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Air Quality Governance in the ENPI East Countries

"Feasibility Study for implementation of two scenarios of Ambient Air Quality Monitoring Network (AQMN) in Georgia"

Activity 4 Report – Task 2

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Summary

PROJECT TITLE:	Preliminary Air Quality Assessment for Georgia
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LIST OF ABBREVIATIONS AND ACRONYMS

Atmospheric Dispersion Modelling System	ADMS
Above Sea Level	a.s.l.
Degrees Celsius (centigrade)	^0C
Carbon Monoxide	CO
Methane	CH_4
Caucasus Environmental NGO Network	CENN
European Union	EU
European Neighbourhood Partnership Initiative	ENPI
Lead	Pb
Maximum Allowable Concentration	MAC
Metre	m
Millimetre	mm
Micrograms per cubic metre	$\mu g/m^3$
Milligrams per cubic metre	mg/m^3
Manganese dioxide	MnO_2
Ministry of Environmental and Natural Resources Protection	MoENRP
National Environmental Agency	NEA
Nitrogen dioxide	NO_2
Nitrogen oxides	NO_x
Non-methane volatile organic compounds	NMVOC
Ozone	O_3
Particulate Matter	PM
SEAP	Sustainable Energy Action Plan
Square kilometre	km^2
Sulphur dioxide	SO_2
Tonnes per year	t/y
Total Suspended Particulates	TSP
Volatile organic compounds	VOC

1. INTRODUCTION

1.1. AIR QUALITY STANDARDS

This report attempts to evaluate the feasibility of development either the minimum or maximum national monitoring network scenarios for and elaborate recommendations using comparative analysis.

In Georgia air quality standards are established by the Order #38/n (February 24, 2003) of the Minister of Labour, Health and Social Affairs of Georgia on ***Approval of Environment Quality Norms*** and Order #297/n of the Minister of Labour, Health and Social Affairs (August 16, 2001) on Amendments to the Orders.

Georgia air quality standards contain maximal allowable concentration (MAC) for 589 substances defined by daily means and maximum values, and almost all of them are identical to the Soviet standards.

Georgian Laws on ***Environment Protection*** and ***Ambient Air Protection*** states that air quality standards shall be determined every 5 years, though this has only occurred once (2012) since 2003.Existing national air quality standards do not cover important pollutants as PM_{10} and $PM_{2.5}$.

Therefore it can be concluded that existing air quality standards are out-dated and essentially irrelevant to the EU principles. It is necessary to renew these standards, taking into consideration Directives 2008/50/EC and 2004/107/EC.

1.2. AIR QUALITY MONITORING STATIONS

Responsible body for air quality monitoring in Georgia is the National Environmental Agency (NEA), which is a Legal Entity of Public Law (LEPL) under the Ministry of Environment and Natural Resources Protection (MoENRP). Measurements of pollutants in ambient air are provided by the Department of Environment Pollution Monitoring. The total number of staff working on air quality monitoring is 14. Of the 589 air polluting substances required to be monitored under existing legislation, regular monitoring is carried-out only for 8 pollutants, such as: dust, SO_2, NO_2, CO, O_3, Pb, MnO_2, NO.

Of the current 8air quality monitoring stations, 4 of them are located in Tbilisi and the remainder located across Georgian cities of Batumi, Kutaisi, Zestaphoni and Rustavi. Only one station, in Tbilisi, is fully automated.

A single rural background EMEP station in Abastumani, measures Cations and Anions in precipitation, and PM_{10}, Ozone and Main Ions in the air.

Information on which substances are monitored in each station is presented in *Table 1*.

Table 1 - **Substances measured on existing stations**

Cities	Tbilisi	Batumi	Rustavi	Kutaisi	Zestaphoni

Cities	Tbilisi				Batumi	Rustavi	Kutaisi	Zestaphoni
Number of Stations / Pollutants	1	2	3	4	1	1	1	1
Dust	✓	✓			✓		✓	✓
SO_2	✓	✓			✓		✓	✓
NO_2	✓	✓	✓		✓	✓	✓	✓
CO	✓	✓	✓	✓	✓	✓	✓	✓
O_3	✓	✓						
Pb		✓						
MnO_2								✓
NO	✓						✓	
NO_X	✓							
PM_{10}	✓							
$PM_{2,5}$	✓							

2. OBJECTIVE AND METHODOLOGY OF THE FEASIBILITY STUDY

Where a project has reached the proposal stage, a series of steps and challenges are required to test the viability, sustainability and value of the proposal. This is typically carried as a set of evaluations and analysis, using prior investigations and research to support the process of decision making. This practice forms what is commonly termed a feasibility study.

2.1. Objective

The objective of this feasibility study is to realistically and quantitatively and/or qualitatively explore the strengths and weaknesses of the institutions, personnel and infrastructure within the existing air quality network. Further the feasibility study will evaluate what, if anything needs, to be enhanced to meet the demands of the proposed national air quality monitoring network. Part of this process examines the existing opportunities and threats to the proposed national air quality monitoring network, the resources and budget required, current skills available and those required and the general likelihood of the proposal succeeding.
In simple terms, the two principal criteria in the feasibility of the national air quality monitoring network have been evaluated are the costs required and the value to be attained.

2.2. Methodology of the Feasibility study

The approach used in assessing the feasibility of the national air quality monitoring network included looking at the background and necessity for a monitoring network, financial resources required, management and organisational and operational aspects of the proposed network and external resources required for the network to operate sustainably.
Three areas of the network programme were explored to examine the viability of the maximum and minimum scenarios, these were:

- Technical Feasibility- Is the project technically possible.
- Economic Feasibility - Can the project be afforded? Will it have long-term benefits and monetary savings?
- Managerial Feasibility – How can the project be controlled, who will be responsible?

In order to consistently categorise the existing staff, resources and management arrangement against the requirements for a CAFE directive compliant national monitoring network, a SWOT (strengths, weaknesses, opportunities, threats) matrix was used for each of the three network programme areas:

Figure 1 SWOT Matrix

	Helpful in strengthening the network	Harmful in establishing the network
Internal (attributes of the organisation)	Strengths	Weaknesses
External (attributes of the environment))	Opportunities	Threats

2.3. EVALUATION

An evaluation of the state of the Georgian air quality monitoring network against the EU directive requirement of national air quality monitoring network was completed.

2.4. MITIGATION

Where threats and weaknesses were identified, an action was identified to either neutralise the threat or support the area which was deemed weak.
Where strengths and opportunities were identified, actions were identified which could either exploit the opportunity or allow the strength to be fully utilized.

2.5. ASSESSMENT TARGET

The implementation of the ambient air quality network in Georgia was assessed against the EU Air Quality Directive requirements. It was these standards to which the Georgian air quality monitoring network was to be capable of reaching, and the transition between the two, existing air quality network and EU Air Quality Directive compliant network, that this feasibility study focused upon.

3. REVIEW OF THE EU AIR QUALITY DIRECTIVE MONITORING REQUIREMENTS

3.1. Common Assessment Approach

EU air quality directives (2004/07/EC and 2008/50/EC) are clear in that they require states to assess concentrations of major air pollutants such as particulate matter (PM_{10} and $PM_{2.5}$) and nitrogen dioxide (NO_2) in outdoor air against legally binding limits. This should be conducted using a ‘Common Approach’ of measurement methods at a certain type and number of sample points against defined concentration limits.

The common approach includes use of ‘Reference Method’ detection systems following internationally established (ISO) and standardised sampling and detection methods.

Use of common or harmonised procedures allows Member States to reliably and consistently quantify the uncertainties associated with their measurements of air pollution.

3.2. Location and number of sample points

EU air quality directives stipulate that there be a minimum number of monitoring stations per ‘zones’ or ‘agglomerations’ of a member state. This is in order to establish a uniform distribution of monitoring sites across member states.

Member states are obliged to assess ambient air quality within their territory, the territory can be divided into zones which reflect their population, population density and land area, and agglomerations.

Ambient air can be assessed within a zone using:

- continuous measurement at a fixed location sampling
- a combination of continuous measurement at a fixed location sampling and modelling techniques and or indicative measurement
- modelling techniques or objective-estimation techniques or both.

The type of monitoring technique to be employed, either fixed sampling or indicative, depends on whether a pollutant exceeds either the lower or upper assessment threshold at the preliminary assessment stage. If the concentration of a pollutant falls below the ‘lower assessment threshold (50% of the limit value)’ then indicative methods may be used for assessments, though the ‘upper assessment threshold (70% of the limit value)’ or between upper and lower assessment thresholds then fixed location sampling must be used.

The location of sampling points, according to the Annexes of both Directives need to be positioned were the measurement of pollutants’ concentration in ambient air provides data on the concentrations of pollutants both in highly populated areas (impact on human health) and in the rural areas which are not influenced by agglomerations or concentrated pollution sources (impact on vegetation and ecosystems). There is a requirement that sampling point locations are to be balanced between the types of sample location (e.g. traffic, industrial or background), area type (e.g. urban, suburban or rural) and the character of the area (residential, commercial, industrial, agricultural or natural).

Sampling points should be chosen so that the measurement of very small micro-environments is avoided, and they are representative for air-quality monitoring in their vicinity. These areas vary for different types of area characters (e.g. 100 m^2 meters in the case of traffic or industrial sites to 1000 km^2 in the case of stations targeted at obtaining the information related to the protection of vegetation).

3.3. CONCENTRATION THRESHOLDS

Air quality is assessed against 'target values', 'limit values' for human health and 'critical levels' for ecosystem protection.

EU Limit values are legally binding EU parameters that must not be exceeded. Most importantly, these are set for individual pollutants and are made up of a concentration value, an averaging time over which it is to be measured.

In order to successfully assess impact air pollutant impacts, LV averaging times vary according the health impacts of a particular pollutant (see Table 2 and 3 below).

Table 2. European Air Quality Directive limit and target values for the protection of human health

Pollutant	Limit Value	Concentration measured as	Date to be achieved within EU by and thereafter	Margin of Tolerance[1]
PM_{10}	50 µg/m^3 not more than 35 times a year	24 hour mean	31 December 2004	50%
	40 µg/m^3	Annual Mean	31 December 2004	20%
$PM_{2.5}$	Target value 25 µg/m^3	Annual Mean (Calendar year)	1January2015	20% on 11 June 2008, decreasing on the next 1 January and every 12 months thereafter by Equal annual percentages to reach 0% by 1 January 2015
	Limit Value 20µg/m^3	Annual Mean (Calendar year)	31 December 2019	0%
Nitrogen Dioxide	200 µg/m^3not to be exceeded more than 18 times a year	1 hour mean	31 December 2009	0% after 31 December 2009
	40 µg/m^3	Annual Mean (Calendar year)	31 December 2009	50% on 19 July 1999, decreasing on 1 January 2001 and every 12 months thereafter by equal annual percentages to reach 0% by 1 January 2010 after 31 December 2009

Pollutant	Limit Value	Concentration measured as	Date to be achieved within EU by and thereafter	Margin of Tolerance[1]
Ozone	Target of 120 µg/m^3 not to be exceeded on more than 25 days per year per calendar averaged over 3 years	Maximum 8 hour mean	31 December 2009	None
Sulphur Dioxide	350 µg/m^3 not to more exceeded more than 24 times a year	1 hour mean	31 December 2004	150 µg/m^3 (43%)
	125 µg/m^3not to more exceeded more than 3 times a year	24 hour mean	31 December 2004	None
Polycyclic aromatic hydrocarbons	1 ng/m^3 B(a)P	PM_{10} Fraction over a calendar year	31 December 2010	None
Benzene	5 µg/m^3	As annual average	31 December 2009	0% after 31 December 2009
Arsenic	6 ng/m^3	PM_{10} Fraction over a calendar year	1 January 2008	0%
Cadmium	5 ng/m^3	PM_{10} Fraction over a calendar year	1 January 2008	0%
Nickel	20 ng/m^3	PM_{10} Fraction over a calendar year	1 January 2008	0%
Carbon Monoxide	10 mg/m^3	Maximum daily running 8 hour mean	31 December 2004	60%
Lead	0.5 µg/m^3	Annual mean (Calendar year)	31 December 2004 (31 December 2004 for Industrial contaminated sites)	100%

Limit and target value averaging times for the protection of vegetation and ecosystems (Table 4) are in addition to those for human receptors and include annual averages for Oxides of Nitrogen and Sulphur Dioxide. Though due to the historically high concentrations of Sulphur Dioxide in ambient air over the winter periods in Northern Europe, due to increased fossil fuel use during that period, an additional Sulphur Dioxide winter average averaging period (1Octoberto31March) has been identified for the purposes of protection of vegetation.

The limit value for ozone, known as AOT40, is the accumulated ozone exposure over a threshold of 40ppb (80 µg/m^3) during hours of sunlight between spring and summer. This sum is takes into account that a high concentration of ozone over a long-period has the potential of damaging habitats.

Table 3. European Directive Limit and target values for the protection of vegetation and ecosystems

Pollutant	Limit Value	Concentration measured as
Oxides of Nitrogen	30 µg/m^3	Annual Mean (Calendar year)
Sulphur Dioxide	20 µg/m^3	Annual Mean (Calendar year) & Winter (1 Oct to 31 March)
	125 µg/m^{3}not to more exceeded more than 3 times a year	Winter average
Ozone: protection of vegetation & ecosystems	Target of 18,000 µg/m^3 based on AOT40[2] to be calculated from 1 hour values from May to July and to be achieved, so far as possible, by 2010	Average over 5 years

3.4. CONCENTRATION THRESHOLDS DATA QUALITY OBJECTIVES FOR AMBIENT AIR QUALITY ASSESSMENT IN EU DIRECTIVES

Quality requirements for the quality of data acceptable to Directive 2008/50/EC are set out in a series of Data Quality Objectives. These include uncertainty, minimal data capture and minimal time coverage.

Data Quality Objectives for fixed measurements (long-term), such as a permanently located continuous monitor are set out in Table 4, and data quality objectives for indicative measurements (short-term) are set-out in Table 5.

Where a pollutant concentration is well below the lower assessment threshold (as set out in part A, Annex II of the CAFE Directive) then it is acceptable to use indicative measurements instead of continuous measurements for benzene, lead and particulate matter. Random measurements may be used where it can be demonstrated that combined uncertainty meets the quality objective of 25%, the time coverage is still larger than the minimum time coverage for indicative measurements; and random sampling is evenly distributed over the year in order to avoid skewing of results.

Table 4. Data quality objectives for the fixed measurement of ambient air quality assessment in National Networks

Objective Criteria	SO_2, NO_2 and NO_x and CO	Benzene	PM_{10}, $PM_{2.5}$ and Pb	Ozone and related NO and NO2	B(a)P	AS, Cd, & Ni	PAH's other than B(a)P, total gaseous Hg	Total Deposition
	Fixed Measurements							
Uncertainty	15 %	25 %	25 %	15 %	50 %	40 %	50 %	70 %
Minimum data capture	90 %	90 %	90 %	90 % during summer	90 %	90 %	90 %	90 %
				75 % during winter				
Minimum time coverage					33 %	50 %		
- Urban Background and traffic	-	35 %	-	-				
- Industrial sites	-	90 %	-	-				

Table 5. Data quality objectives for indicative measurement of air quality assessment in National Networks

Objective Criteria	SO_2, NO_2 and NO_x and CO	Benzene	PM_{10}, $PM_{2.5}$ and Pb	Ozone and related NO and NO_2	B(a)P	AS, Cd, & Ni	PAH's other than B(a)P, total gaseous Hg	Total Deposition
	Indicative Measurements							
Uncertainty	25 %	30 %	50 %	30 %				
Minimum data capture	90 %	90 %	90 %	90 %				
Minimum time coverage	14 %	14 %	14 %	> 10 % during summer	14 %	14 %	14 %	33 %
Objective estimation Uncertainty	75 %	100 %	100 %	75 %				

4. REVIEW OF THE PROPOSED SCENARIOS

4.1. AIR QUALITY SCENARIOS

Based on preliminary air quality assessment results maximum and minimum air pollution scenarios were derived. These relate to the scale of the initial national network, in terms of number of EU-compliant stations, pollutants' to be monitored and geographic areas where these species to be monitored.

For both scenarios, it is proposed to limit the species to be monitored to SO_2, NO_2/ NO_x and $PM_{10/2.5}$.This was in response to the monitoring data available and the risk associated that it was amongst those species that an exceedance was most likely. Similarly, in terms of geographic scope of the network it is proposed to limit the initial network to zones/cities and agglomerations to those areas where enough data are available to judge about the exceedances of EU LAT, UAT and LVs.

Both scenarios used evidence from a minimum of two out of three data sources (monitoring, modelling, passive sampling) to assign whether an LAT, UAT or LV were at risk of being exceeded. Where less than three sources were available, greater weight was given to the data source which indicated a risk of an exceedance.

For the maximum scenario, long-term monitoring measurements were assumed as being valid measurements and thus, pollutants' concentrations received through these measurements were also considered valid.

The verification factor of 0.43, derived from the ratio between diffusion tube data and continuous monitoring data, was applied to all continuous monitoring data in order to provide a minimum scenario of long-term measurement. This bias factor of 0.43 was applied nationally to all continuous monitoring data for clarity.

In the absence of a statistical relationship between hourly and daily SO_2 concentrations, against annual average SO_2 concentrations in Georgia, a conservative assumption was made that maximum daily SO_2 concentrations would achieve a magnitude of a factor of 3 of the annual average. Therefore an assessment of compliance against SO_2 daily concentrations was made by multiplying the annual average by a factor of 3.

Ambient air quality monitoring data availability was limited to the spots where the existing air quality sampling network stations are located. Therefore it is apparent that the new air quality network will be biased towards the locations already occupied by the current network. Evidence suggests that air quality is currently very poor in both Tbilisi and Rustavi, and at risk of exceeding as a minimum LAT's in all locations where an air quality sampling station is currently located due to high concentration of point and non-point sources in these urban areas and their suburbs and high health risks related to these pollution sources. It is therefore recommended that the ambient air quality network is developed in the same host cities where air quality has been assessed as currently at risk of exceeding either LATs, UAT's or LV's. The focus should be made on urban and suburban atmospheric air quality.

4.2. CITIES IN GEORGIA WHERE AMBIENT AIR SPECIES MONITORING IS REQUIRED ASSUMING A MINIMUM SCENARIO UNDER THE CAFE DIRECTIVE

Based on the assessment of risks of exceeding EU LAT, UAT and LVs for major pollutants of CAFE Directive, scoped out for Georgia's initial network design, cities where ambient air species should be monitored were identified under minimum scenario. Below is given the table of cities where monitoring is required assuming minimum scenario under the CAFE Directive:

Table 6.Cities in Georgia where Ambient Air Species Monitoring is Required Assuming a Minimum Scenario under the CAFE Directive

Assessment Method	SO_2	NO_2	PM_{10}
		Batumi*(Adjara)*	
Continuous Monitoring		Hourly UAT Annual LV	Daily LV, Annual LV
Passive Sampling	N/A	Hourly LV, Annual LV	N/A
		Zestaphoni *(Imereti)*	
Continuous Monitoring			Daily LV, Annual LV
Modelling		Annual LV	
Passive Sampling	N/A	Annual LV	N/A
		Kutaisi*(Imereti)*	
Continuous Monitoring	Daily LAT	Hourly UAT, Annual LV	Daily LV, Annual LV
Modelling		Hourly UAT, Annual LV	Annual LAT
Passive Sampling	N/A	Annual LAT, Annual UAT,	
		Rustavi *(Kvemo Kartli)*	
Continuous Monitoring		Hourly UAT Annual UAT	N/A
Modelling	Daily LV	Hourly UAT, Annual LV	Daily LAT, Annual UAT
Passive Sampling	N/A	Annual LAT	N/A
		Tbilisi (agglomeration)	
Continuous Monitoring	Daily LV	Hourly LV,Annual UAT	Daily LV, Annual LV
Modelling	No exceedances	Annual LAT, Annual UAT	Annual UAT
Passive Sampling	N/A	Hourly LV, Annual LV	N/A

4.3. CITIES WHERE AMBIENT AIR SPECIES MONITORING IS REQUIRED ASSUMING A MAXIMUM SCENARIO UNDER THE CAFE DIRECTIVE

Based on assessment of risks of exceeding EU LAT, UAT and LVs for major pollutants of CAFE Directive, scoped out for Georgia's initial network design, Georgia cities where ambient air species should be monitored were identified under maximum scenario. Below is given the table of cities where monitoring is required assuming minimum scenario under the CAFE Directive.

Table 7.Cities in Georgia where Ambient Air Species Monitoring is Required Assuming a Maximum Scenario under the CAFE Directive

Assessment Method	SO_2	NO_2	PM_{10}
		Batumi (Adjara)	
Continuous Monitoring	Daily UAT	Hourly LV, Annual LV	Daily LV, Annual LV
Passive Sampling		Hourly LV, Annual LV	

Zestaphoni (Imereti)			
Continuous Monitoring	Daily UAT	Annual LV	Daily LV, Annual LV
Modelling		Annual LV	
Passive Sampling		Annual LAT, Annual UAT	
Kutaisi (Imereti)			
Continuous Monitoring	Daily LV	Hourly LV, Annual LV	Daily LV, Annual LV
Modelling		Hourly UAT, Annual LV	Annual LAT
Passive Sampling		Annual LAT, Annual UAT	
Rustavi (Kvemo Kartli)			
Continuous Monitoring		Hourly LV, Annual LV	
Modelling	Daily LV	Annual LV.	Daily LAT, Annual UAT
Passive Sampling		Annual LAT	
Tbilisi (Agglomeration)			
Continuous Monitoring	Daily UAT	Hourly LV, Annual LV	Daily LV, Annual LV
Modelling	No exceedances	Annual LAT, Annual UAT	Annual UAT
Passive Sampling		Hourly LV, Annual LV	

4.4. Minimum Scenario National Network Requirements

The national network under a minimum assessment scenario requires continuous monitoring at 15 locations, of which 8 should be SO_2, NO_x/NO_2 measurement locations and 7 – $PM_{2.5}$ and PM_{10} locations.

Table 8. Minimum Number of Monitoring Stations required against Zone and Agglomeration Populations for the Minimum Scenario

Number	Zone	Population	Land Area (km^2)	Min Number Monitoring Stations				Monitoring / Modelling Data
				Max Concentrations exceed UAT		Max Concentrations are between the LAT and UAT		
				Pollutant (except PM)	$PM_{10+2.5}$	Pollutant (except PM)	$PM_{10+2.5}$	
1	Abkhazia	180,000[1]	8,660					No data
2	Racha Lechkhumi, Kvemo and Zemo Svaneti	51000[2]	4954					No data
3	Samegrelo, Guria	407,100[2] 140,300[2]	7440 2033					No data
4	Adjara region	393,700[2]	2,900			1	2	Monitoring Modelling/ Passive Sampling
5	Imereti Region	109,000[2]	6,552	1	2			Monitoring Modelling/ Passive Sampling
6	Shida Kartli + South Ossetia	314,600[2]	6,200					No data
7	Akhaltsikhe (Samckhe	214,200[2]	6,413					No data

	Javakheti)							
8	Kvemo Kartli	511,300[2]	6,528	2				Monitoring Modelling/ Passive Sampling
	including Rustavi	(122,900)						
9	Mtskheta – Mtianeti	479,500[2]	6,785					No data
	Kakheti	47,000[2]	11,379					
10	Tbilisi	1,1727,700[2]	726	4			3	Monitoring Modelling/ Passive Sampling

Co-locating PM_{10} and $PM_{2.5}$ instruments withNO_2 and SO_2 instruments will reduce the total number of stations to 8. Taking into considerations that there is 1 automated urban background monitoring station in Tbilisi measuring all above pollutants only 7 new monitoring stations will be required for the network.

Table 9.*Regional Distribution of National Air Monitoring Stations in Georgia under Minimum Scenario with measurement o-locations*

Zone Number	Potential Monitoring Locations	Min Number Reference Monitoring Stations					
		If Max Concentrations exceed UAT			If Max Concentrations are between the LAT and UAT		
		Co-located stations: Pollutant SO_2, NO_2, $PM_{10+2.5}$	SO_2, NO_2	$PM_{10+2.5}$	Co-located stations: Pollutant SO_2, NO_2, $PM_{10+2.5}$	SO_2, NO_2	$PM_{10+2.5}$
1	Imereti Region:	1		1			
	Kutaisi						
	Zestaphoni						
	Chiatura						
5	Adjara region:				1		1
	Batumi						
8	Kvemo Kartli:	2					
	Rustavi						
10	Tbilisi	3	1				

The locations of the existing monitoring network stations have been reported as not compliant with EU classification criteria for "urban background station" and are categorised as "road-side monitoring stations", except for new automated station in Tbilisi that is located in the sub-urban location of Tbilisi and can be considered as "suburban/urban background" station. It is proposed that the EU compliant national air quality monitoring network be located within the same cities as the existing monitoring stations, though that sampling locations be tested for their compliance with the category of urban background station. Where an existing sample station fails this test, then an alternative, more suitable location is to be sought.

4.5. Maximum Scenario National Network Requirements

Under a maximum air quality scenario, monitoring is required at 24 locations, of which 9 should be SO2, NO_x/NO_2 measurement locations and 15 – $PM_{2.5}$ and PM_{10} measurement locations.

Table 10. Number of Monitoring Stations required against Zone and Agglomeration Populations alone for the Maximum Scenario

Number	Zone	Population	Land Area (km^2)	Min Number Monitoring Stations				Monitoring / Modelling Data
				Max Concentrations exceed UAT		Max Concentrations are between the LAT and UAT		
				Pollutant (except PM)	$PM_{10+2.5}$	Pollutant (except PM)	$PM_{10+2.5}$	
1	Abkhazia	180,000[1]	8,660					No data
2	Racha Lechkhumi, Kvemo and Zemo Svaneti	119,400[2]	4954					No data
3	Samegrelo, Guria	407,100[2] 140,300[2]	7440 2033					No data
4	Adjara region	393,700[2]	2,900	2	3			Monitoring Modelling/ Passive Sampling
5	Imereti Region	707,500[2]	6,552	2	3			Monitoring Modelling/ Passive Sampling
6	Shida Kartli + South Ossetia	314,600[2]	6,200					No data
7	Akhaltsikhe (Samckhe Javakheti)	214,200[2]	6,413					No data
8	Kvemo Kartli	511,300[2]	6,528	2	3			Monitoring Modelling/ Passive Sampling
	including Rustavi	(122,900)						
9	Mtskheta – Mtianeti	109,700[2]	6,785					No data
	Kakheti	407,000[2]	11,379					
10	Tbilisi	1,172,700[2]	726	4	6			Monitoring Modelling/ Passive Sampling

1 http://www.britannica.com/EBchecked/topic/1358/Abkhazia
2 National Statistics Office of Georgia, Number of Population as of January 1, 2010-2012

Co-locating PM_{10} and $PM_{2.5}$monitors with SO_2 and NO_2instruments could reduce total number of sampling locations down to 10.Taking into considerations that there is 1 automated urban background monitoring station in Tbilisi measuring all above pollutants only 9 new monitoring stations will be required for the network.

Table 11.***Regional Distribution of National Air Monitoring Stations in Georgia under Maximum Scenario with measurement instrument co-locations***

Zone	Potential Monitoring	Min Number Reference Monitoring Stations

Number	Locations	If Max Concentrations exceed UAT			If Max Concentrations are between the LAT and UAT		
		Co-located stations: Pollutant SO_2, NO_2, $PM_{10+2.5}$	SO_2, NO_2	$PM_{10+2.5}$	Co-located stations: Pollutant SO_2, NO_2, $PM_{10+2.5}$	SO_2, NO_2	$PM_{10+2.5}$
1	Imereti Region:	1		1			
	Kutaisi						
	Zestaphoni						
	Chiatura						
5	Adjara region:	2		1			
	Batumi						
8	Kvemo Kartli:	2		1			
	Rustavi						
10	Tbilisi	4		2			

4.6. SUPPLEMENTARY MONITORING TO THE NATIONAL MONITORING NETWORK

Several regions of Georgia (Abkhazia, Racha Lechkhumi, Kvemo and Zemo Svaneti, Samegrelo, Guria, Akhaltsikhe, Shida Kartli, South Ossetia, Kakheti and Mtskheta – Mtianeti) currently have little or no record of air quality being monitored within their boundaries. Due to a combination of resources constraints, low populations and a lower density of point sources within these regions, it has had to be assumed that these regions therefore have a lower risk of air quality LV's being exceeded with a lower risk of local populations being exposed to unacceptable levels of air borne pollutants. However, all of the above assumptions currently remain untested, and will require justification within any future Preliminary Assessment of Georgian air quality.

In order to provide an air quality monitoring record with sufficient geographical coverage to test the above assumptions, whilst meeting the CAFE Directive data quality objectives for indicative measurements, a proposal to distribute supplementary monitoring across the low risk regions has been developed (Table12), which are the same for both minimum and maximum scenarios. Monitoring methods include passive sampling for NO_2, SO_2 and Benzene, and indicative combined particulate monitoring for both PM_{10} and $PM_{2.5}$. Lead sampling and analysis has also been included to determine any underlying risks associated with exposure to residual lead occurring from historic metal processing sites.

It is proposed that passive sampling for SO_2 and NO_2 should continue for a minimum of 12 months at all suggested sampling points. This would provide a solid monitoring record against which an air quality assessment of those regions can be undertaken. It is also proposed that passive sampling for Benzene, indicative sampling for PM_{10} and $PM_{2.5}$ as well as lead sampling be undertaken for a minimum of 8 weeks over a 12 month period. This would ideally be achieved through 4 two week monitoring campaigns providing an even distribution of sampling across the year, thereby meeting the CAFE directive data quality objectives for indicative measurements.

Table 12. Regional Distribution of Supplementary Monitoring points in Georgia

Zone Number	Potential Monitoring Locations	Supplementary Monitoring points	
		Max Concentrations are either below LATs or no monitoring data exists	
		Pollutant SO_2, NO_2, Benzene*	$PM_{10+2.5}$* and Lead*

1	Abkhazia Region	***Passive sample points***	***Indicative Monitoring Points***
	Sokhumi	3 NO_2, 2 SO_2	1 Combined $PM_{10/2.5}$ sampler, 1 Lead filter sample
2	Racha Lechkhumi, Kvemo and Zemo Svaneti Regions	***Passive sample points***	***Indicative Monitoring Points***
	Ambrolauri	3 NO_2, 2 SO_2	1 Combined $PM_{10/2.5}$ sampler 1 Lead filter sample
3	Samegrelo + Guria Regions	***Passive sample points***	***Indicative Monitoring Points***
	Poti	3 NO_2, 2 SO_2	1 Combined $PM_{10/2.5}$ sampler Lead filter sample
	Sufsa	3 NO_2,2 SO_2	1 Combined $PM_{10/2.5}$ sampler
	Zugdidi	3 NO_2, 2 SO_2	Combined $PM_{10/2.5}$ sampler
6	Akhaltsikhe Region	***Passive sample points***	***Indicative Monitoring Points***
	Akhaltsikhe	3 NO_2, 2 SO_2, 1 Benzene	1 Combined $PM_{10/2.5}$ sampler, 1 Lead filter sample
7	Shida Kartli + South Ossetia Regions	***Passive sample points***	***Indicative Monitoring Points***
	Gori	3 NO_2, 2 SO_2, 1 Benzene	1 Combined $PM_{10/2.5}$ sampler 1 Lead filter sample
	Java	3 NO_2, 2 SO_2	1 Combined $PM_{10/2.5}$ sampler
9	Kakheti + Mtskheta – Mtianeti Regions	***Passive sample points***	***Indicative Monitoring Points***
	Mtskheta	3 NO_2, 2 SO_2	1 Combined $PM_{10/2.5}$ sampler 1 Lead filter sample
	Telavi	3 NO_2, 2 SO_2, 1 Benzene	1 Combined $PM_{10/2.5}$ sampler 1 Lead filter sample

4.7. Technical Feasibility of Minimum and Maximum Scenario Monitoring Networks

In order to identify the technical feasibility of minimum and maximum scenario air quality monitoring networks, these networks were assessed against following criteria:

1. Availability of EU compliant automated monitoring instruments to measure targeted CAFE pollutants (SO_2, NO, $PM_{2.5/10}$) as well as the availability of SO_2, NO_2/NO_X passive samplers and $PM_{2.5/10}$ samplers in the local or regional market;
2. Technical resources required to operate and maintain a sustainable national monitoring network :
    a. Option to equip a laboratory sufficient to analyse passive samplers;
    b. Availability/access to web enabled method for transfer of digital data;
    c. Capacity to store, process and retrieve data, e.g. presence of central data depository
    d. Necessary technical qualification/staff at every level to analyse and report, manage the network, operate monitoring devices, service and repair all instruments
    e. Access to full list of spare parts and consumables
    f. Access to round-the-clock electricity sources;
    g. Local Security
3. Capability of operating and sustaining a national Quality System
    a. Access to an accredited national reference laboratory (e.g. analysis of heavy metals, PAHs, gravimetric filter analysis)
    b. Access to certified standards
    c. Access to third party specialised calibration and auditing services

As in the first step, each network scenario was assessed individually against above criteria. Then, both scenarios were compared to one another each other in terms of technical resources required, in order to identify which option is more technically feasible.

It should be mentioned that both scenario networks will have the same level of feasibility in terms of availability of measuring equipment, since they differ by the number of sampling locations and not by the technology needed.

Availability of EU Compliant Automated Monitoring Instruments

In terms of availability of monitoring equipment, EU complaint automated air quality monitoring equipment, including passive and PM samplers are not produced locally. These instruments are easily accessible from either suppliers in Turkey, China, India, all EU countries, Japan, US, Australia, or directly from manufacturers based in, France, Germany, Italy, Japan, US, Australia Reliability and quality instrument varies between manufacturers. The most common brands are listed in Table 13 below:

Table 13. Major Air Quality Equipment Manufacturers, instrument type and Countries of Origin

Manufacturer	Instrument types	Country of Origin
Thermo Electron	All gases, VOC's, PM's, Atomic Absorption Spectrometers	USA, EU Countries
Monitor Labs (Monitor Europe)	All gases, VOC's, PM's	USA, EU Countries
Advanced Pollution Instrumentation (API)	All gases	USA, EU Countries
Horiba	All gases, VOC's, PM's, Atomic Absorption Spectrometers	Japan, EU Countries
Signal Ambitech (Ambirak)	All gases	USA
Environnement SA	All Gases, PM	France
Rupprecht and Patashnick (dust analysers)	PM	USA, EU Countries
Met One (dust analysers)	PM	USA, EU Countries
Kleinfiltergerät, GRIMM, etc.[3]	PM	Germany
Ecotech	All gases	Australia
PALAS	PM	Germany
OPSIS	All Gases, PM, VOC	Sweden

[3] Preliminary Air Quality Assessment in Malta, August 2002, file:///C:/Users/Use/Downloads/Preliminary%20assessment%20of%20air%20quality%20in%20Malta.pdf

Synspec	VOCs	The Netherlands

Should monitoring equipment be purchased via EU financing processes, then equipment will be expected to be sourced from an EU member state.

It is technically feasible to replace the existing monitoring stations using non-reference instruments and requiring samples to be collected manually with reference automated monitoring stations. It is also technically feasible to periodically procure aerosol and PM samplers to conduct indicative measurements.

Technical Resources Required to Operate and maintain an national monitoring network

A pool of qualified staff are currently in place within the NEA's Environmental Quality Monitoring Department that in theory could provide the resource required to operate and maintain the national air quality monitoring network. However suitability of current staff for specifically skilled roles such as maintenance of specialised sensitive monitoring instruments, data acquisition, screening and auditing, data analysis and interpretation cannot be fully confirmed at this stage.

In terms of access to communications, in Georgia there are three mobile service operators and several internet providers though, the coverage and the quality of service is better in Tbilisi than in other urban areas. Mobile and internet communications services are more established and widespread in the urban areas which will host part of the monitoring network, than rural and remote mountainous area of Georgia. Access to continuous power supply in Georgia is almost unencumbered, with most settlements being fully electrified at all times of the day. However, periodic power cuts are common nationwide, therefore UPS (uninterrupted power supplies) and backup power sources should be sought to ensure that data losses due to interruptions to monitoring station power supplies are kept to a minimum.

Security of the air quality instruments and their enclosures can be viewed on a case by case basis. Security of the stations from theft, criminal damage or interference can be largely designed out by careful choice of materials, site location and encouraging local communities to view the monitoring station as of benefit to them and their health. Areas considered to be high risk in terms of station security will be avoided.

Capability of Operating and sustaining a National Quality System

The existing central analytical laboratory of the NEA is not sufficiently equipped with devices required of a national reference laboratory. There is no current regulatory requirement for analysis such pollutants as PAH's or $PM_{2.5}$ to be sampled or analysed in air in Georgia. Therefore there no national certified analytical laboratory within Georgia capable of analysing a number of CAFE directive and fourth daughter directive pollutant species. However, it is feasible that this resources could be contracted out, when required, to existing accredited analytical laboratories in a neighbouring state, and that capacity could be slowly introduced into the NEA central analytical laboratory to begin to meet this need within Georgia.

Thus, we can conclude that both minimum and maximum scenarios are technically feasible in terms of availability of necessary equipment and provision and adequate resources and conditions to smoothly operate the system.

As for the amount of technical resources required, maximum scenario will require more technical resources in terms of electricity, service personnel, consumables and auxiliary materials than the minimum scenario therefore, the latter is more feasible than the first.

SWOT Analysis of the Technical Feasibility

A series of SWOT indicators have been identified to assess the technical feasibility of the network against each weakness and threat.

Figure 2 SWOT Matrix for the technical feasibility of the National Air Quality Monitoring network

	Helpful in strengthening the network	Harmful in establishing the network
Internal (attributes of the organisation)	Strengths Capable and technically qualified staff in place. NEA are a coherent regulatory body. NEA has current experience of operating a single EU compliant air quality monitoring station.	Weaknesses Staff not experienced in specifically required techniques. Individual NEA technical roles in operating the new monitoring network are unclear. Data transfer and analysis capability is currently at a rudimentary level.
External (attributes of the environment))	Opportunities New network will allow for an influx of new young staff into the NEA. Adoption of new communications methods may help with public health messages. Overseas training of NEA staff will strengthen the air quality network. Good opportunity to compare data outputs & link with the other networks in ENPI states.	Threats EU may abandon or fail to support the monitoring network. Over reliance on a small technical team at NEA could result in failure of the network. Once trained staff could seek more lucrative employment elsewhere.

The SWOT analysis identified major 4 risks and 4 major threats to the technical feasibility of the national monitoring network. A series of mitigating actionshave been proposed to either reduce these risks or eliminate the threats (Table 14).

Where practicable, these mitigationscouldbe integrated into the development plan for Georgia'snational air quality monitoring network.

Table 14. Mitigations to off-set weaknesses and eliminate the threats faced by the technical feasibility of the network

Weaknesses	Mitigation	Proponent

Staff not experienced in required techniques	Use this as an opportunity to re-launch and refresh staff in the NEA. Where appropriate, introduce non-national regional staff who have the necessary skills and experience. Establish a comprehensive staff training package. Avoid focussing all training a limited pool of staff. This will leave the network vulnerable to absences or departures. Use a technical mentor or an external support mechanism for staff to draw upon after staff receive their technical training	NEA, EU, Neighbouring States with EU compliant Air Quality Networks Universities NEA Neighbouring States with EU compliant Air Quality Networks
Individual NEA technical roles in operating the new monitoring network are unclear	Produce a clear hierarchical and communications structure with the monitoring and data analysis team. Roles should meet skills sets and not staff seniority	NEA
Data transfer and analysis at rudimentary level	Integral to staff training will be the use of a digital data transfer protocol. Physical/ manual data transfer will cease.	NEA
EU may abandon or fail to support the monitoring network	Air Quality monitoring network development should programmed in a modular way, allowing individual stations be introduced/ relocated allow its scale and spatial coverage to reflect the budget available.	NEA
Over reliance on a small technical team at NEA could result in failure of the network.	In order to allow for redundancy and avoid staff absences becoming critical to the performance of the network, all skills will be spread and shared across the NEA team. No task shall be	NEA

	owned exclusively by one individual. All tasks will have a principal designate and a deputy.	
Once trained staff could seek more lucrative employment elsewhere.	Key staff are more likely to remain if they are securely employed and suitable financially rewarded, and receive recognition through a combination of periodic salary rises and individual professional development/training programmes.	NEA

4.8. Economic Feasibility of Minimum and Maximum Scenario Monitoring Networks

Economic feasibility of minimum and maximum scenarios was tested against such criteria as profitability, affordability, cost-efficiency. As a first step, economic feasibility of each scenario was assessed and then two scenarios were compared with each other.

In terms of profitability, simple CBA analysis was conducted, by calculating B/C (benefit-cost) ratio and NPV (Net present value). Following formulas were used for both indicators:

$$BC\ Ratio = \frac{PV \sum Benefits}{PV \sum Costs} \geq 1.0$$

$$NPV = \sum_{t=0}^{N} \frac{(Benefits - Costs)_t}{(1+i)^t}$$

BC is a ratio of benefits to costs. It should be equal to or more than 1, in order the project to be considered feasible. However, it does not take into consideration a time horizon of the project and future value of the money (discount rate).

More accurate indicator for economic profitability/viability of the project is NPV that compares the monetary value of benefits and costs (in Euro equivalent to 2005 constant Georgian Lari) at different points in the future. If the NPV of a prospective project is positive, it should be accepted. However, if NPV is negative, the project should probably be rejected as the costs outweigh the benefits.

For NPV analyses, following steps were undertaken:

- Identification of possible benefits and costs of the proposal
- Assigning monetary values to the various categories of costs and benefits
- Aggregating various cost and benefits

- Discounting benefits and costs

For the CBA model we also made following assumptions:

1. Automated monitoring instruments will be co-located, where it is possible, bringing down total number of new stations to 7 under minimum scenario and to 9 under maximum scenario;
2. The project covers the period of effective lifetime of gas and particulate analysers estimated at 10 years;
3. Total duration for the network establishment is4-years from 2015 through 2018, suggesting a step-wise approach for the project implementation, with a following schedule:
    a. Detailed network design (2015);
    b. Purchase of monitoring stations for Tbilisi and Batumi (2015-2016);
    c. Re-equipping of Tbilisi and Batumi laboratories (2015-2016);
    d. Training of staff for operations of Tbilisi and Batumi networks (2016);
    e. Purchase of equipment for Rustavi and Imereti (2017);
    f. Training of staff for operations of Tbilisi and Batumi networks (2018);
4. Costs and benefits will be monetised using 2005 constant GEL price equivalent EURO;
5. For the CBA model 5%discount rate is suggested;
6. Benefits related to the project will appear later on (starting from 2018).

Types of costs related to the network setting and operations are as follows:

- Network design
- Hardware procurement
- Staff training
- Running costs (electricity, communications, phone, etc.)
- Calibration standards
- Manpower: Site calibrations and call outs for equipment faults
- Manpower: Data Acquisition, processing, ratification, QA/QC and management

Procurement, installation, operations and maintenance costs per station were taken from Malta air quality assessment (2002) and Tbilisi automated monitoring station costs.

Benefits associated with implementation of EU-compliant air quality monitoring network are related to the reduction of health (Disability Adjusted Life Years or DALY for health, DALY for death) related costs and benefits/revenues to be received from increased agriculture productivity (related to the decline of O_3 ambient concentrations, due to reduced emissions of ozone precursor gases) as a result of establishment of alert systems and implementation of effective pollution abatement measures. These benefits appear later than cost, but might significantly overshadow the first. Health and agriculture-related benefits were taken from Clean Air Act CBA Analyses conducted by the group of MoENRP experts with an assistance of high calibre international expert Mr. Michael Williams in 2014 under USAID/GLOWS project: "Integrated Natural Resources Management in Watersheds of Georgia". Among other benefits we may consider improved data collection and decision-making, generation of extra money by the NEA through providing various air quality-related consultancies to various businesses, e.g. spot air quality measurements, modelling, etc. as well as reduced costs of sampling and analysis. These benefits were not included in the CBA model.

Based on the CBA, discounted costs of the installation and operations of the monitoring network under minimum scenario were estimated at ***EURO 3,144,482*** while the discounted benefits – ***at EURO 277,787,415***. With these figures NPV was calculated at***EURO 274,642,933***and B/C **–** at***88***indicating that scenario 1 network is financially feasibility.

Table 15. Costs under Minimum Scenario

Year	type cost	Units	EURO	Deflator	PV COSTS
2015	Network design		170895		
	Purchase multi-pollutant analyser, Tbilisi	2	500,000		
	Purchase PM sampler for Tbilisi	1	57,000		
	Purchase of multi-species analyser, Batumi	1	250,000		
	Calibration standards+auxiliaries	5	50,000		
	Training of staff		20,000		
	Running costs		7,500		
Sub-total			**1,055,395**	1	1,055,395
2016	Purchase of 1 chemiluminescent analysers	1	20,000		
	Purchase of fluorescent spectrometer	1	20,000		
	Purchase of PM gravimetric monitor	1	60,000		
	Purchase of 1 PM analyser, Batumi	1	57,000		
	Calibration standards+auxiliaries	6	60,000		
	Training of staff		20,000		
	Running costs	6	18,600		
	Manpower	6	21,600		
			277,200	1.05	264000
2017	Purchase multi-pollutant analyser, Rustavi	2	500000		
	Purchase multi-pollutant analyser, Imereti	1	250000		
	Purchase PM sampler for Imereti	1	57000		
	Training of staff		20,000		
	Calibration standards	10	100,000		
	Running costs	10	30,000		
	Manpower	8	28,800		
Sub-total			**985800**	1.10	894150
2018					
	Calibration standards+auxiliaries	10	100,000		
	Running costs	10	30,000		
	Manpower	8	28,800		
			158,800	1.16	137177
2019	Calibration standards+auxiliaries	10	100,000		
	Running costs	10	30,000		
	Manpower	8	28,800		

			158,800	1.22	130645
2020	Calibration standards+auxiliaries	10	100,000		
	Running costs	10	30,000		
	Manpower	8	28,800		
			158,800	1.28	124424
2021	Calibration standards+auxiliaries	10	100,000		
	Running costs	10	30,000		
	Manpower	8	28,800		
			158,800	1.34	118499
2021	Calibration standards+auxiliaries	10	100,000		
	Running costs	10	30,000		
	Manpower	8	28,800		
			158,800	1.41	112856
2022	Calibration standards+auxiliaries	10	100,000		
	Running costs	10	30,000		
	Manpower	8	28,800		
			158,800	1.48	107482
2023	Calibration standards+auxiliaries	10	100,000		
	Running costs	10	30,000		
	Manpower	8	28,800		
			158,800	1.55	102364
2024	Calibration standards+auxiliaries	10	100,000		
	Running costs	10	30,000		
	Manpower	8	28,800		
			158,800	1.63	97489
Total			**3,588,795**		**3,144,482**

Table 16. Benefits under Minimum Scenario

Year	Type, benefit	National benefits, EURO	Per capita Benefits, EURO	Benefits Per target cities, EURO	Deflator	NP Benefit, EURO
2018	Medical	1,590,909				
	DALY	21,136,364				
	Agric.	30545454.55				
Sub-total		***32,157,500***	***7***	***19,148,064***		19,148,064
2019	Medical	2,272,727				
	DALY	30,000,000				
	Agric.	37,545,455				
		69,818,182	***15***	***41,572,977***	1.05	39,593,311

2020	Medical	3,045,455				
	DALY	39318181.82				
	Agric.	37,545,455				
		79,909,091	***17***	***47,581,571***	1.10	43,157,888
2021	Medical	3,818,182				
	DALY	48,727,273				
	Agric.	37,545,455				
		90,090,909	***19***	***53,644,297***	1.16	46,339,961
2022	Medical	4,000,000				
	DALY	49,727,273				
	Agric.	37,545,455				
		91,272,727	***20***	***54,348,006***	1.22	44,712,239
2023	Medical	4,136,364				
	DALY	50,818,182				
	Agric.	37,545,455				
		92,500,000	***20***	***55,078,781***	1.28	43,155,666
2024	Medical	4350000				
	DALY	51909090.91				
	Agric.	37,545,455				
		93,804,545	***20***	***55,855,568***	1.34	41,680,285
Total		**493,293,864**		**327,229,265**		**277,787,415**

It should be mentioned that procurement, running, operations and maintenance costs might be underestimated, while the benefits – overestimated due to their strong association with emission reduction measures and not with setting and operations of EU-compliant monitoring network.

As for the NPV and B/C values under the maximum scenario, discounted benefits stayed the same, while the discounted costs soured to ***EURO 4,227,611.*** Thus, NPV value under the maximum scenario was reduced to ***EURO273,559,804***and B/C ratio – to ***66***, which is also very high figure indicating on financial feasibility of the maximum scenario.

Table 17. Cost under Maximum Scenario

Year	type cost	Units	EURO	Deflator	PV COSTS
2015	Network design		228850		
	Purchase multi-pollutant analyser, Tbilisi	3	750,000		
	Purchase PM sampler for Tbilisi	2	114,000		
	Purchase of multi-species analyser, Batumi	2	500,000		
	Calibration standards+auxiliaries	8	80,000		
	Training of staff		20,000		

	Running costs		7,500		
Sub-total			**1,700,350**	1	1,700,350
2016	Purchase of chemiluminescent analysers	1	20,000		
	Purchase of fluorescent spectrometer	1	20,000		
	Purchase of PM gravimetric monitor	1	60,000		
	Purchase of PM analyser, Batumi	2	57,000		
	Calibration standards+auxiliaries	9	90,000		
	Training of staff		20,000		
	Running costs	9	27,900		
	Manpower	6	21,600		
			316,500	1.05	301429
2017	Purchase multi-pollutant analyser, Rustavi	2	500000		
	Purchase multi-pollutant analyser, Imereti	1	250000		
	Purchase PM sampler for Imereti	1	57000		
	Training of staff		20,000		
	Calibration standards	14	140,000		
	Running costs	14	42,000		
	Manpower	10	36,000		
Sub-total			**1045000**	1.10	947846
2018					
	Calibration standards+auxiliaries	14	140,000		
	Running costs	14	42,000		
	Manpower	10	36,000		
			218,000	1.16	188317
2019	Calibration standards+auxiliaries	14	140,000		
	Running costs	14	42,000		
	Manpower	10	36,000		
			218,000	1.22	179349
2020	Calibration standards+auxiliaries	14	140,000		
	Running costs	14	42,000		
	Manpower	10	36,000		
			218,000	1.28	170809
2021	Calibration standards+auxiliaries	14	140,000		
	Running costs	14	42,000		
	Manpower	10	36,000		
			218,000	1.34	162675
2021	Calibration standards+auxiliaries	14	140,000		
	Running costs	14	42,000		

	Manpower	10	36,000		
			218,000	1.41	154929
2022	Calibration standards+auxiliaries	14	140,000		
	Running costs	14	42,000		
	Manpower	10	36,000		
			218,000	1.48	147551
2023	Calibration standards+auxiliaries	14	140,000		
	Running costs	14	42,000		
	Manpower	10	36,000		
			218,000	1.55	140525
2024	Calibration standards+auxiliaries	14	140,000		
	Running costs	14	42,000		
	Manpower	10	36,000		
			218,000	1.63	133833
Total			**4,805,850**		**4227611**

Out of two scenario networks, minimum scenario is more feasibility, given it requires lower expenses than the maximum scenario.

As for the affordability of the networks for minimum and maximum scenarios, under current level of public financing it is improbable that the country will be able to implement any of air quality scenario projects with its own resources. Annual average budget of NEA is only 3-5 million GEL that apart from air quality monitoring is earmarked for monitoring of other media.

SWOT Analysis of the Networks Economic Feasibility

A series of SWOT indicators have been identified to assess any weaknesses and threats faced by the economic feasibility of the network.

Figure 3. SWOT Matrix for the economic feasibility of the National Air Quality Monitoring network

	Helpful in strengthening the network	Harmful in establishing the network
Internal (attributes of the organisation)	Strengths NEA has experience of running budgets for national monitoring networks NEA received funding from the central government	Weaknesses Assumptions made in the CBA model may have overstated benefits to agriculture (e.g. decline in O_3) Operational lifetime of equipment is overestimated Financial commitment required to setup and run a monitoring network is beyond the resource of the Georgian national Government

External (attributes of the environment))	Opportunities National monitoring network has the potential to provide health benefits to Georgia’s population, these could be monetised to express wider economic benefits. Economic sustainability of the network could be secured via industrial pollution fines/ permits fees – e.g. ‘polluter pays’ principle. Major polluting industries could be required to install and operate network stations, to monitor their operations	Threats Costs of consumables and other imported technical supplies may fluctuate in price, putting the whole network quality at risk. Benefits gained are wholly dependent upon the success of air quality management measures

The SWOT analysis identified 3 major weaknesses and 2 major threats to the economic feasibility of the national monitoring network. A series of mitigating actionshave been proposed to either reduce theserisks or eliminate the threats (Table 18).

Where practicable, these mitigationscould be integrated into the development plan for Georgia’snational air quality monitoring network.

Table 18. Mitigations to off-set Weaknesses and eliminate the faced by the economic feasibility of the network

Weaknesses	Mitigation	Proponent
Assumptions made in the CBA model may have overstated benefits to agriculture (e.g. decline in O_3)	Segregate impacts and benefits to stipulate benefits to human health, ecosystems and wider economic impacts (e.g. agriculture, influencing land use in currently polluted areas).	CENN, NEA
Operational lifetime of equipment is overestimated	Introduce cost of spare parts and maintenance into the operational budget to ensure that all instruments operate for their entire proposed lifetime.	NEA
Financial commitment required to setup and run a monitoring network is beyond the resource of the Georgian national Government	National programme should be tuned to meet budgetary expectations of national government. Seek an opportunity for alternative sources of sustainable funding, such as via industrial pollution fines/ permits fees – e.g. ‘polluter	Ministry of Environment Ministry of Environment

	pays’ principle. Major polluting industries could be required to install and operate network stations, to monitor their operations If budget is not present then expectations have to reduce.	
Costs of consumables and other imported technical supplies may fluctuate in price, putting the whole network quality at risk	Seek long-term costs commitment and contracts from reputable well established suppliers. Seek out opportunities to buy in bulk with other laboratories and institutes in Georgia.	NEA NEA
Benefits gained are wholly dependent upon the success of air quality management measures	Introduce support from a broad range of government departments and industrial stakeholders. This will allow the air quality data to begin to influence public policy in all spheres.	Ministry of Environment Industrial Associations/ Institutes Public Health Bodies Transportation Bodies

4.9. Managerial Feasibility

Air Protection Service and NEA’s Environmental Pollution Monitoring Department are two units of the Ministry of Environment and Natural Resources Protection to share prime responsibilities for the implementation of the project with close cooperation of local authorities in target cities and low pollution zones. The Air Protection Service would be responsible for mobilizing financial resources for the project, providing political backstopping and overall oversight to how it will be implemented. The NEA would assume all remaining responsibility required in implementing the network. Initially NEA staffing of the network would need to be supplemented, as the number of technically qualified staff is currently in sufficient to secure a successful network plan. This applies to technical staff at all levels and network specialities, including technical service personnel, local laboratory operators and database managers.

The existing QA/QC system is currently poor to non-existent, and could be deemed as non-compliant with EU requirements.

All of the NEA’s air quality monitoring personnel requires extensive training in equipment operations, calibration, and maintenance as well as in data processing, interpretation and retrieval. Thus, without increasing/optimizing the number of necessary personnel and training of staff in above matters it would be managerially infeasible to implement any of scenarios.

As for the staff of local authorities, they might be engaged in identification of spots for locating the stations, as well as in placing and collecting passive gas and PM samplers in their respective zones/cities. Therefore all field operators will require extensive training in the operation, calibration, basic servicingand troubleshooting of field instruments.

SWOT Analysis of the Managerial Feasibility

A series of SWOT indicators have been identified to assess the managerial feasibility of the network against each weakness and threat.

Figure 4.SWOT Matrix for the managerial feasibility of the National Air Quality Monitoring Network

	Helpful in strengthening the network	Harmful in establishing the network
Internal (attributes of the organisation)	Strengths An established/ incumbent management structure of technical staff and resources is in place. NEA has experience of managing other types of monitoring stations across Georgia. Experience in generic data management is available in responsible institutions.	Weaknesses Insufficient capacity of NEA both in staffing/ resources and current institutional experience of EU compliant national air quality monitoring network. Absence of a national QA/QC system. Insufficient national financing.
External (attributes of the environment))	Opportunities Growth of a new monitoring network will allow for an influx of fresh staff into the NEA. Generation & sharing of real-time air quality monitoring data should attract the interest of local administrations to seek out air quality management solutions.	Threats Inadequate network management by NEA may result in poor data capture and or network failure. Political interest and commitment to the monitoring network may reduce. The supply chain for equipment, consumables and chemicals is not in place.

The SWOT analysis identified 2 major risks and 3 major threats to the technical feasibility of the national monitoring network. A series of mitigating actions have been proposed to either reduce these risks or eliminate the threats (Table 19).

Where practicable, these mitigations could be integrated into the development plan for Georgia's national air quality monitoring network.

Table 19.Mitigations to off-set managerial weaknesses and eliminate the threats faced by the managerial feasibility of the network

Weakness/ Threat	Mitigation	Proponent
Insufficient capacity of NEA both in staffing/ resources and current institutional	Produce a clear hierarchical and communications structure with the monitoring and data	NEA

experience of EU compliant national air quality monitoring network.	analysis team. Roles should meet skills sets and not staff seniority	
Absence of a national QA/QC system	Adherence to EU Air Quality Directives requires data scrutiny and evaluation at a national level. A national Quality Plan will address these issues, one of which is the establishment of a national QA/QC laboratory.	Ministry of Environment
Insufficient national financing	An annual realistic budget for consumables & chemicals, labour, communications and equipment spares will need to be approved and ring-fenced.	Ministry of Environment
Inadequate network management by NEA may result in poor data capture and or network failure	Realistic demands should be placed on network monitoring staff, with a clear set of duties set-out. Staff should not be moved onto additional duties, as often this will result in network errors going unchecked & data loss. Scrutiny of NEA network duties at Minister level will ensure that tasks are completed adequately. NEA staff mentoring with monitoring staff in other EU states will assist in solving low level queries and uncertainties.	NEA/ Ministry of Environment
Political interest and commitment to the monitoring network may reduce	Resourcing for the monitoring network should be secured through regulatory means. Thereby avoiding any changes in political culture influencing operations and continuity of the monitoring network.	Ministry of Environment
The supply chain for equipment, consumables and chemicals is not in place	Establish links to technical suppliers in other neighbouring states.	NEA NEA

	Combine purchasing power with laboratories working in other sectors, e.g. medical suppliers, waste and sanitation chemical suppliers. Avoid local non-specialists suppliers, who have little or no comprehension of the complexity behind chemical and technical purchasing.	NEA

4.10. Risks and Implementation Considerations

Major weaknesses for both minimum and maximum scenarios are related to projects' affordability and the lack of necessary in-country capacities. Both scenarios need significant amount of capital investments, consumables, expenses and labour budgets, system operations, maintenance, necessary staff qualifications and skills to smoothly operate the system that the NEA is lacking.

For capital investments, resources other than public finances can be attracted from various external international donors and in certain specific industrial settings support from may polluting industries may be forthcoming.

The major challenge faced by the proposed network is in identifying a source for a budget sufficiently large enough to realistically meet all annual operational, calibrations, travel expenses, consumables and laboratory costs. This is only second to the challenge of meeting staffing resources for the national network to succeed.

Current NEA staff, including field operators and chemists, who routinely collect and analyse samples from the existing national monitoring sites 3-times a day, could feasible be re-deployed to operate the fully automated air quality monitoring stations which are being proposed to replace the manual systems. This transition of roles and duties would require significant retraining and an extensive period of additional support for all field staff. Some staff members' skills and technical understanding may not be suited to this change of working and redundancy or redeployment may be required in these cases.

Both minimum and maximum scenarios attract similar level of risks, though the maximum scenario requires proportionally greater financial and human resource and therefore attracts the greater risk of failure.

4.11. Implementation Time

Since the project under both scenarios are very costly and the relevant in-house expertise is lacking in Georgia, the most feasible way to implement the project is to use step-wise approach and distribute procurement, network commissioning and staff training activities over years from 2015 through 2018.

4.1. FINDINGS AND RECOMMENDATIONS

The proposed national air quality monitoring network should, whenever possible, replicate the successes and coordinate with the existing continuous project Air quality monitoring in Tbilisi. This station measures the following pollutants: PM_{10}, $PM_{2.5}$, SO_2, NO_x, CO, and O_3using EU monitoring standards.

Wherever appropriate, this pilot project should be coordinated with relevant projects and donor activities to achieve synergy and to avoid overlaps.

It is recommended that financial support be explored from external sources (e.g. GEF, trust funds under the Convention on Long-range Transboundary Air Pollution (CLRTAP), USAID and bilateral cooperation).Furthermore, links with the planned activities of the ***Task Force for the Implementation of the Environmental Action Programme for Eastern Europe, Caucasus and Central Asia countries*** (EECCA) and the ***Regulatory Environmental Programme Implementation Network*** (REPIN) could be identified.