets from "Galp Energy Solutions"

Normal Net Saving per EPC = 155

Units: K Eur/yr/Cli Variable type: constant

Documentation: Normal yearly net revenues produced by each EPC project

Source: Sales reports from "Galp Energy Solutions"

$$\text{Operating Costs} = \text{HR Expenses} + \text{Overhead Costs}$$

Units:K Eur/da Variable type: auxiliary

Documentation: Daily operating costs of the ESCO

$$\text{Operating Expenses} = \text{Operating Costs} + \text{Depreciating Projects}$$
Units: K Eur/yr  
Variable type: auxiliary

Documentation: Daily operating expenses of the ESCO

Outflowing Cash = Investing in Projects + Taxes + Operating Costs + Interest Expense + Repaying

Units: K Eur/da

Variable type: auxiliary

Documentation: The daily outlay of cash to pay for investments in EPC projects, as well as to pay taxes, operating costs and repay principal on debt.

Overhead Costs = 100

Units: K Eur/yr

Variable type: constant

Documentation: Yearly overhead costs

Source: Reports from "Galp Energy Solutions"

Potential = Initial Market +  $dt$  \* (Increase in Potential Market + Regain Potential) –  $dt$  \* (Become Interested + Not Interested)

Units: Cli

Variable type: level

Documentation: A number of firms with buildings capable (legal, economically and technically) of adopting EPC that are not aware or are not interested in EPC.

PP Call = 0 (base case = 0; reference value = 2; min = 1; max = 3)

Units: Cli/yr

Variable type: constant

Documentation: The calling rate for EPC public projects involved in the public procurement programme. These are public buildings selected for EPC project implementation.

Source: Discussion with ESCO professionals

PP Calling Rate = IF(TIME < (STARTTIME + PP Programme Term), PP Call, 0)

Units: Cli/yr

Variable type: auxiliary

Documentation: The calling rate for EPC public projects. These are public buildings selected for EPC project implementation.

PP Programme Term = 3

Units: yr

Variable type: constant

Documentation: Term of the public procurement programme

Productivity Factor Change per Double Experience = 0.3

Units: Dimensionless

Variable type: constant

Documentation: Fractional change in HR productivity factor per doubling of their experience. This variable represents the strength of the learning curve.

Source: Sterman (2000), Miller and Sterman (2007), and discussion with ESCO professionals

Projects Depreciation Time = 10

Units: yr

Variable type: constant

Documentation: Average life time of project equipment

Projects in Progress =  $dt$  \* (Adopt EPC + Adopt Demo EPC) –  $dt$  \* (Implement EPC)

Units: Cli

Variable type: level

Documentation: Clients that are implementing energy efficiency projects under an EPC agreement.

Public Projects =  $dt * (\text{PP Calling Rate}) - dt * (\text{Adopt PP Audit})$

Units: Cli

Variable type: level

Documentation: These public buildings are selected for EPC project implementation as part of a public procurement programme to stimulate ESCO market. These public buildings are capable (legal, economically and technically) of adopting EPC. These building' managers launch a call for implementing EPC project in partnership with an ESCO. These buildings will be submitted to energy audit, project development, and EPC agreeing. It is assumed that that the number of public projects will be available to the startup firm.

Regain Potential = Lost Prospects/Time to Regain Potential

Units: Cli/yr

Variable type: auxiliary

Documentation: The rate in which lost prospects become potential clients.

Reject Audit = Audits Offered \* (1-Fraction of Audit Adoption)

Units: Cli/mo

Variable type: auxiliary

Documentation: The rate in which potential clients reject ESCO offer for performing energy audit. These clients decide to purchase the energy audit from another ESCO or lose interest in EPC and they decide otherwise not to adopt EPC and to implement in house projects .

Reject EPC = EPC Developed\*(1-Fraction of EPC Adoption)

Units: Cli/yr

Variable type: auxiliary

Documentation: The rate in which potential clients reject the ESCO offer for EPC. These clients decide to sign the EPC with another ESCO or they decide otherwise not to adopt EPC and to implement in house projects.

Repaying = IF (Debt Ratio > Target Debt Ratio, MIN( MAX(Cash - Maximum Cash Level, 0), Debt - Debt/Debt Ratio \* Target Debt Ratio), 0)/TIMESTEP

Units: K Eur/da

Variable type: auxiliary

Documentation: Principal is paid on the debt, if the debt to equity ratio is higher than the desired ratio. The amount paid is the lesser of (1) debt over the desired debt level, or (2) available cash. Available cash is the amount over the maximum desired cash level.

Revenue per Audit = 40

Units: K Eur/Cli

Variable type: constant

Documentation: The average price paid for energy audit and efficiency project design.  
Source: Reports from "Galp Energy Solutions"

Revenue per EPC Developed = 20

Units: K Eur/Cli

Variable type: constant

Documentation: The average price paid for efficiency project design. This value is applied to public projects and demonstration projects.

Revenues = EPC Net Saving + Adopt Audit \* Revenue per Audit + (Adopt PP Audit + Adopt Demo EPC) \* Revenue per EPC developed

Units: K Eur/yr

Variable type: auxiliary

Documentation: Yearly revenues of the ESCO

Saving Variation from EPC adoption = Implement EPC\*Net Saving per EPC

Units: K Eur/yr/da

Variable type: auxiliary

Documentation: This variable represents the yearly net revenues added per day from new EPC projects.

Saving Variation from EPC Ending = End EPC \* IF(EPC Net Saving>0, (EPC Net Saving/EPC Adopters), 0)

Units: K Eur/yr/da

Variable type: auxiliary

Documentation: This variable represents the yearly net revenues lost per day from ending EPC projects.

Target Debt Ratio = 0.5

Units: Dimensionless

Variable type: constant

Documentation: Desired debt ratio. Debt ratio = debt/ (equity + debt)

Tax Rate = 26.5

Units: %

Variable type: constant

Documentation: The annual ESCO tax rate is assumed to be 26.5%.

Taxes = (EBIT-Interest Expense)\* Tax Rate

Units: K Eur/da

Variable type: auxiliary

Documentation: Taxes are based on profits before taxes (EBIT-Interest Expense) multiplied by the tax rate.

Term of Audit Subsidy = 3

Units: yr

Variable type: constant

Documentation: Term to apply the subsidy on cost of energy audit

Term of Interest Rate Subsidy = 10

Units: yr

Variable type: constant

Documentation: Time to apply the subsidy on debt interest rate.

Source: It is assumed that the subsidy will last for 10 years as this is the term of the first EPC

Time to Adopt Audit = 4

Units: mo

Variable type: constant

Documentation: Average time to persuade prospects to adopt energy audit

Source: Reports from "Galp Energy Solutions"

Time to Develop EPC = 4

Units: mo

Variable type: constant

Documentation: Average time to perform audit, design, and sell EPC

Source: Reports from "Galp Energy Solutions"

Time to Implement Project = 9

Units: mo

Variable type: constant

Documentation: Average time to implement an EPC project

Source: Reports from "Galp Energy Solutions"

Time to Inform Prospects = 4

Units: yr Variable type: constant

Documentation: Average time to inform prospects on EPC

Source: Reports from "Galp Energy Solutions"

Time to Regain Potential = 10

Units: yr                      Variable type: constant

Documentation: Average time to regain potential prospects

$$\text{Total Audits Offered} = \text{HR Effort Assigned For Selling Audits} / \text{HR Effort per Audit Offered}$$
Units: Cli/yr  
Variable type: auxiliary

Documentation: Number of energy audits that can be sold per year. It includes energy audits from public programme.

$$\text{Total EPC Adopters} = \text{EPC Adopters} + \text{Projects in Progress}$$

Units: Cli Variable type: auxiliary

Documentation: Total EPC adopters

$$\text{Total EPC Developed} = \text{HR Effort Assigned for Developing EPC} / \text{HR Effort per EPC Developed}$$
Units: Cli/yr  
Variable type: auxiliary

Documentation: Number of energy audits (including EPC design) performed per year. It includes demonstration projects.

$$\text{Total HR Effort Assigned For EPC} = \text{HR Effort Assigned for Developing EPC} + \text{HR Effort Assigned for Implementing EPC} + \text{HR Effort Assigned for Running EPC}$$

Units: Whr/da Variable type: auxiliary

Documentation: The number of person-hours (HR effort) per day assigned for developing, selling, implementing, and running EPC projects

Total HR Effort Available = HR\*Work Hours per Month

Units: Whr/mo Variable type: auxiliary

Documentation: The number of person-hours of effort that are available per day

$$\text{Total HR Effort Desired for EPC} = \text{HR Effort Desired For Developing EPC} + \text{HR Effort Desired For Implementing EPC} + \text{HR Effort Desired For Running EPC}$$

Units: Whr/da Variable type: auxiliary

Documentation: The number of person-hours of effort per day desired for developing, selling, implementing, and running EPC projects

$$\text{Total Lost Prospects} = \text{Not Interested} + \text{Reject Audit} + \text{Reject EPC} + \text{End EPC}$$
Units: Cli/yr  
Variable type: auxiliary

Documentation: The total rate in which potential clients reject the ESCO offer for EPC. These clients decide to sign the EPC with another ESCO or they decide otherwise not to adopt EPC and to implement in house projects.

$$\text{Total Potential Market} = \text{Potential} + \text{Interested} + \text{Audits in Progress} + \text{Projects in Progress} + \text{EPC Adopters} + \text{Lost Prospects}$$

Units: Cli Variable type: auxiliary

Documentation: Total of EPC adopters and potential prospects

$WACC = \text{Cost of Equity} * (\text{Equity}/(\text{Debt} + \text{Equity})) + \text{Cost of Debt} * (1 - \text{Tax Rate}) * (\text{Debt}/(\text{Debt} + \text{Equity}))$

Units: %/yr

Variable type: auxiliary

Documentation: The weighted average cost of capital (WACC) calculates the weighted average cost of having equity holders and debt holders, who have different rates of return that they require. The WACC is used to calculate the capital charge.

$WOM \text{ Contact Rate} = (\text{reference value} = 3; \text{min} = 3; \text{max} = 9)$

Units: Cli/Cli/yr

Variable type: constant

Documentation: The rate of Word-of-mouth contact between adopters and prospects. The number of prospects contacted per adopter per year.

Source: Reports from "Galp Energy Solutions" and discussion with ESCO professionals

$\text{Work Hours per Month} = 160$

Units: Whr/Emp/mo

Variable type: constant

Documentation: How many hours each employee works per month

$\text{Yearly Increase in Potential Market} = 1$

Units: %/yr    constant

Documentation: Yearly increase in potential market

Source: It is assumed a rate equivalent to the growth of national economy