"INOGATE Technical Secretariat & Integrated Programme in support of the Baku Initiative and the Eastern Partnership energy objectives" Project

BUILDING PARTNERSHIPS FOR ENERGY SECURITY

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EE/RES Project Feasibility Assessment through Life Cycle Cost Analysis

Workshop AM.093:

“Capacity building for financing EE/RES projects”

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Vahan Babajanyan
Banking and Financial Expert,
INO Gate Technical Secretariat
1. To learn more about Life Cycle Cost Analysis (LCCA)

2. To learn to apply the analysis
SECTION 1

KEY NOTIONS

ENERGY EFFICIENCY and RENEWABLE ENERGY SOURCES
WHAT is ENERGY?

E = mc²

ENERGY IS LIFE

Global Political Factor
Determining Factor of Development
Determining Ecological Factor
ENERGY SAVING and ENERGY EFFICIENCY

Energy Saving
- Any decrease / reduction of losses
- Less energy for the same function

Energy Efficiency
- More functions for the given energy
- More production for the same energy
RENEWABLE ENERGY SOURCES

Natural Resources

- Solar
- Wind
- Geothermal
- Hydro
- Waves

Bio Resources

- Biomass
- Biofuel

FAST REPLACEMENT

LIMITLESS RESOURCES
NON-RENEWABLE ENERGY SOURCES

Fossil resources

- Oil
- Natural Gas
- Coal

Limited resources

No replenishment
SECTION 2

KEY ECONOMIC NOTIONS and FINANCIAL INDICATORS

FINANCIAL FEASIBILITY of a PROJECT
The NEED for ECONOMIC ANALYSIS

- Economics play a dominant role in the decision whether the management/owner and the financing institutions will invest in an EE/RES project.

- The energy manager must learn to speak management’s language.

- The energy manager must present projects in relevant economic terms.
Project Profitability Analysis

- **Profitability analysis** is a method used for financial feasibility of a project.

- **Life Cycle Cost Analysis (LCCA)** takes into account the entire life of a project and time value of money.
Life Cycle Cost Analysis

- **Life Cycle Cost Analysis (LCCA)**
  - Considers all costs,
  - Separates savings from investments
  - Outputs both absolute (NPV) and relative (SIR) savings

- **Cost of capital perspective**
  - The value of energy savings diminishes each year
  - High interest rate limits the scope of projects
TIME VALUE of MONEY

Why do we need it?

Cash is the KING

Money you have today worth more than in the future

- Future Value (FV) shows how much money will be worth at a specific time in the future. *Compounding.*
- Present Value (PV) shows how much future money is worth today. *Discounting.*
- Discount Rate (i) is a rate at which the future benefit can be compared to the present value.
## Weighted Average Cost of Capital

<table>
<thead>
<tr>
<th>#</th>
<th>INDICATOR</th>
<th>REFERENCE</th>
<th>VALUE</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Weighted Average Cost of Capital</td>
<td>WACC</td>
<td>0.1200</td>
<td>$WACC = KE \cdot WE + KD \cdot (1-T) \cdot WD$</td>
</tr>
<tr>
<td>2</td>
<td>Cost of Equity</td>
<td>KE</td>
<td>0.1265</td>
<td>$KE = RFR + B \cdot MRP + SCP + ARP$</td>
</tr>
<tr>
<td>3</td>
<td>Equity Weight</td>
<td>WE</td>
<td>0.5500</td>
<td>Equity share in liabilities</td>
</tr>
<tr>
<td>4</td>
<td>Cost of Debts</td>
<td>KD</td>
<td>0.1400</td>
<td>Max interest rate</td>
</tr>
<tr>
<td>5</td>
<td>Profit Tax</td>
<td>T</td>
<td>0.2000</td>
<td>Profit Tax – 20%</td>
</tr>
<tr>
<td>6</td>
<td>Weight of Liabilities</td>
<td>WD</td>
<td>0.4500</td>
<td>Debt Share in Liabilities</td>
</tr>
<tr>
<td>7</td>
<td>Risk Free Return</td>
<td>RFR</td>
<td>0.0600</td>
<td>Average bond profitability</td>
</tr>
<tr>
<td>8</td>
<td>Business Risk / Beta</td>
<td>B</td>
<td>0.5500</td>
<td>Risk of the Business</td>
</tr>
<tr>
<td>9</td>
<td>Market Risk Premium</td>
<td>MRP</td>
<td>0.0400</td>
<td>For this country</td>
</tr>
<tr>
<td>10</td>
<td>Small Company Risk</td>
<td>SCR</td>
<td>0.0245</td>
<td>Volume/Scale of business</td>
</tr>
<tr>
<td>11</td>
<td>Add. Risk Premium</td>
<td>ARP</td>
<td>0.0200</td>
<td>Market Trends</td>
</tr>
</tbody>
</table>
Discounting rate includes:

- Risk free rate
- Inflation
- Risk premium

Example:

Discount rate - Central (National) bank discount rate.
Compounding:

- Sum: $100
- Interest: 5%
- Period: 5 yr

TIME VALUE of MONEY

\[ FV_1 = 100 \times (1+5\%)^1 \]
\[ FV_2 = 100 \times (1+5\%)^2 \]
\[ FV_3 = 100 \times (1+5\%)^3 \]
\[ FV_4 = 100 \times (1+5\%)^4 \]
\[ FV_5 = 100 \times (1+5\%)^5 \]
Compounding

• Year 1: \(+ 5\% \text{ of } $100.00 = $105.00\)
• Year 2: \(+ 5\% \text{ of } $105.00 = $110.25\)
• Year 3: \(+ 5\% \text{ of } $110.25 = $115.76\)
• Year 4: \(+ 5\% \text{ of } $115.76 = $121.55\)
• Year 5: \(+ 5\% \text{ of } $121.55 = $127.63\)

Formula for calculation of compounding

\[ FV = PV \times (1+i)^n \]
COMPOUNDING EFFECT

Investments

Compounded investments
COMPOUNDING EFFECT: AGGREGATE

Compounded Investments

Investments

0 1 2 3 4 5 6 7 8 9 10

0 500 1000 1500 2000 2500 3000
Discounting:

- Sum - $100
- Interest - 5%
- Period - 5 лет

\[ FV_1 = \frac{100}{(1+5\%)^1} \]
\[ FV_2 = \frac{100}{(1+5\%)^2} \]
\[ FV_3 = \frac{100}{(1+5\%)^3} \]
\[ FV_4 = \frac{100}{(1+5\%)^4} \]
\[ FV_5 = \frac{100}{(1+5\%)^5} \]
Discounting

- Year 5: $100 / (1+0,05)^5 = $78,35
- Year 4: $100 / (1+0,05)^4 = $82,27
- Year 3: $100 / (1+0,05)^3 = $86,38
- Year 2: $100 / (1+0,05)^2 = $90,70
- Year 1: $100 / (1+0,05)^1 = $95,24

Formula for calculation of discounting

\[ PV = FV / (1+i)^n \]
DISCOUNTING EFFECT

Savings

Discounted Savings
DISCOUNTING EFFECT, AGGREGATE

Savings

Discounted Savings
NET PRESENT VALUE

\[ NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1 + i)^t} \]

and

INTERNAL RATE of RETURN

\[ NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1 + IRR)^t} = 0 \]

\[ IRR = IRR \left( i: \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t} = 0 \right) \]

- **B** – Benefits
- **C** – Costs
- **t** – Period
- **I** – K / interest rate
• **Payback Period (PBP)** is the length of time required to recover the cost of an investment

\[ PBP = \text{Cost of Project} / \text{Cash Inflow} \]

• There are two main problems with the payback period (PBP):
  – This method does not inform about profitability.
  – This method ignores the time value of money.
SECTION 3

TEN STEPS

Algorithm to Determine FINANCIAL FEASIBILITY of a Project
1. Repair of equipment.
2. Investments, Capital expenditures.
3. Energy and O&M costs.

Two scenarios

Scenario “1” - OLD

1. Repair of equipment.
2. Investments, Capital expenditures.
3. Energy and O&M costs.

Scenario “2” - NEW

1. Purchase of new equipment.
2. Investments, capital expenditures.
3. Energy and O&M costs.

Comparison of scenarios

Evaluation of effectiveness
1. Determine Old Costs.
2. Determine New Costs.
3. Calculate the difference.
4. Choose discount rate.
5. Choose analysis period.

Stage 2. CHOICE and ASSESSMENT
7. Calculate Present Value of Annual Savings.

8. Calculate Present Value of Investments.


10. Calculate Internal Rate of Return (IRR).
LCC indicators demonstrate the economic project feasibility of a project

- Absolute project worth: **NPV** (net present value)
- Relative project worth: **SIR** (savings-to-investment ratio)
- Specific to user: **IRR** (internal rate of return)

**These are economic indicators that investors understand.**
STEP 1.

DETERMINE OLD COSTS
(Baseline Conditions)

a) Life Cycle re-investments;

b) Annual energy costs;

c) Annual operation & maintenance (O&M) costs;

d) Other annual costs
STEP 1. DETERMINE OLD COSTS

a) Life cycle re-investments

Questions you have to find answers to !!!

- Does equipment need an overhaul?
- When and how often?
- How much money to re-invest?

Examples of re-investments:

- Overhaul of a compressor every 5 years;
- Replacing lamps every 10,000 hours
Suppose:

- Old equipment needs periodic re-investments to keep going.
- These «old» re-investment costs = €50 000 every 4 years
  
  *(from maintenance records)*

- Last replacement was 2 years ago, so next one is in year 2.
STEP 1. DETERMINE OLD COSTS

a) Old Re-investments Table

Enter data in “OLD” Column

<table>
<thead>
<tr>
<th>ГОД</th>
<th>СТАРЫЕ</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
</tr>
<tr>
<td>1</td>
<td>50,000</td>
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<tr>
<td>2</td>
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<td>4</td>
<td></td>
</tr>
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<td>5</td>
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<td>6</td>
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<td></td>
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<td>14</td>
<td>50,000</td>
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<td>15</td>
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<td>16</td>
<td></td>
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<tr>
<td>17</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>50,000</td>
</tr>
<tr>
<td>19</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

Starting Point Year “0”
STEP 1. DETERMINE OLD COSTS

b) Annual Energy Costs

Old annual energy costs

Old energy consumption \times Energy tariffs

Information source:
- actual, paid bills
- Metre data multiplied by cost of energy

Example:
Old annual energy costs

\[ \text{= €177,000/yr (from energy audit)} \]
1. Come from actual records of maintenance and bills; 
2. Often data is missing, auditor is forced to estimate.

Example:

- Assume poor maintenance at low cost.
- O&M = €2 500/yr.
• Penalties should be included in the analysis as a cost of operating the old equipment.

• List other annual old costs that will be affected by the project, such as:
  - productivity;
  - penalties for pollution.
STEP 2. DETERMINE NEW COSTS

a) Initial Investments;
b) Life Cycle Re-investments;
c) Annual Energy Costs;
d) Annual Operations and Maintenance (O&M) costs;
e) Other annual costs.
STEP 2.

DETERMINE NEW COSTS

a) Initial Investments

Initial Investment = Basic project cost + Engineering + Profit + Contingency + Taxes + Other

Important to uncover all the initial costs!

For estimation purposes, add costs as %.
## STEP 2. DETERMINE NEW COSTS

### a) Initial Investments

<table>
<thead>
<tr>
<th>B / Basic project cost</th>
<th>=</th>
<th>€78,000 (from Energy Audit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial investment</td>
<td>=</td>
<td>B/cost + engineering + profit + contingency + taxes</td>
</tr>
<tr>
<td></td>
<td>=</td>
<td>Basic project cost \times (1 + 0.2 + 0.1 + 0.1 + 0.2)</td>
</tr>
<tr>
<td></td>
<td>=</td>
<td>€78,000 \times 1.6</td>
</tr>
<tr>
<td></td>
<td>=</td>
<td>€124,800</td>
</tr>
</tbody>
</table>

Starting Point Year “0”
## STEP 2. DETERMINE NEW COSTS

### b) Life Cycle Re-investments

<table>
<thead>
<tr>
<th>5-year replacement costs</th>
<th>= 25% of the initial investment (from manufacturer’s recommendation)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>= 0.25 x €124,800</td>
</tr>
<tr>
<td></td>
<td>= €31,200</td>
</tr>
</tbody>
</table>

Enter data in years «1» to end of «New re-investments» column of the investment table.
a) and b) New Investment and Re-investment

- There is no 20th year for reinvestment, even with 20-year analysis.

- Investments are regarded to be made at the end of each year.

- At the end of the last year of analysis, the project is over.

- Further investment requires a new project with new analysis.

<table>
<thead>
<tr>
<th>ГОД</th>
<th>НОВЫЕ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>124,800</td>
</tr>
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</tr>
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<td>4</td>
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<td>5</td>
<td>31,200</td>
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<tr>
<td>6</td>
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<td>7</td>
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<td>8</td>
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<td>9</td>
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<td>10</td>
<td>31,200</td>
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<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>
**Where to find?**

- Information from manufacturers
- The most realistic operating assumptions

**Example:**

New annual energy costs = \( \text{€132.000/yr} \)  
(from energy audit)
O&M Costs must be estimated realistically

Example:
New O&M costs

€5,000/yr
(from manufacturer’s recommendations)
List other annual new costs that will be improved by the project,

**Such as:**

- Improved productivity;
- Reduced penalties.
STEP 3. CALCULATE DIFFERENCES

Difference = Life cycle re-investments

Annual savings

GOAL

ASSESS ABSOLUTE FINANCIAL EFFECT

HOW

Calculation of Investments

Calculation of Savings
Investments and re-investments

ONLY non-annual costs

Spreadsheet subtracts old costs from new costs

Net = new – old
Increased O&M costs

VITAL ! ! ! Rigorous observance of new maintenance rules

STEP 3. CALCULATE DIFFERENCES

b) Annual Savings

Annual cost savings = New Energy costs - Old energy costs

Factors in annual savings may be negative

Old O&M + Old other = New O&M + New other

Increased O&M costs
STEP 3. CALCULATE DIFFERENCES

b) Annual Savings

Annual Savings: €176,000 - €132,000 = €44,000

= €41,500

+ €2,500 - €5,000 = €0

+ €0 - €0 = €0

Enter in appropriate input cell

<table>
<thead>
<tr>
<th>Annual Savings</th>
<th>EUR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>41,500</td>
</tr>
</tbody>
</table>
The discount rate for an investment depends on the type of financing, equity or loan.

Choose a discount rate

\[ r = 12\% \] (from lender interest rate)

Enter discount rate in appropriate input cell.
Only a short analysis period should be used in an unstable economic situation with high interest rates.

Savings and expenses beyond 10 years become trivial due to heavy discounting.

Choose analysis period

\[ T = 20 \text{ years} \]

Enter data in appropriate input cell

<table>
<thead>
<tr>
<th>Annual Savings</th>
<th>EUR</th>
<th>41,500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount Rate</td>
<td>%</td>
<td>12</td>
</tr>
<tr>
<td>Analysis Period</td>
<td>Years</td>
<td>20</td>
</tr>
<tr>
<td>Residual Value</td>
<td>EUR</td>
<td></td>
</tr>
</tbody>
</table>
STEP 6. ESTIMATE RESIDUAL VALUE of EQUIPMENT

• What is equipment worth at the end of analysis period?

• Residual value acts as a credit to the project in final year

Residual Value

• market price at the project end
• 10% of purchase price

Estimated residual value of equipment
€ 16,000

Enter residual value in appropriate input cell

<table>
<thead>
<tr>
<th>Annual Savings</th>
<th>EUR</th>
<th>41,500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount Rate</td>
<td>%</td>
<td>12</td>
</tr>
<tr>
<td>Analysis Period</td>
<td>Years</td>
<td>20</td>
</tr>
<tr>
<td>Residual Value</td>
<td>EUR</td>
<td>16,000</td>
</tr>
</tbody>
</table>
For each year:

- Present value (PV) of savings = year’s savings (AS) divided by (1+ discount rate), raised to the power of the year when the savings occur.

- Total PV of savings during the analysis period is the sum of all annual PVs_{AS}.

\[
PV_{AS} = \sum_{t=1}^{T} AS_t \times \frac{1}{(1+r)^t} = AS_1 \times \frac{1}{(1+r)^1} + AS_2 \times \frac{1}{(1+r)^2} + \ldots + AS_{20} \times \frac{1}{(1+r)^{20}}
\]
STEP 7. CALCULATE PRESENT VALUE of ANNUAL SAVINGS

<table>
<thead>
<tr>
<th>$\text{PV}_{\text{AS}}$</th>
<th>=</th>
<th>Total present value of all annual savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T$</td>
<td>=</td>
<td>Total number of the years in the analysis</td>
</tr>
<tr>
<td>$\text{AS}_t$</td>
<td>=</td>
<td>Annual savings in the year $t$</td>
</tr>
</tbody>
</table>

If $T = 20$ years

$\text{PV}_{\text{AS}} = €309,982$

<table>
<thead>
<tr>
<th>YEAR</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>18</th>
<th>19</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANNUAL SAVINGS</td>
<td>-</td>
<td>41,500</td>
<td>41,500</td>
<td>41,500</td>
<td>41,500</td>
<td>41,500</td>
</tr>
<tr>
<td>PV ANNUAL SAVINGS</td>
<td>-</td>
<td>37,054</td>
<td>33,084</td>
<td>5,397</td>
<td>4,818</td>
<td>4,302</td>
</tr>
<tr>
<td>TOTAL PV ANNUAL SAVINGS</td>
<td>-</td>
<td>37,054</td>
<td>33,084</td>
<td>5,397</td>
<td>4,818</td>
<td>4,302</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>309,982</td>
</tr>
</tbody>
</table>
STEP 8. CALCULATE PRESENT VALUE of INVESTMENTS

For each year:

\[ PV = \text{year's investment}\ (I) \div (1 + \text{discount rate}) \times (1 + \text{discount rate})^t \]

- **Total PV** of investments is the sum of all annual PVs.
- **Investment in the final year is the decommissioning/clean-up cost (if any), minus the residual value of the equipment**.

\[ PV_I = \sum_{t=0}^{T} I_t \times \frac{1}{(1+r)^t} = I_0 \times \frac{1}{(1+r)^0} + I_1 \times \frac{1}{(1+r)^1} + \ldots + I_{19} \times \frac{1}{(1+r)^{19}} + \frac{\text{Res. Val.}}{(1+r)^{20}} \]
STEP 8. CALCULATE PRESENT VALUE of INVESTMENTS

If \( T = 20 \) years

\[
PV_1 = \text{Present Value of Investments}
\]

\[
I_t = \text{Investment in the year } t
\]

\[
PV_1 = €58,568
\]
STEP 9. CALCULATE NET PRESENT VALUE (NPV)

- The net present value (NPV) of a project is its life cycle net savings.

- It is the absolute monetary value of a project.

- NPV shows the total potential earnings of a project.

- NPV considers the effect of interest on future net savings.

- NPV is a major decision making tool for project owners and investors.
STEP 9. CALCULATE NET PRESENT VALUE (NPV)

Example:

\[ \text{NPV} = \text{PV}_{\text{AS}} - \text{PV}_1 \]

\[
\text{NPV} = €309,982 - €58,568 \\
\text{NPV} = €251,414
\]

If **NPV > 0**, a project is profitable (economically feasible).
STEP 10. CALCULATE SAVINGS-to-INVESTMENT RATION (SIR)

Savings-to-Investment Ration (SIR) can be a vital indicator for some project owners and for a comparative analysis.

\[ SIR = \frac{PV_{AS}}{PV_i} \]

**Example:**

\[ SIR = \frac{\€309,982}{\€58,568} \]

\[ SIR = 5.29 \]

If SIR > 1.0, a project is profitable (economically feasible).
If $\text{IRR} \geq$ the discount rate used in the analysis, the investment is worthwhile (economically feasible).

A high IRR means more profit per investment Euro.

IRR is a major decision making tool for lenders, usually the first question they ask.

Investors may each arbitrarily set their own minimum acceptable IRR, called a “hurdle rate”.

$$\text{SIR} = 1.0 \text{ or } \text{NPV} = 0$$
OUTPUT

INDICATORS of FINANCIAL FEASIBILITY of a PROJECT
A positive NPV shows how much money the project will make in its lifetime.

A negative NPV shows how much money the project will lose.

NPV shows the project’s absolute feasibility in terms of money.

NPV = €309,982
SIR (savings-to-investment ratio) is the same as a benefit / cost ratio.

If $SIR > 1.0$, the project makes more money than it costs.

If $SIR < 1.0$, the project costs more than it makes.

SIR shows the project’s relative feasibility in percent.
IRR is the interest in per cent that the project’s investment will earn.

- Theoretical discount rate for which $NPV = 0$ or $SIR = 1.0$.

- Theoretically, any project with $IRR$ greater than the company’s cost of capital is profitable.

- “Hurdle rates” for $IRR$ are higher than a company’s cost of capital.
Simple payback (SPB), expressed in years, does not discount its input or consider future re-investment costs.

SPB is only used for projects with quick return.

If a project can pay in a year, there is no little need to calculate discounted future values.

For longer paybacks, SPB becomes inaccurate.

OUTPUT - SPB

SPB = 3.01
• What is the purpose of Life Cycle Cost analysis?

• Why is it necessary to have correct and complete data for the analysis?

• What stages of LCC analysis do you know?

• What do the results of LCC analysis tell you?
For additional information

l.good@inogate.org
v.babajanyan@inogate.org
Secretariat.kiev@inogate.org
www.inogate.org

Larry Good, Key Expert, Sustainable Energy
Vahan Babajanyan, Financial and Banking Expert