Tacis

Traceca: Central Asian Railways Restructuring Project.

Module C: Turkmenistan Railways

Supplementary Study on Electrification:

Final Report.

August 1998

Project Title	:	TRACECA : CENTRAL ASIAN RAILWAY RESTRUCTURING : SUPPLEMENTARY STUDY ON ELECTRIFICATION	
Project Number :		TNREG 9602	
Country	:	Turkmenistan	
		Local operator	EU Consultant
Name	:	C I E CONSULT/SYSTRA	C I E CONSULT/SYSTRA
Address	:		Grattan Bridge House, 3 Upper Ormond Quay Dublin 7, Ireland.
Tel. number	:	+007 3632 473981	+ 353- 1 703 4701
Fax number	:	+007 3632 473981	+ 353-1-703 4725
Telex number	:		
Contact person	:	Pat Jennings	Michael Barry
Signatures	:		

Date of report : August 1998

Reporting period : May – June 1998

Author of report :Pat Jennings

EU M & E team	_____	_____	_____
	(name)	(signature)	(date)
EU Delegation	_____	_____	_____
	(name)	(signature)	(date)
TACIS Bureau	_____	_____	_____
(task manager)	(name)	(signature)	(date)

Tacis

TRACECA

Central Asian Railways Restructuring - Turkmenistan

TDY

RESTRUCTURING

ELECTRIFICATION

STUDY

TABLE OF CONTENTS

TABLE OF CONTENTS

1. Executive summary

1.1 Economic assessment of the project

The first objective of this electrification project was to review former studies on the subject and in particular to assess costs according to western standards and independently from any manufacturers. The most detailed study was produced by Kiev Gipotrans Institute. There are some very significant differences between international standard costs and these produced in that study. Its review raises the following comments :

- traffic is highly overestimated,
- cost of energy is not exact as electricity was estimated lower than it is and fuel higher,
- some fixed installations were quoted higher than realistic figures,
- diesel rolling stock is estimated to be more expensive than electric.

The second objective was to learn more about electrification. At TDY, there is very little knowledge about electrification. As a Presidential Decree has ordered the progressive electrification of the network, TDY staff are interested in understanding more on this subject.

The third objective was to assess the viability of the project based on reasonable assumptions. The resulting internal rate of return (IRR) is unexpectedly positive though quite low : 4.11%. This is without taking into account some costs which are not linked to the railways : construction of a 500km long high voltage line, improvement of telecommunications for ministries, construction of residential areas including social services, etc. We have not included in our costs the various taxes applicable in the country, as the railways are state owned.

Some of the investments proposed for Ashgabad depot are not directly linked to electrification as they were included in the Central Asian Railways Restructuring study. Therefore some additional benefits should be drawn.

Signalling and telecommunication costs for the railways were included. They may not be needed if recommendations of Module E of the main study cover this line section and are to be funded and implemented anyway. In that case the IRR is 9.88%.

The unexpected positive results of the electrification are also due to TDY's requirement for locomotives in the near future. Therefore on rolling stock the balance for electrification is positive, the only cost is for fixed installations.

The electrification project is justified in great part due to the introduction of commuter services (decided by the local authorities) which increases significantly the level of traffic. These will hardly be profitable as they are social services. The state should then give compensation to the railways to operate such services.

We found a very high sensitivity to investment costs. Sensitivity to traffic is unexpectedly low. It is due partly to the fact that TDY has an old locomotive fleet which needs to be replaced in any event.

Electricity is produced using gas which is environmentally more friendly than other sources (coal or nuclear). Therefore the impact on the environment is rather positive.

1.2 Fixed Installations

As, from the results, funding might be difficult, a more detailed feasibility study should be implemented by an independent party without links with manufacturers and companies

A necessary cost calculation with up to date equipment having a usual RAMS (Reliability, Availability, Maintainability, Safety), must be implemented, mainly in traction sub-stations

Project-related expenses which are not necessary to the railways (external energy supply, communications for the ministries and others such as construction of residential areas) do not have to be taken into account in the project cost

Recommendations regarding the fixed equipment are as follows:

- It is essential for good service quality to use up-to-date components as well as gas or vacuum circuit breakers and modern transformers in substations, available on the international market.
- Whenever possible, international invitations to tender have to be issued, i.e.: catenary, traction substations, telecommunications. For signalling it is more difficult because the new equipment has to be compatible with the old.
- Communications and external energy supply expenses have to be shared by the different parties, and TDY should not have to pay for all the communications works

We recommend to TDY an independent and neutral consultant for preparation of international tender documents

1.3 Rolling Stock and depots

We can assume that the electrification project would save about US$ 8.5 million per year by using electric locomotives in place of D/E locomotives, as indicated in the following table (US$).

Item	Freight	Passengers	Total
Maintenance costs	4 253 710	984 040	5,237,750
Diesel fuel consumption	2,803,950	189,275	2,993,225
Lubrication oil consumption	319,000		319,000
TOTAL			8,549,975

This result is estimated by a methodology similar to that used for the justification of re-engining. Though it does not take into account some parameters, it does give a good indication of the levels of money which can be saved. This calculation is based on the traffic estimated by Kiev Gipotrans Institute. In our approach, this traffic is lower.

Our study is based on a western modern electric locomotive which has a low maintenance cost and a high reliability and availability.

We recommend the procurement of electric locomotives and electric trains by international tendering in order to obtain the best cost effectiveness.

Functional requirements will need to be produced with the help of a western consultant (this consultant shall be completely independent from any supplier) who has a good knowledge of what is required and of the world market.

For the depots, the information collected is not sufficient to perform a correct analysis in this report.

2. Introduction

2.1 Objectives

The study of electrification on the section between Bami and Dushak was geared towards three objectives :

- to review former studies (in particular the study carried out by Kiev Giprotrans Institute) on the matter and provide an appraisal
- to set the main characteristics of the systems to be implemented together with their corresponding costs on the basis of international standards
- On the basis of reviewed investment, operating and maintenance costs, to appraise the opportunity and economic profitability of such electrification for further funding.

2.2 Methodology

This study is based on visits to sites and technical discussions with local executives.

- First Deputy Director of TDY, M. H. BERDIEV
- Chief Engineer of TDY H. NEPESOV
- TDY Electrification Project Manager: M. E. MALIAVIN
- Deputy Head of Locomotives Department M. V. KATAEV

between 19 May and 10 June, 1998

The Ministry of Energy is the General Contractor for the works : there would be some need for further steps to discuss the outputs of the present report.

2.3 Conventions

All prices are expressed in:

- US Dollars (US$).

The local currency in Turkmenistan is the MANAT.

The exchange rate on 19 May 1998 was as follows:

- 1 US$ = 5200 MANATS
- 1 MANAT = 0.00019 US$

2.4 Abbreviations

A	Ampere
AC	Alternative Current
CTC	Centralised Traffic Control
CIS	Community of Independent States
DC	Direct Current

Hz	Hertz
Km	kilometre (1,000 metres)
KV	kilovolt (1,000 Volts)
MIS	Management Information System
Mm	millimetres
MVA	Mega volt-ampere (10^6 VA)
MW	megawatt (10^6 W)
RAMS	Reliability Availability Maintainability Safety
TRACECA	Transport Corridor Europe Caucasus Asia
SCADA	Supervision Control And Data Acquisition
MANAT	Turkmenistan currency
US $	United States Dollars
USSR	Union of Soviet Socialist Republics
TDY	TurkmenDemirYollary (Turkmenistan Railways)
V	Volt(s)

2.5 *Presidential Decree*

The electrification of TDY is in accordance with a Decree N°. 2986 of 20 January, 1997 signed by President TURKMENBASHI, which could be summarised as follows :

- The Ministry of Energy is to develop on behalf of TDY a feasibility study and cost estimation for the electrification of the railway line Bamy - Ashgabad – Dushak
- TDY orders the Ministry of Energy to be the general contractor for the scope of works regarding electrification of the railway line Geokdepe - Ashgabad - Enev for operation to start in October 1998
- TDY must finance electrification from its own resources

3. Technical assessment

3.1 The feasibility study

3.1.1 Russian proposal

For the Section Bamy-Ashgabad-Dushak, The Mosgiprotrans Institute of Moscow built in 1996 an Electrification Technical Proposal based on the former Soviet Union Technology (1*25 kV & 2*25 kV), showing the advantage of 2*25 kV. This proposal was used as a basis for deeper examination by the Kiev Giprotrans Institute.

3.1.2 Romanian proposal

For the Section of Geokdepe - Ashgabad – Enev, The Railway Research Institute of Bucharest Romania made an Electrification Technical Proposal based on single phase transformer for traction substations; this proposal was presented in May 1997 by the AM & K Maxima Holding and is rejected for technical standards reasons, and in particular incompatibility with Russian standards.

3.1.3 Feasibility study

The Terms of Reference (TOR) of the feasibility study prepared by TDY cover two phases:

- First : line section Enev-Ashgabad-Dushak (55 km)
- Second : line section Dushak-Ashgabad- Bamy

Both of them were issued on 5 February 1998 and signed by M. A. NEPESOV Chief Engineer of TDY and M. V. SHERMARIN Chief of Power Supply Department of TDY

The feasibility study was made by Kiev Giprotrans Institute. The first version was examined and reviewed by TDY. The feasibility study document was designed by Kievgiprotrans Institute as subcontractor to Turkmenergoproject Institute of Ashgabad, General Contractor. The document was made up of 14 volumes in Russian. Examining this document required much time and only some data could be checked in the short time of our mission. TDY's summary was only made available at the end of May 1998.

The conclusion of the report recommends the electrification as a means to:

- reach the expectancy of passengers by using EMU,
- improve the reliability of power supply,
- reduce environmental impact,

- improve international transportation on the main line.

The summary made by TDY of the Technical & Economic Feasibility Study for the railway section of Dushak-Ashgabad-Bamy designed by Turkmenergoproject Institute (General Contractor) and Kievgiprotrans Institute (Sub Contractor) was finally made available at the end of May.

3.2 Fixed installations

Insofar as time allowed, we reviewed the Ukranian study as the Russian and Romanian studies are purely technical studies. The following paragraphs provide some information on the equipment characteristics proposed by the Kiev Gipotrans Institute.

3.2.1 Phasing

The global length of the electrification construction is 335.1 km and will last 48 months in 3 phases.

- First phase:
  Enev-Ashgabad-Geokdepe 54.5 km

- Second phase:
  Enev-Dushak 161.5 km

- Third phase:
  Geokdepe-Bamy 119.1 km

3.2.2 Traction Power supply

The technology retained is an old one (see volume 1 page 20 and volume 7 page 15 to 30), used first in the sixties in the former Soviet Union. This system is very complicated and performances and reliability of components are weak (transformers, oil circuit breakers).

The price of a substation including 42 % contingencies, taxes and transport is (for 7 traction substations) about US$5.08 M and without any taxes US$3.58 M. The price of a substation depends mainly on its power. The average international price for 2x25 MVA substation is between US$1.7 M and US$2.00 M. For that item a realistic price could be maximum US$14M.

The technology retained is composed of type TDTNG 25/110 kV 25 MVA ORU transformers. The main suppliers are from Ukraine (Zalorogski, Rovenski and Simferiipol) and Russia (Kursk, Moscow and Sakansky).

3.2.3 Catenary

The same remarks apply (volume 1 page 21 and volume 7 pages 19, 20 and 21): the technology is old, the components are unreliable and the choice of a steel messenger wire is not the best one as a bronze messenger would be preferred.
The unit price for catenary per km, including the 42 % contingencies, taxes and transportation is about US$150 000, and without US$105 000. This price is within the average international price range.

3.2.4 Energy Dispatching

No specific comment. The description is shown in volume 1 page 24 and volume 7 page 24.

3.2.5 Longitudinal Energy Supplying

The description is shown in volume 1 page 23 and volume 6 page 23.

3.2.6 Operation and Maintenance Team for Traction and Longitudinal Power supply, Catenary

The total forecast manpower is 257 men. It is excessive and it will heavily encroach on the maintenance and operating cost in the future. 120 men for that job could be enough (more in accordance with usual standards). In western Europe the level of staff would be around 60.

3.2.7 External Power supply from National Grid

3 Options were presented and the middle one was accepted. This option was a good balance between cost and quality of the proposed equipment. An analysis of the options should be carried out through deeper examination of the feasibility study in order to validate the choice. According to TDY, the construction of a high voltage line between Turkmenbashi and Ashgabad is also included. But this whole distance is not necessary for the railways. As it is not part of the electrification, this item must not be taken into consideration.

Options for external power supply are linked to the two options for substations. As the second option for substation was preferred for being the best compromise between cost/reliability, the middle one was chosen.

3.2.8 Signalling and Railway Communications

Old former Soviet Union Technology is retained. A newer technology could not be retained without an excessive cost because it has to be compatible with actual installations. Two options have to be considered :

- remodelling of existing installations and therefore the old technology is retained

- new signalling systems are introduced and the old one is dismantled.

Our main remark is that electrification could be an opportunity for TDY to develop a telecommunication network with optical fibre which could be used by the national network. This may be included in Module E of the main study (Central Asian Railways Restructuring).

Additional staff for this communication is 23. This item requires examination as generally modernised installations need less manpower, while here it is increased.

3.2.9 Other Communications

Other communications concern Ministry of Communication, Ministry of Water, border troops. They should not be part of this project.

3.2.10 Department and Radio Lines

These communications are not directly linked to the railway electrification but are affected through Electro Magnetic Compatibility. The expert survey to determine the necessary works is out of our scope, and information is classified as top secret

3.2.11 Cost Estimate

All prices include VAT, Contingencies, Taxes and Transportation Costs at 42%

	(US$ M)
Total construction cost for Dushak-Ashgabad-Bamy	44,583
External energy supply	56,918
Other costs for the modernisation of ministries	31,125
Traction substations	35,620
Catenary	50,000
Communications for centralisation, signalling and blocking	70,000

This resume of cost estimates was commented on in former sections. Our estimated total cost is shown in §4.2.

3.3 *Rolling Stock fleet*

3.3.1 Fleet requirements

For year 2010, the traffic forecast in number of trains planned in the "Feasibility study" is as follows:

SECTION	TOTAL	FREIGHT	PASSENGERS	COMMUTERS
ASHGABAD DUSHAK 1	31	16	5	10
ASHGABAD DUSHAK 2	39	24	5	10
ASHGABAD BAMY 1	25	10	5	10
ASHGABAD BAMY 2	34	19	5	10

The expected traffic (by Kiev Gipotrans) between Bamy and Dushak was estimated at 4,423 Mt-km in 1997 and 18,095 Mt.km (13.2 Mt in 1997 and 54 Mt when electrification is to be finalised). Final traffic statistics of TDY show only 4.5 Mt in 1997 which makes 1.6 Mt-km only.

For the following calculations, we have taken this assumption of 54 Mt/km.

The electric fleet requirement estimation indicated in the feasibility study is:

- 1st phase
  2 electric trains for US$6.2 M

- 2nd phase
  6 electric trains for US$18.6 M
  22 electric locomotives (18 for F and 4 for P) for US$50.6 M

- 3rd phase
  15 electric locomotives (12 for F and 3 for P) for US$34.5 M
  7 electric trains for US$21.7 M

The cost for the rolling stock requirement is US$131.6 M
- 15 electric trains in place of 32 D trains
- 37 electric locomotives in place of 50 D/E locomotives.

Comments on the number of commuter trains: 15
To ensure 20 commuter trains per day between Ashgabad and Dushak (171 km) or Ashgabad and Bamy (166 km), 10 commuter trains are required when considering the running times. So, the total amount of commuter trains should be about 12, 10 + 2 as stand-by.

During phase 1, they want to put in service 2 commuter trains, but it is clear that a good quality commercial service will be difficult to ensure with only two trainsets, mainly because of the lack

of reserve. On the other hand, starting the operation will allow training both on rolling stock and installations.

Comments on the number of locomotives: 37
Moreover, the ratio between the number of electric and diesel locomotives is about 1.5 (1.5 diesel locomotive for 1 electric locomotive).
So, to replace 50 D/E locomotives, the number of electric locomotives should be about 34. Considering the new technology and the possible reserve, a number of 37 locomotives is reasonable.

3.3.2 Comments on the cost of Rolling Stock

The following table is drawn from the feasibility study:

Type	*Manufacturer Country*	*Series*	*Cost in US$*	*Comments*
1	2	3	4	5
Electric locomotive	Novocherkasky electric locomotive factory, Novocherkassk city, Rostovskaya oblast, Russia	VL80CM	2 300 000	
Diesel locomotive	GHK "Luganskteplovoz" GHK "Luganskteplovoz"	2TE116 2TE10Y	3 200 000 2 400 000	
Electric train	Rizhsky wagon factory, Latvia	ER9T 10 wagons	3 100 000	One wagon cost US$ ~ 310.000
Diesel train	-"-	DR 1A 6 wagons	1 800 000	One wagon cost US$ ~ 310,000

We can make the following remarks:

- the 2 TE are expensive compared to western costs (about US$ 2.5 M)
- the VL80CM are very cheap compared to western costs (about US$ 3 M)
- the electric train is very cheap compared to western costs (about US$ 8 M)
- the diesel train is also very cheap compared to western costs

These figures are not realistic when compared to international prices.

3.4 Rolling stock maintenance

The analysis of the maintenance cost is summarised in the following tables. It is based on western Europe maintenance costs with modern locomotives.

As the manpower costs are smaller in Turkmenistan, the ratio between the two maintenance costs should change in favour of electric locomotives.

This analysis takes into account the maintenance of modern electric locomotives, which have a very low maintenance cost, and a very high reliability and availability. We have not enough experience of the Russian electric locomotives.

It is important to note that when new locomotives are purchased, maintenance cost, reliability and availability are very important factors to be taken into account before making a decision as a locomotive is supposed to last at least 25 years.

3.4.1 Freight loco maintenance costs

Section	N train / day	N km/way	N km/Day	Maintenance Cost/km US$		Maintenance cost/year US$		Difference US$
				Elec Loco	D/E Loco	Elec Loco	D/E Loco	
Ashgabad Dushak	16	171	2736	0.70	1.70	699 048	1 697 688	998 640
Dushak Ashgabad	24	171	4104	0.70	1.70	1 048 572	2 546 532	1 497 960
Ashgabad Bamy	10	166	1660	0.70	1.70	424 130	1 030 030	605 900
Bamy Ashgabad	19	166	3154	0.70	1.70	805 847	1 957 057	1 151 210
							TOTAL	4 253 710

3.4.2 Passenger loco maintenance costs

Section	N train / day	N km/way	N km/Day	Maintenance Cost/km US$		Maintenance cost/year US$		Difference US$
				Elec Loco	D/E Loco	Elec Loco	D/E Loco	
Ashgabad Dushak	5	171	855	0.50	1.30	156 038	405 698	249 660
Dushak Ashgabad	5	171	855	0.50	1.30	156 038	405 698	249 660
Ashgabad Bamy	5	166	830	0.50	1.30	151 475	393 835	242 360
Bamy Ashgabad	5	166	830	0.50	1.30	151 475	393 835	242 360
							TOTAL	984 040

3.5 *Depots*

In the feasibility study the following table indicates the investment amount for each phase. It includes 42% VAT, taxes and contingencies.

Construction sites	*Costs in USD (M)*							
	Enev-Geokdepe 1 phase		Enev – Dushak 2 phase		Geokdepe - Bamy 3 phase		Total	
Project	Electrific project	Modern project	Electrific. project	Modern project	Electrific project	Modern project	Electrific. project	Modern project
Reconstruction of loco depot	0.43	-	4.30	3.20	26.82	-	31.55	3.20
Motor car depot	0.06	-	20.25	-	7.85	-	28.16	-
TOTAL							59.71	3.20

In the feasibility study they intend to reconstruct the existing locomotives depot in Ashgabad for US$ 34.75 M and build a new depot in Enev for the maintenance of electric trains for US$28.16 M.

3.5.1 Phase 1

The investment for Ashgabad depot is US$0.43 M, without any explanations.
During this phase, it is planned to introduce 2 electric trains. So, a pit, administration and technical building, a compressor unit (8m3/mn) and a sand feeding installation in Enev are required for US$0.06 M.

3.5.2 Phase 2

In the depot of Ashgabad, the investment is US$4.3 M for the electrification project and US$3.2 M for modernisation.

- Construction of workshop for TO3/TR1, rheostat testing, washing machine, feeding installations and boiler house for electric locomotives.

Feeding installations in the routine maintenance depot are in a poor condition and have to be rebuilt.

- Distribution network to be renewed (electricity, water)
- Other depot modifications for TO2/T03/TR1.

The running maintenance depot has to be renewed.

The investment in Enev is US$20.25 M for TO2/TR1 handling installations, external washing of locomotives, internal sanitary cleaning and a boiler house.

3.5.3 Phase 3

In the depot of Ashgabad, the investment is US$26.82 M for the electrification project.

- Construction of shops, painting shop, storage of transformer oil,
- Electric locomotive cleaning and washing,
- Facilities modernisation of TR3 workshop and wheel workshop.

The depot has to be renewed and a lot of work has to be done whether the electrification is carried out or not.

The "Turkmenistan Railway Restructuring Study" indicates that US$4 M are required for equipment and workshop changes.

In Enev depot, the investment amounts to US$7.85 M for the electrification project. It is the second stage of the construction of TR3, painting shops, shops, distribution network, etc.

3.5.4 General comments on depots

We could not make a deep expert survey of Ashgabad depot to make sure that they can handle electric locomotives (less than 40), D/E locomotives and electric commuter trains (15). Nevertheless taking into account final traffic forecasts, the surplus of locomotives is not excessive as they will replace the old diesel ones removed.

If we assume that a new depot is necessary in Enev to maintain the electric commuter trains, it is clear that some equipment should be shared with Ashgabad (such as wheel lathe or painting shop).

3.5.5 Enev depot

For Enev depot the following minimum equipment is necessary:

- A 4-track building with 2 pits and a bay for offices, warehouse, sanitary requirements, repair sidings, etc.
- One outside pit track
- One underfloor jack to replace components
- Tool engines (a lathe, a milling machine and a drill)
- A mobile girder to replace components on the roof of electric locomotives
- A 5-tonne travelling crane
- A 10-tonne travelling crane
- One electric fork lift truck
- 4 20-tonne lifting stands
- One High Pressure spray cleaner
- Roof gangways for electric locomotives

The total cost of this type of depot is about US$12 M compared to the US$28.16 M presented in section 3.5 (Ukrainian estimate).

3.5.6 Ashgabad Depot

It is difficult to properly appraise the total cost for the rehabilitation and modification of depots. The main comment we can make is on the unit cost of the equipment which is generally too high.

For example the cost given for a painting shop is about US$6 M compared to US$2 M in France.

The total cost of US$34.75 M to rebuild, modify and modernise the depots is too high. On the basis of west European standards for this type of depots (in terms of equipment and size) the estimated cost would be around US$20 M.

3.6 Comparison between electric and diesel locomotive operating costs

According to the data given by the Railways Study and Research Centre, we have made the following comparisons between electric locomotive and diesel locomotive operating costs (on the basis of Kiev Gipotrans traffic estimates).

3.6.1 Assumptions

We have made the following assumptions based on the information given by TDY.

	Freight	Passengers
Number of tonnes transported per year (feasibility study report)	54 Mt	
Cost. of 1t of Fuel oil (US$)	69.5	
Cost of 1 t of Lubrication oil (US$)	580	
Cost of 1 kW (US$)	0.025	

In the feasibility study the cost of 1 t of fuel oil is US$230 (69.5 according to TDY) and the cost of 1 kW is US$0.007 (0.025 according to TDY) .

It is clear that the differences between these costs increase or decrease the interest of the electrification project.

3.6.2 Comparison between fuel oil and kW consumption

For freight trains :

	Electric locomotive	**Diesel locomotive**
Consumption per 1000 gross tonnes km	12 kW	7.1 litre
Cost of a kW or a litre in US$	0.025	0.064
Cost per 1000 gross tonnes km in US$	0.3	0.455
Number of gross tonnes transported	54,000,000	54,000,000
Cost for one year for 1 km in US$	16,200	24,570
Cost for one year for 335 km in US$	5,427,000	8,230,950
Difference in US$		***+ 2,803,950***

This table shows that US$2,803,950 can be saved per year on the freight trains.

For passenger trains:

	Electric locomotive	**Diesel locomotive**
Consumption per 1000 gross tonnes km	12 kW	7.1 litre
Cost of a kW or a litre in US$	0.025	0.064
Cost of 1000 gross tonnes km in US$	0.3	0.455
Number of tonnes/ train	1,000	1,000
Number of trains per day	10	10
Number of gross tonnes transported	3,650,000	3,650,000
Cost for one year for 1 km in US$	1,095	1,660
Cost for one year for 335 km in US$	366,825	556,100
Difference in US$		***+ 189,275***

This table shows that US$189,275 can be saved per year on the passenger trains.

3.6.3 Lubrication oil consumption

	Diesel locomotive
Consumption of lubrication oil per loco per year	11 t
Consumption of lubrication oil for 50 loco per year	550 t
Cost of lubrication oil per loco per year in US$	580
Cost of lubrication oil for 50 loco per year in US$	*319,000*

This table shows that US$319,000 can be saved per year.

4. Economic assessment of the electrification

4.1 Traffic forecasts

The basis for traffic forecasts was mainly the results of the restructuring study amended by real figures for 1997. These were 25% higher than the previous year. The Ukrainian study expected traffic to reach 54 Mt. by the year of implementation of the electrification. It is not realistic when we consider present total traffic is about 12% of such a figure.

Then we assumed that this spectacular growth would decrease in the next 5 years to 3% per year. Secondly part of the traffic which is running on TDY is not going through this section to be electrified. This is the case of crude petrol from Uzbekistan, which is going to Seidi refinery (nearby Tchardjew) which amounts to 400,000 tons a year, or the traffic which is going along the Uzbek border towards the north west (Karakal Pakistan). Present figures show that more than 50% of the traffic is going through Ashgabad. Traffic with Ashgabad as origin or destination is negligible (about 200,000 t per year). It has been assumed that the share of the total traffic which will be running on this section is expected to increase because of the development of the area, the increased refined petrol flows from Turkmenbashi refinery and the growth of traffic towards and from Iran (the potential is 120 wagons per day).

Forecasts in million tonnes for the next 20 years appears to be the following:

YEAR	Total traffic (restructuring-Optimistic)	Total traffic (restructuring-Pessimistic)	Total traffic	Traffic Around Ashgabad
1996	7.0	7.0	7.0	n.a.[1]
1997	7.1	7.1	8.7	4.5
1998	7.3	7.3	10.4	5.6
1999	7.4	7.4	12.0	6.6
2000	7.6	7.6	13.2	7.5
2001	7.7	7.7	13.9	8.1
2002	8.0	7.9	14.3	8.6
2003	8.3	8.0	14.7	8.8
2004	8.6	8.2	15.2	9.1
2005	8.9	8.4	15.6	9.4
2006	9.2	8.5	16.1	9.6
2007	9.5	8.7	16.6	9.9
2008	9.8	8.9	17.1	10.2
2009	10.2	9.1	17.6	10.5
2010	10.5	9.2	18.1	10.8
2011	10.9	9.4	18.6	11.2
2012	11.3	9.6	19.2	11.5
2013	11.7	9.8	19.8	11.9
2014	12.1	10.0	20.4	12.2
2015	12.5	10.2	21.0	12.6
2016	12.9	10.4	21.6	13.0
2017	13.4	10.6	22.3	13.3
2018	13.9	10.8	22.9	13.7
2019	14.4	11.0	23.6	14.2
2020	14.9	11.3	24.3	14.6

The average increase during this 20 years period is nearly 4.5% per year. This growth is relatively high compared to international statistics (around 2 to 3%). It is due to the start of the recovery of TDY after the strong traffic reduction, which happened in the 90's: in 1997, the traffic increase was about 25%.

For passengers, the 10 year program set by a Presidential Decree is intended to develop intensively the Ashgabad area. The development of passenger means of transport is critical for achieving such objective.

[1] not available

As for any electrification project, traffic forecast is a very critical item.

4.2 Costing of project

The cost breakdown in the Ukrainian study is as follows :

ITEM	*COST (in MUSD)*
High voltage feeder lines	56,918
Residential sector	14,442
Other ministries external supply	31,125
Other ministries communications	25,000
Substations	35,620
Depot	34,750
Motor Depot	28,160
Catenary	50,000
Telecommunications and signalling	70,540
Electric locos	85,100
Commuter trains	46,500
TOTAL	478,155

4.2.1 Observations

The study produced includes 42% extra cost to cover taxes, VAT and contingencies. They should not be included.

Some items should not be included in the project as they are not railway-related:

- High voltage feeder lines

Within the US$57 M figure a new high voltage line between Turkmenbashi up to nearly Ashgabad is included. The cost of such a line, which is not necessary to the railways, is US$31 M. Therefore only the remaining part (25 M) should be included.

- Residential sector

It includes kindergarten building, school, social services and residential housing construction. This obviously should not be included.

- Other ministries' external supply and communication

Through electrification, some electrical feeding lines and communication lines to connect with other ministries' facilities are also planned. They should be taken out of the project.

Substations

One substation costs about US$2 M. As 7 are needed a total cost of around US$14 M is considered acceptable.

- Catenary

Prices are among normal costs

- Depots

The cost of the depot is considered to be very high. As the fleet was relatively oversized (due to a very optimistic approach of the traffic forecasts!), the capacity of the depots and workshops has to be reviewed to a lower level. Even though it was felt that the cost assessed in the study was highly overestimated. Starting at a level of US$32 M for the fleet planned in the feasibility study we believe that US$25 M should be enough to cover the cost of such depots.

- Rolling stock

Prices of electric rolling stock are very much underestimated, while diesel rolling stock prices are overestimated. In this study we have assumed international prices:

⇒ Diesel locomotives: US$2.5 M.
⇒ Electric locomotives: US$3.0 M.
⇒ 1 set of 10-coach diesel commuter train: US$6.5 M.
⇒ 1 set of 10-coach electric commuter train: US$8 0 M.

These costs did not include contingencies and taxes.
Due to lower traffic forecasts and optimisation of the operation, the number of rolling stock has been reduced to 12 for commuter trains and 12 for electric locos.

4.2.2 Estimated project cost

Based on the previous observations and international prices, the estimated total cost is shown hereafter :

ITEM	*COST (in MUSD)*
High voltage feeder lines	18,25
Substations	20,00
Depots	25,00
Catenary	35,21
Telecommunications and signalling	49,68
Electric locos	36,00
Commuter trains	96,00
TOTAL	280,14

The main differences come from:
- adjustments to unit prices
- cancellation of some items which are not related to the railways
- difference in terms of traffic and therefore rolling stock

This budget does not include the technical assistance required. As TDY has no experience of electrification the railways would need assistance for:

- design and technical specifications
- preparation of tender documents
- appraisal of tenders and contract preparation
- project management including work supervision.

4.3 Main assumptions considered

The main advantages of electrification are:

- reduced cost of rolling stock maintenance
- reduced energy costs
- reduced needs for rolling stock due to greater availability

- Maintenance costs

The maintenance cost per km considered here is US$0.70 for electric freight locos, US$1.70 for diesel freight locos, US$0.50 for passenger electric locos and US$1.30 for passenger diesel locos.

- Energy costs

The energy cost of a loco for transporting 1000 tonnes/km is US$0.3 for electric and US$0.455 for diesel.
The cost of lubricants for one loco is set at US$580 per year.

- Reduced needs for rolling stock

The usual ratio considers that 1 electric locomotive is comparable to 1.5 diesel locomotive.

4.4 The base scenario

In the base scenario we have considered that commuter services will be implemented independently from electrification as these fit into a Presidential Decree which aims at developing a so called "Greater Ashgabad" area. Therefore planning the implementation of such services is similar in both cases. This issue is very important as this traffic accounts for nearly 40% of the total number of trains.

The existing fleet of locomotives was also taken into account. As indicated in the restructuring report, TDY's present fleet is rather old and by the year 2006 they will definitively need to purchase new locomotives. Then if the choice of electrification was made, this need would be converted into electric locomotives.

The cost breakdown of the base scenario is shown herebelow (in MUSD) :

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
INVESTMENTS																					
Rolling Stock																					
Diesel locos	0,00	0,00	0,00	0,00	0,00	0,00	35,00	0,00	0,00	0,00	0,00	2,50	0,00	0,00	0,00	0,00	5,00	0,00	0,00	0,00	2,50
Commuter trains	19,50	0,00	0,00	39,00	0,00	0,00	39,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Energy																					
Oil (freight)	1,85	2,00	2,12	2,19	2,25	2,32	2,39	2,46	2,54	2,61	2,69	2,77	2,85	2,94	3,03	3,12	3,21	3,31	3,41	3,51	3,62
Lubricants (freight)	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
Oil (passengers)	0,58	0,58	0,58	3,88	3,88	3,88	6,03	6,03	6,03	6,03	6,03	6,03	6,03	6,03	6,03	6,03	6,03	6,03	6,03	6,03	6,03
Lubricants (passengers)	0,00	0,00	0,00	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
Maintenance Costs																					
Maintenance for diesel locos	1,00	1,08	1,15	1,18	1,22	1,25	1,29	1,33	1,37	1,41	1,45	1,50	1,54	1,59	1,64	1,68	1,73	1,79	1,84	1,90	1,95
Maintenance for commuter trains	0,15	0,15	0,15	0,51	0,51	0,51	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79
TOTAL	23,10	3,83	4,02	46,78	7,88	7,98	84,52	10,63	10,74	10,86	10,98	13,61	11,24	11,37	11,50	11,64	16,79	11,94	12,09	12,25	14,91

4.5 The project scenario

It is considered here that the three phases will take place according to the following schedule :

- Phase 1 : year 2000
- Phase 2 : year 2003
- Phase 3 : year 2006

As most diesel trains go farther away, it is considered that freight trains will be hauled by electric locomotives by the end of phase 3 when the 335 km are fully operational. Otherwise, operation costs (to change locomotive for a small distance) would increase.

Therefore the cost breakdown of the project scenario is shown herebelow (in MUSD) :

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
INVESTMENTS																					
Electrification																					
Catenary	5,69	2,00	10,00	4,99		10,00	2,53														
Substations	2,28	6,80	2,28	2,28	2,28	2,28	2,28														
Feeders	3,98	1,33	1,33	1,33	2,92	2,92	2,92														
Signalling & Telecommunications	7,97	7,93	7,93	7,93	5,85	5,85	5,85														
Depots	0,49	5,00	5,00	5,00	3,50	3,50	2,54														
Others	0,00	0,00	0,00	0,00	0,00	0,00	0,00														
Rolling Stock																					
Electric locos	0,00	0,00	0,00	0,00	0,00	0,00	27,00	0,00	0,00	0,00	0,00	3,00	0,00	0,00	0,00	0,00	3,00	0,00	0,00	0,00	3,00
Commuter trains	19,50	0,00	0,00	39,00	0,00	0,00	39,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
ENERGY																					
Oil (freight)	1,85	2,00	2,12	2,19	2,25	2,32	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Lubricants (freight)	0,01	0,01	0,01	0,01	0,01	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Electricity (freight)	0,00	0,00	0,00	0,00	0,00	0,00	1,45	1,50	1,54	1,59	1,64	1,68	1,74	1,79	1,84	1,90	1,95	2,01	2,07	2,13	2,20
Electricity (passengers)	0,04	0,04	0,04	0,24	0,24	0,24	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37	0,37
MAINTENANCE COSTS																					
Maintenance for electric locos	1,00	1,08	1,15	1,18	1,22	1,25	0,53	0,55	0,56	0,58	0,60	0,62	0,63	0,65	0,67	0,69	0,71	0,74	0,76	0,78	0,80
Maintenance for commuter trains	0,06	0,06	0,06	0,20	0,20	0,20	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31	0,31
Oper/maint. of electric installations	0,09	0,09	0,09	0,10	0,10	0,10	0,10	0,11	0,11	0,11	0,11	0,11	0,11	0,11	0,11	0,11	0,11	0,11	0,11	0,11	0,11
TOTAL	42,95	26,33	30,00	64,43	18,56	28,66	84,88	2,82	2,88	2,95	3,01	6,08	3,15	3,22	3,29	3,37	6,45	3,53	3,61	3,69	6,78

4.6 *Rate of return*

From the above the IRR would be 4.11%. This does include signalling and telecommunications improvements to limit electrification interactions on the system. This item may be implemented according to Module E results. Therefore it should not be accounted for here. If this should be the case the IRR would reach 9.88%.

4.7 *Sensitivity analysis*

The main items to analyse in the sensitivity analysis concern :

- the investment cost
- the maintenance cost
- the traffic
- energy

This evaluation is based on total costs without signalling and telecommunications costs.

The following table shows the IRR sensitivity to each item.

	+10%	+20%	-10%	-20%
Investments elect.installations	8.82%	7.87%	11.05%	12.38%
Maintenance	9.73%	9.58%	10.03%	10.17%
Traffic	10.17%	10.48%	9.49%	9.16%
Electricity	9.57%	9.25%	10.19%	10.49%

The analysis shows a very high sensitivity to investment costs. Sensitivity to maintenance and energy costs is quite low as the ratio is 1 to 2.35 for maintenance (which we deem high compared to western standards, but it is due to a very low cost of labour-around US$45 per month- in Turkmenistan), and 1 to 1.5 for energy costs. Therefore the investment costs should really be strictly estimated, but sensitivity may be affected by success in exporting gas in the future, and the effect this may have on price. The ratio between energy costs should be modified in the future as Turkmenistan has gas (which it uses for producing electricity) and petroleum. The difficulties which it experienced for exporting it may not be solved as quickly as expected.

It is worth mentioning that electricity production is clean and so is electric traction compared to diesel traction.