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- 05b Industrial facility south of Paamiut, 1:500 000
- 06a Industrial facility between Paamiut and Nuuk, 1:500 000
- 06b Nuuk, Buksefjord, etc, 1:250 000
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1 Introduction

Historical overview

Reports on Greenland's hydropower resources have been prepared regularly since the mid-1970s. The first report prepared was called 'Localisation of hydropower resources on the west coast of Greenland' [ACG/VBB 1975^M], and contained studies of 16 major potential sites.

At the time of the issue of this publication, field studies concerning major hydropower stations had been initiated in several locations along the west coast. Within a few years the interest shifted from major facilities to the supply of energy to towns, and in 1979 a long list of facilities located close to towns was prepared. The potential was determined exclusively on the basis of map studies and, after feasibility studies had been made, the report entitled '*Grønlands vandkraft, Byforsyning, lokalisering af vandkraftressourcer*' was revised [ACG 1981^C].

In the 1970s the focus was on major facilities for supply to industry: Imarsuaq for the Isua iron ore mine, Johan Dahl Land for the Kvanefjeld mine, Tasersiaq for supply to energy-intensive industries at Sisimiut, etc. However, in the 1980s the interest shifted to facilities close to urban areas. Feasibility studies were intensified, and various outline and draft proposals were prepared for the most promising facilities: Taseq at Narsaq, Paakitsup Akuliarusersua at Ilulissat, Tasersuaq at Sisimiut, Buksefjord at Nuuk, Iterlaa at Paamiut and others.

Established facilities

The Buksefjord facility at Nuuk was the first facility to be constructed in 1989-1993. Subsequently it was decided in 1992 to construct Tasersuaq/SIS, but this project was stopped after tenders had been invited, the reason being new priorities for the use of the construction funds. Later, Aammangaaq at Tasiilaq was constructed and put into operation at the end of 2004, and Qorlortorsuaq, which is to supply Narsaq and Qaqortoq, is currently being constructed.

Recent localisation reports

Concurrently with the planning and expansion of facilities close to urban areas, lists of localised potential sites have been prepared on several occasions. In the mid-1980s, GTO prepared several reports on the potential sites and the relevant results of hydrological measurements: *Generelle hydrologiske bassin-informationer, GEHBI, Vandkraftmuligheder og prioritering af vandkraftudbygningen i Grønland, Nukissiorfiit March 1992, Bynære vandkraftpotentialer i Grønland, Nukissiorfiit May 1994 and Lokaliserede Vandkraftpotentialer i Grønland, Status 1995*. The report [Nukissiorfiit 1995^B], which concerns 14 major facilities and 16 facilities close to urban areas, provides an update of the basis for potential exploitation

	<p>including a brief description, sketches and data, but it is not always possible to see where the data provided comes from or how it has been verified.</p> <p>Attempts have subsequently been made to localise other hydropower potential, and the report entitled <i>Grønlands vandkraftpotentialer</i> [Hydropower potential in Greenland] [Nukissiorfiit 2004^F] provides updated information on some of the most interesting potential sites, while other potential sites are mentioned only sporadically.</p>
Purpose of this report	<p>The purpose of this report is to provide a complete picture of the total potential localised since 1974, no matter whether exploitation of the potential of individual sites seems realistic or unrealistic at present. The potential sites are listed in tables and shown on maps for each local authority area, the emphasis being on creating an unequivocal, comparable list with indication of the most recently published sources.</p> <p>With a few exceptions, no supplementary calculations of the potential have been made, the only reference being to previously published reports. Matters such as hydrological measurements, reconnaissance and other surveys conducted after the publication of the source material have not been taken into account. For each facility there is an indication of the extent to which hydrological measurements have been made, but it has not been possible to take such measurements into account, since the results have not been publicised.</p> <p>Descriptions have been prepared of several of the most interesting facilities. These descriptions may include a historical outline as well as some subjective remarks as to whether it would be realistic to exploit the potential.</p>
Contents of this report	<p>Chapters 2, 3 and 4 describe the assumptions and methods applied in relation to the preparation of the lists of hydropower potential, while chapter 5 contains lists of localised facilities.</p> <p>Chapter 6 describes some of the most realistic facilities that future studies and surveys should concentrate on.</p> <p>Chapter 7 contains information about hydrological measurements made in relation to the hydropower potential identified.</p> <p>A complete list of literature registered by Nukisiorfiit and Greenland Resources is given in Annex 19.</p>

2 Categorisation of hydropower projects

The localised hydropower facilities are categorised on the basis of their purpose, degree of regulation and size. The degree of regulation depends on the extent to which it is possible to create a reservoir that is sufficiently large to store water from years with an abundance of water to years with scarcity of water.

The category is indicated by means of an alphanumeric code, eg B1, which indicates that the facility is a facility for the supply of an urban area with annual regulation.

The following codes are used:

Based on purpose

- A. Industrial hydropower (> 100 MW)
- B. Urban hydropower (1-50 MW)
- C. Settlement hydropower (< 100 kW)

Based on degree of regulation

0. Unknown
1. Annual regulation (Reservoir able to store water from wet years to dry years)
2. Seasonal regulation (Reservoir able to store water from wet periods to dry periods)
3. Unregulated

No codes are used for size categories, but hydropower facilities are normally divided into the following categories:

- Large facilities > 10 MW
- Small facilities < 10 MW
- Mini facilities < 1 MW
- Micro facilities < 100 kW

Planning stage

The planning stage indicates the extent to which the hydropower facility in question has been investigated as stated in the table below. It is not always possible to state the planning stage unequivocally and the remarks are therefore indicative only. Further information may appear from the detailed description of selected facilities and the remarks on the most promising urban facilities given in chapter 6.

Stage	Planning stage	Hydrological data	Map material	Geotechnical surveys	Other
I	Map localisation				
II	Reconnaissance	Theoretical calculations and/or estimate	Existing map	None	On-site visits to assess run-off conditions and reservoir
III	Outline design	A few years' measurements and/or theoretical calculations, possibly based on measurements in neighbouring areas	Existing map	None	Construction estimate
IV	Outline proposal	A few years' measurements supplemented by correlations with neighbouring areas or model calculation based on meteorological data	Map, at least 1:50000 and aerial photos	Geological assessment	Construction and operations estimate
V	Preliminary design	10-25 years' hydrological time series, measured or generated	Special maps drawn	Geophysical surveys for construction work	As conceptual design and simulation of operations
VI	Decision	25 year's hydrological time series of at least ten years' measurements	As preliminary design	As preliminary design	As preliminary design – plus cost/benefit analyses
VII	In operation				

3 Calculation of potential

The potential of hydropower facilities is often calculated in the documentation to which reference is made. However, different assumptions may have been applied as regards possible storage.

If no information is available, the following data will be applied:

Hydrology	Estimated or measured precipitation/ablation Q hm^3/a .
Reservoir size	Estimated on the basis of the best maps available
Degree of regulation	The ratio of reservoir volume to mean annual run-off Q
Regulation factor	The ratio of the unused water volume Q' to the mean annual run-off Q . If the size of the reservoir is known, the regulation factor will be calculated on the basis of the table below:

Degree of regulation	Regulation factor
0.5	70%
0.7	80%
1.0	85%
1.5	95%

Theoretical potential Calculated using the following formula:

$$E = \eta \times \gamma \times \frac{Q' \times h_n}{f}$$

where:

- E = energy potential ex works (kWh/a)
- η = the efficiency of the power station (here set at 0.87)
- γ = the specific gravity of water (here set at 9.81×10^3 kN/m³)
- Q' = the regulated (used) volume of water (m³/a)
- h_n = net (effective) head
- f = factor for conversion between units (3.6×10^6 Ws/kWh)

Effect If there is no specific calculation of the effect installed, the nominal effect is calculated on the basis of the time of use:

- Industrial hydropower: 8000 h/a
- Urban hydropower: 5000 h/a
- Settlement hydropower: 4000 h/a

Updating of hydrological basis Generally the hydrological basis stated in the documentation mentioned will be used. In relation to some hydropower potential, where the rate of flow has been measured after the date of the documentation in question, the potential

has been recalculated in accordance with [Nukissiorfiit 1995^D]. Hydrological measurements made after 1995 are not included, unless specifically mentioned in the detailed description of the facilities.

Climate changes

The hydrological conditions relating to the hydropower resources will be affected by sustained climate changes. Global warming may mean that temperatures in the Arctic area go up, winters become shorter and the volume of precipitation increases [DMU 2004^A].

The primary effect on the hydrological resources will be that water volumes will increase, partly because of increased precipitation in the ice-free areas, and partly because of increased melt off from glaciers and the ice cap.

However, the warmer climate will mean increased evaporation, and in the long term increased evaporation will entail increased evapo-transpiration. The ice front will withdraw, and glaciers may disappear. All things being equal, this will mean that smaller volumes of water will be available for hydropower facilities.

Changes in the occurrence of glaciers may have various effects. Withdrawal may open up new land areas, thus increasing flows to hydropower facilities [Meyer 2003^B], or it may result in a smaller ablation area and consequently reduced run-off.

It is therefore extremely important that hydrological measurements are made on an ongoing basis to determine the most important hydropower potential in relation to regional basins and existing facilities.

4 Key data

Naming	<p>Each facility located is designated by the number of the relevant municipality and consecutive letters. In addition, the name most frequently used in publications is stated:</p> <p>Example: Iterlaa in Paamiut municipality: 05.g</p> <p>If there is more than one proposal for each basin, each proposal is given a number, eg -1, -2, etc.</p>
Key data	<p>The following key data is given for each facility:</p> <ol style="list-style-type: none">1. Category (eg: B1 indicated urban hydropower with annual regulation)2. Planning stage (eg IV)3. Coordinates for power station (WGS84)4. Calculated/installed nominal effect (MW)5. Theoretical/calculated/actual energy production ex works¹ (GWh/a)6. Precipitation catchment area including local areas covered with ice (km²). The area cannot be stated with any great accuracy.7. Catchment area of ablation area (glaciers) (km²)8. Mean annual run-off (hm³ = million m³)9. Reservoir size (hm³ = million m³)10. Head, max.² (m)11. Horizontal distance from inlet to outlet (m)12. Distance from town (along probable transmission line) (km)13. Fiord crossings (number × m)14. The documentation states the publication from which the data mentioned is taken.15. Hydrological measurements: Indication as to whether hydrological measurements have been made. The years stated are indicative only, as they do not apply to all measuring stations for the facility in question.
Deviation from design basis	<p>In the form of notes it is stated whether the design basis deviates from the information provided under planning stage, eg the extent of hydrological measurements, the drawing of maps, etc.</p>
Calculation of energy consumption	<p>For each town, energy consumption data is given, broken down on lighting/power, district heating including interruptible electrical heating, if such heating is installed, and individual heating including permanent electric heating. The data is taken from Energy Plan 2020³. Consumption in 2020 is estimated for various population scenarios.</p>







¹ Calculation: see chapter 3

² For facilities which are exclusively based on localisations on maps, the head stated will generally be the gross head, ie without loss in water routes. For facilities in relation to which calculations are available in conceptual or preliminary design projects, the head stated is the net head.

³ Scheduled for publication in mid- or end-2005

5 Localised facilities

The individual facilities are included in tables for each local authority and indicated on maps. The maps show the boundaries of catchment areas, the location of the power stations, waterways and hydrological measuring stations. For settlement facilities only the location of the power station is indicated.

Legend:	
	Catchment area boundary
	Waterways (tunnels, canals, ducts, etc)
	Power station
	Possible power station, not described
	Hydrological measuring station - in operation
	Hydrological measuring station – closed down

Key to signs and symbols used in tables:

- ... No information available
- .. Available information is uncertain
- . Figures obviously not available
- 0 Less than half of the unit used
- Zero
- * Figure estimated in this report
- + Data available but included in other data

If a facility covers several local authority areas (supplies several towns), it is only mentioned in connection with one of those towns, and a reference to it is made in relation to the other town(s).

List of localised potential

No.	Name	Other name	Local authority	Category	Status	Page
01.a	Tasiusaarsuk		NAN	B1	III	11
01.b			NAN	B0	I	11
01.c			NAN	B0	I	11
01.d			NAN	B0	I	11
01.e	Narsap Sarqaa		NAN	B1	I	11
01.f	Tasersuaq		NAN	B0	.	11

No.	Name	Other name	Local authority	Category	Status	Page
03.a	Killavaat	Redekammen	QAQ	B1	III	13
03.b			QAQ	B0	I	13
03.c	Taseq		NAR	B1	V	13
03.d	Igaliku		NAR	B0	III	13
03.e			QAQ	B0	II	13
03.e-3	Qallimiut		NAN	C3	II	14
03.f	Qorlortorsuaq		NAN	B1	VI	14
03.h	Johan Dahl Land	Nordbosø	NAR	A1	IV	14
03.j	Motzfeldt Sø		NAR	A0	II	14
05.a			PAA	B0	I	16
05.b	Nigerleq		PAA	B2	II	16
05.c			PAA	B0	I	16
05.d			PAA	B0	I	16
05.e			PAA	B0	I	16
05.f			PAA	B0	I	16
05.g	Iterlaa	Qingua	PAA	B1	IV	17
05.h	Killeqarfik	Grænseland	PAA	A1	I	17
05.j	Isorsua		PAA	A1	I	17
05.k	Kangaarsuup tasersua		PAA	A1	I	17
06.a	Kangerluarsunnguaq	Buksefjord	NUU	B1	VII	18
06.b-1	Kangerluarsunnguaq, udb. 2	Buksefjord	NUU	A1	IV	18
06.b-2	Kangerluarsunnguaq, udb. 3	Buksefjord	NUU	A1	IV	18
06.c	Allumersat	Bjørnesund	NUU	A1	I	19
06.d	Qaqqat Akuleriit		NUU	A1	I	19
06.e	Kangerluarsussuaq	Grædefjord	NUU	A1	II	19
06.f	Isortuarsuup		NUU	A1	II	19
06.g	Imarsuup Isua	Imarsuaq, Qaamasup tasia	NUU	A1	IV	19
06.h	Tasersuup Isua		NUU	A1	II	19
07.a	Qapiarfusaap	Sø 358	MAN	B1	II	21
07.b	Qapiarfusaap	Sø 520	MAN	B1	II	21
07.a+b	Qapiarfusaap Sermia	Qapiarfiup Sermia	MAN	B1	III	21
07.c	Alangua	Alanguata tasersua	MAN	B2	I	21
07.d	Søndre Isortup Isua		MAN	A1	I	21
07.e	Tasersiaq		MAN	A1	IV	21
07.f	Umiiviit		MAN	A1	III	21
08.a			SIS	B0	I	23
08.b	Tasersuaq		SIS	B1	VI	23
08.c			SIS	B0	I	23
08.d	Amerloq		SIS	B2	I	23
08.f	Kangerlussuaq		SIS	B0	I	23

No.	Name	Other name	Local authority	Category	Status	Page
11.a	Salliup tasia	Salliup Tunulia	QAS	B2	III	25
11.b			QAS	B0	I	25
11.c			QAS	B0	I	25
11.d	Akiamiut		QAS	B0	I	25
11.e	Sarqarlleq	Akiamiut tasmusua	QAS	B2	I	25
11.f	Kuussuup tasia		QAS	B1	IV	26
11.g	Kangersuneq		QAS	B2	I	25
12.a			ILU	B3	I	28
12.b			ILU	B0	I	28
12.c			ILU	B0	I	28
12.d	Tasersuaq		ILU	B1	I	28
12.e			ILU	B0	I	28
12.f			ILU	B0	I	28
12.g	Paakitsup Akuliarusersua		ILU	B2	V	29
12.h	Paakitsup Sarfaa		ILU	B3	III	29
12.j	Nuussuaq		ILU	A1	II	29
12.j	Paakitsup Sarfaa		ILU	B3	II	29
14.a	Kuussuaq	Røde Elv	QEQ	B3	III	31
18.a	Aammangaaq	Præstefjeld	TAS	B2	VII	33
18.b	Qorlortoq		TAS	B1	III	33

Nanortalik

Town data

	Population	Light/power Net GWh	District heating including interruptible electric heating Net GWh	Individual heating including permanent electric heating Gross GWh
1998	1,506	3.0	2.8	...
2003	1,549	4.0	2.0	12.6
2020	1,209-1,379	2.8-3.4	1.8-1.9	11.0-11.7

Hydropower facilities

		01.a	01.b	01.c	01.d	01.e	01.f	
Name		Tasusaarsuk				Narsap Sargaa	Tasersuaq	
Category		B1	B0	B0	B0	B1	B0	
Planning stage		III	I	I	I	I	I	
Power station coordinates		60°13'N 45°04'V	60°16'N 45°02'V	60°13'N 44°55'V	60°28'N 44°34'V	60°07'N 44°39'V		
Nominal effect	MW	6	0.8*	0.8*	1.3*	3.5		
Energy production ex works	GWh/a	14	3.8	4.1 ⁴	6.5	15.2		
Catchment area, precipitation	km ²	12.8	5.0	9.5	3.8	14.3		
Catchment area, ablation	km ²	.	.	.	.	2.0		
Mean annual run off	hm ³	18	4.0	8.6	3.8	16		
Reservoir size	hm ³	25	...	...	...	15		
Damming	M	-	...	...	...	...
Head	M	347	400	200	730	400		
Horizontal distance from inlet to outlet	M	3000	1900	2500	2900	1400		
Distance from town	km	16.5	20	25	60	40		
Fjord crossings ⁵	Number/m	400- 850	...	...	...	1000		
Documentation		1983 ^C 1995 ^D	1981 ^E	1981 ^E	1981 ^E	2004 ^F	See descrip- tion	
Hydrological measurements		1980-90					1987-90	
Notes								
Data check		yes	yes	Yes	yes	yes		

Qorlortorsuaq

See Narsaq/Qaqortoq 03.f.

⁴ Based on feasibility studies carried out by GTO, the potential is estimated at 8 GWh/a

⁵ In connection with all projects there will be a span of at least 200 metres above water.

01.a Tasiusaarsuk

The outline proposal [V&S/NVK/PAP 1983^C] shows an alternative that uses the fall from Sø 373 to an underground power station at level 25, possibly with intake from Sø 390, which includes Sø 524's catchment area.

A number of alternatives are treated in a working paper [V&S/NVK 1982^G]. These alternatives must be recalculated in connection with any future treatment.

Three hydrological measuring stations in the area have measured the flow of water for 4-7 years. The measurements can form the basis for improved hydrological simulation. In [Nukissiorfiit 1995^D] run-off and output data have been updated, but the hydrology is still uncertain. In [Nukissiorfiit 2004^F] the project is mentioned and there are some data as well as a sketch that does not match the above. There is no coherence between the catchment area, the annual rate of flow and the hydrological head.

See also the description in chapter 6.

01.e Narsap Sarqaa

See also the description in chapter 6.

01.f Tasersuaq

A relatively large catchment area and lake area but very low head have been registered at measuring station 452. The ground is completely flat near the river, which means that it will not be possible to build a dam.

There is no possibility of commercial exploitation of the potential.

Qaqortoq

Town data

	Population	Light/power Net GWh	District heating including interruptible electric heating Net GWh	Individual heating including permanent electric heating Gross GWh
1998	3,132	9.8	10.9	...
2003	3,129	9.7	13.0	22.1
2020	2,789-3,809	8.3-11.8	12.3-16.6	20.9-28.3

Hydropower potential: see Narsaq/Qaqortoq

Narsaq/Qaqortoq

Data for Narsaq

	Population	Light/power Net GWh	District heating including interruptible electric heating Net GWh	Individual heating including permanent electric heating Gross GWh
1998	1,725	6.5	-	...
2003	1,699	6.5	-	21.7
2020	1,529-1,954	5.7-7.5	-	20.8-25.7

Hydropower facilities

See annex 03a		03.a	03.b	03.c-1	03.c-2	03.d	03.e
Name		Killavaat (Redekammen)		Taseq. 1. etape	Taseq. 2. etape	Igaliku	
Category		B1	B0	B1	B1	B0	B0
Planning stage		III	I	V	IV	III	I
Power station coordinates		60°50'N 45°49'V	60°50'N 45°49'V	60°59'N 45°30'V	60°59'N 45°30'V	60°59'N 45°30'V	60°47'N 45°28'V
Nominal effect	MW	1.1	0.5*	3.1	+5	2.1*	1.2*
Energy production ex works	GWh/a	8.8	2.5	9.0	27.1	10.6	6 ⁶
Catchment area, precipitation	km ²	6.3	21.7	9.9	13.9	19.3	60 ⁷
Catchment area, ablation	km ²	0	0	0	2	0	0
Mean annual run off	hm ³	7.8	13.0	8.7	+15.5	13.4	49
Reservoir size	hm ³	7.8	...	11.0	18.0	...	...
Damming	M	2	...	0	9.0	I 20 / II 10	...
Head	M	630/452	80	479	488	270/390	120
Horizontal distance from inlet to outlet	M	1900	1600	3800	3800	4500	1700
Distance from town	Km	QAQ 25	QAQ 30	NAR 5	NAR 5	IGA 6	QAQ 45
Fjord crossings	Number/m	-	-	-	-	-	2200
Documentation		1981 ^H	1981 ^E	1981 ^I	1981 ^J	1983 ^K	1981 ^E
Hydrological measurements		1980-84		1980-92 2002-	1980-84		1988-90
Notes		8		See description		9	
Data check		yes	yes	yes	yes	yes	yes

(Continues on the next page)

⁶ Uncertain, as it has previously been stated as 13.9 GWh/a

⁷ Catchment areas I and II

⁸ The project uses precipitation in three catchment areas. Catchment areas I and III includes reservoir lakes that provide two different hydrological heads. Catchment area II will be dammed, and the water will be led to a reservoir in catchment area III.

⁹ The project uses precipitation in three part catchment areas. Catchment areas I and III includes reservoir lakes that provide two different hydrological heads. Catchment area II is used unregulated. No construction estimates have been prepared.

Hydropower facilities, Narsaq/Qaqortoq (continued)

See annexes 03a and 03b		03.e-1	03.e-2	03.e-3	03.f	03.h	03.j
Name				Qallimut	Qorlor-tor-suaq	Johan Dahl Land	Motzfeldt Sø
Category		B0	B0	C3	B1	A1	A0
Planning stage		II	II	II	VI ¹⁰	IV	II
Power station coordinates		60°44'N 45°24'V	60°50'N 45°25'V	60°42'N 45°22'V	60°47'N 45°14'V	61°15'N 45°28'V	61°10'N 45°12'V
Nominal effect	MW	1,6*	1,3*	0,1	7,2	40	30
Energy production ex works	GWh/a	8	6,5	¹¹	29,6	300	148
Catchment area, precipitation	km ²	60 ⁷	27	106 ¹²	208	150	434
Catchment area, ablation	km ²	...	...	...	See description	~25	1394
Mean annual run off	hm ³	40 ^M	...	139	139	225	905
Reservoir size	hm ³	...	...	-	126	225	585
Damming	M	...	...	-	6.5	5	0
Head	M	110 ^M	...	7.5	114	640	110
Horizontal distance from inlet to outlet	M	...	...		500	18.300	9000
Distance from town	Km	...	...	0	QAQ 62,2 NAR 53,0	NAR 56	NAR 65
Fjord crossings	Number/m	ja	Ja	-	3600/1920/ 2010	ja	2000
Documentation		1980 ^L	1980 ^L	1994 ^M	2004 ¹³	1980 ^N 1995 ^D	1980 ^L
Hydrological measurements		1988-90		1988-90	1987-	1976-84	
Notes					See description	See description	See description
Data check		no	no	no	no	yes	no

03.c Taseq

In 1981 a draft proposal for Taseq stage 1 and an outline proposal for stage 1 and stage 2 were prepared. Stage 1 (03.c-1) comprises catchment area I and transfer of water from catchment area II with a power station in Dyrnaes Valley. Alternative locations with a lower-lying power station can generate an output of 9.8 GWh/a.

The outline proposal illustrates alternative locations of the power station as well as stage 2 (03.c-2) where water is transferred from catchment area III, Narsaq Elv, and a dam is established at the Taseq reservoir lake.

¹⁰ Will be put into operation in October 2007

¹¹ This power station will be a micro hydropower station with a short canal and unregulated feed that can generate power 6-9 months a year, but no output figures have been calculated. [Nukissiorfiit 1995^D] indicates a potential of 11 GWh/a if the entire 20-metre head is used.

¹² Catchment areas I, II and III

¹³ Detail design and supplementary calculations; see description.

03.f Qorlortorsuaq

This station is currently being built. The data have been assessed on the basis of the detail design from November 2004 and supplementary calculations of output based on a dam going to level +128. In 2002, main catchment area I was extended to include catchment area II through natural penetration of a blocking glacier. The size of this catchment area is unknown, and no new output calculation has been made.

The station will be prepared for the addition of a third turbine.

It may be possible to lead water from the glacier river to the north of catchment area I.

03.h Johan Dahl Land

The system described in the sketch project [ACG/VBB 1980^N] uses water from catchment areas I (Nordbosø), II (Thor Sø) and III (Odin Sø), all of which is stored in Nordbosø, and from catchment areas IV (Sø 760) via an intake from a stream.

Run-off and output are reassessed in [GTO1980^L] and are now estimated at 300 GWh/a including catchment area V (Sø 910).

It is also possible to use catchment area V (Sø 910) with 9 hm³/a and to pump up water from catchment area VI (Hullet/The Hole)). Hullet is an ice-dammed lake, which is tapped every one or two years when the water level drops from +530 to +110 m. The potential in relation to this catchment area is estimated at 230 GWh/year [GTO 1980^L]. See also [ACG 1981^O].

03.j Motzfeldt Sø

The data come from [ACG 1975^P] and [Braithwaite 1980^O], while the potential has been calculated on the basis of [GTO 1980^L]. As suggested in [ACG 1975] there is a risk that there is no barrier under the glacier to the west and consequently no possibility of creating a reservoir. This would mean that the potential described would not exist.

Plans for pumping water from a glacier catchment area to the south have been presented [GTO 1980^L]. Such pumping would require a large dam and another location of the power stations. The supplementary potential is stated as 69 GWh/a.

Ivittuut

No hydropower potential

Paamiut

Town data

	Population	Light/power Net GWh	District heating including interruptible electric heating Net GWh	Individual heating including permanent electric heating Gross GWh
1998	1,957	6.0	14.5	...
2003	1,842	5.5	13.4	13.7
2020	1,162-1,332	3.0-3.6	11.2-11.6	12.3-12.6

Hydropower facilities

See annex 05a		05.a	05.b	05.b'	05.c	05.d	05.e	05.f
Name			Nigerleq ¹⁴ Sø 430	Nigerleq ¹⁴ Sø 165				
Category		B0	B2	B2	B0	B0	B0	B0
Planning stage		I	II	II	I	I	I	I
Power station coordinates		62°03'N 49°21'V	62°04'N 49°19'V	62°04'N 49°19'V	62°00'N 49°22'V	62°05'N 49°09'V	62°08'N 49°17'V	62°12'N 49°18'V
Nominal effect	MW	0.5	2.4	2.4	1.6	1.5	1.5	2.3
Energy production ex works	GWh/a	2.4	7.2	7.2	7.9	7.3	7.7	11.7
Catchment area, precipitation	km ²	3.1	11.0	26.0	9.5	5.3	22.5	55.0
Catchment area, ablation	km ²	.	.	.	.	.	.	.
Mean annual run off	hm ³	2.8	10.5	24.9	9.5	4.4	20.3	49.5
Reservoir size	hm ³	...	5.0	11.8	...	...	...	...
Damming	M	...	3.0	6.0	...	...	...	...
Head	M	360	430	158	350	700	160	100
Horizontal distance from inlet to outlet	M	850	2 600	3 200	3 500	2 500	2 100	1 200
Distance from town	km	20	22	22	27	32	32	40
Fjord crossings	Number/ m	-	-	-	-	-	-	-
Documentation		1981 ^E	2004 ^F	2004 ^F	1981 ^E	1981 ^E	1981 ^E	1981 ^E
Hydrological measurements				2004-				
Notes			See description					
Data check		no	No	No	No	no	no	no

(Continued on the next page)

¹⁴ Potential b and potential b' are collectively described as 'Nigerleq' with a communal power station.

Hydropower facilities, Paamiut (continued)

See annexes 05a and 05b		05.g-1	05.g-2	05.h	05.j	05.k	
Name		Iterlaa	Iterdla (reduced)	Killeqarfik (Grænse- land)	Isorsua	Kangaarsuup tasersua	
Category		B1	B1	A1	A1	A1	
Planning stage		IV	II	I	I	I	
Power station coordinates		62°14'N 49°18'V	62°14'N 49°18'V	61°20'N 48°01'V	61°39'N 48°35'V	62°28'N 49°45'V	
Nominal effect	MW	12.0	4.8	58	45-100*	65-125*	
Energy production ex works	GWh/a	48.0 ¹⁵	19	310-625	340-850	500-1000	
Catchment area, precipitation	km ²	91.5	91.5	155	175	310	
Catchment area, ablation	km ²	.	.	445	250	1650	
Mean annual run off	hm ³	76.7	76.7	250-500	200-500	1600-3500	
Reservoir size	hm ³	50	50	350	430	2160	
Damming	M	0	0	...	...	...
Head	M	305	305	510	700	150	
Horizontal distance from inlet to outlet	M	2 725	1 800	5 900	27 700	4 100	
Distance from town	Km	46	46	.	.	.	
Fjord crossings	Number/m	-	-	.	.	.	
Documentation		1986 ^R 2004 ^F		1975 ^P 1995 ^D	1975 ^P 1995 ^D	1975 ^P 1995 ^D	
Hydrological measurements		1980-91	1980-91				
Notes			16			17	
Data check		Yes		no	no	no	

05.b Nigerleq

The station is described in [Nukissiorfiit 2004^F] and a subsequent inspection as well as field studies were made in September/October 2004. The ensuing results have not yet given rise to the preparation of a sketch project, for which reason it is difficult to interpret the results.

No hydrological measurements have been made, but a measuring station was established in 2004.

It seems that several large dams must be established to create reservoirs.

The data given are preliminary data.

05.g Iterlaa

See description in chapter 6

Continues on page 17a

¹⁵ [Nukissiorfiit 1995^D] assessed that the output can be increased by about 20 GWh/a by transferring water from glacier-dominated neighbouring catchment areas.

¹⁶ The power station has a reduced effect and output as compared with the hydrological potential (see chapter 6).

¹⁷ The reservoir lake is ice-dammed and run-off conditions have not been identified.

Nuuk

Town data

	Population	Light/power Net GWh	District heating including interruptible electrical heating Net GWh	Individual heating including permanent electrical heating Gross GWh
1998	13,024	52.3	77.7	...
2003	13,884	57.0	117.7	96.6
2020	15,584-18,984	66.8-78.0	134.9-171.1	111.2-142.2

Hydropower facilities

See annex 06b		06.a	06.a	06.b-1	06.b-2	
Name		Kangerluarsuunguaq (Buksefjord) Construction stage I	Kangerluarsuunguaq Construction stage II	Kangerluarsuunguaq Extension 2	Kangerluarsuunguaq Extension 3	
Category		B1	B1	A1	A1	
Planning stage		VII	VI	IV	IV	
Coordinates of power station		63°55'N 50°53'V	63°55'N 50°53'V	63°55'N 50°53'V	63°59'N 50°12'V	
Nominal effect	MW	30	45	+70	+45	
Energy production ex works	GWh/a	190 ¹⁸	250	+580	+390	
Catchment area, precipitation	Km ²	856 ¹⁹	856	+684 ²⁰	684	
Catchment area, ablation	Km ²	-	-	480	480	
Mean annual run-off	Hm ³	345	345	+910	910	
Reservoir size	Hm ³	2050	2050	+2350	2350	
Damming	M	15	15	+0 ²¹	0	
Head	M	261	261	261	200	
Horizontal distance from inlet to outlet	M	12.000	12.000	+16.600	16.600	
Distance from town	Km	56,5	56,5	56,5	87 ²²	
Fjord crossings	number/m	5376/2643	5376/2643	5376/2643	5376/2643	
Documentation		See description		1994 ^S		
Hydrological measurements		1981-92	1982-89	1985-	1985-	
Notes		See description		See description		
Data check		No	No	No	no	

(continued)

¹⁸ Registered production; see description

¹⁹ Comprises catchment areas I, II, IV and V as well as stream intake from catchment area A

²⁰ Comprises transfer of water from catchment areas IX, VII and VIII (Isortuarsuup tasia 06.f). Isortuarsuup tasia is used as a supplementary reservoir.

²¹ Concrete threshold at the outlet of Isortuarsuup tasia.

²² The transmission line to Nuuk needs to be doubled.

Hydropower facilities, Nuuk (continued)

See annexes 06a and 06c		06.c	06.d	06.e	06.f	06.g	06.h
Name		Allumersat (Bjørnesund)	Qaqat Akulerit	Kangerluarsus- suaq (Grædefjord)	Isortuarsuup	Imarsuup Isua (Imarsuaq)	Tasersuup Isua
Category		A1	A1	A1	A1	A1	A2
Planning stage		I	I	II	II	IV	II
Power station coordinates		62°58'N 49°47'V	63°13'N 49°57'V	63°23'N 50°04'V	63°41'N 50°32'V	64°50'N 50°11'V	64°53'N 50°43'V
Nominal effect	MW	40-85*	40-65*	110-160*	93*	154	65*
Energy production ex works	GWh/a	300-700	300-500	900-1300	740	1480	500
Catchment area, precipitation	Km ²	88	330	620	625	540	3000
Catchment area, ablation	Km ²	220	270	1120	480	1500	2900
Mean annual run off	Hm ³	200-400	300-550	2840	770	1000	4200
Reservoir size	Hm ³	240	550 ²³	930	1330	1080	2350
Damming	M	44+5	0	3 stk.	1 stk.	28/19/17/13 /4	2 stk.
Head	M	700	440	220/95/27 0	440	635	65
Horizontal distance from inlet to outlet	M	6000	4200	1000/600/ 250	14000	11.500	8500
Distance from town	Km	.	.	.	.	.	.
Fjord crossings	Number/m	.	.	.	.	.	.
Documentation		1975 ^P 1995 ^D	1975 ^P 1995 ^D	1975 ^P 1995 ^D	1975 ^P 1985 ^T	See description	See description
Hydrological measurements				1976-88	1985-	1974-94	1974-83
Notes				²⁴	²⁵	See description	See description
Data check		No	no	No	no	no	no

06.a Kangerluarsunnguaq Urban supply

Stage I of the Buksefjord Hydropower Station was constructed in 1989-1993 to supply Nuuk with energy for light, power and heating.

In Stage I, 30 MW was installed, and production ex works is 190 GWh/a.

²³ The size of the reservoir requires a 25 metre lowering of the reservoir. It is uncertain whether this is feasible.

²⁴ Output, run-off and storage size are stated for all three power stations. Mean run-offs are as stated in [Nukissiorfiit 1995^D]. The highest energy potential is calculated in accordance with this but calls for reservoirs with substantial lowering of water levels, which have not been verified.

²⁵ Run-off and output are given for all catchment areas. Catchment areas II and II are currently used in 06.a Buksefjorden, and extensions 2 and 3 of Buksefjorden will also use catchment area I. There will thus no longer be a potential.

In Stage I, the power station hall was prepared for a third aggregate of 15 MW, and the overall hydrological catchment area comprising sub-catchment areas I, II, IV, V and stream catchment area A were extended.

Stage II, which comprises the installation of the third aggregate, is scheduled for installation in 2005-2010, whenever the need arises. In the first ten years of operation an average overrun from the current hydrological catchment area of 85 m³/year has been registered, which can bring total output up to 250 GWh/year following installation of the third aggregate.

06.b+c Kangerluarsunnguaq

Industrial supply

In 1993 the possibility of a second and a third extension of the Buksefjord Hydropower Station was investigated with a view to supplying power to a zinc refinery in Nuuk.

The hydrological basis for such extension can be provided by transferring water from catchment areas IX, ISTA (Isortuarsuup tasia, catchment 06.f), through an approximately 15 km long tunnel system.

By installing an additional 90 MW partly in a new 70 MW power station next to the existing power station (06.b) and establishing a completely new 45 MW power station exploiting the fall of 190 metres between Isortuarsuup tasia and Kangersunnguup tasersua (06.c), total output can be brought up to about 1200 GWh/a.

An expansion of this magnitude calls for doubling of the existing transmission line.

Alternatives

Extensions II and III described above were conditional on a specific zinc project and are not necessarily the optimal extensions for future scenarios.

See also the description given in chapter 6.

06.g Imarsuup Isua

This facility was originally investigated and planned in 1974 in connection with plans to open an iron ore mine at Isukasia. On the basis of this, a detailed sketch project [ACG/VBB 1975^U] was prepared in 1975. Hydrological measurements continued until 1994. Based on these measurements, the total run-off available is estimated at 1,000 hm³/a [Nukissiorfiit 1995^D]. The output stated is calculated on the basis of this estimate. The nominal effect is based on a time of use of 7400 hours.

Later an outline design was prepared for a smaller scale facility for the supply of Nuuk [ACG 1980^V]. This facility uses only a minor proportion of the run-off and a smaller reservoir, but requires a 130 km long transmission line with a 4.3 km long sea-cable crossing of Godthåb Fjord.

06.h Tasersuup Isua

This facility was investigated in 1974 and described in [ACG/VBB 1975^P]. Hydrological measurements were made until 1983, and output has been adjusted accordingly. In the calculation of catchment and run-off it has been assumed that the northern catchment area for 06.g Imarsuup Isua will be used in this facility. If it is not, it would be possible to increase output by about 30%.

See also description in chapter 6.

Maniitsoq

Town data

	Population	Light/power Net GWh	District heating including interruptible electrical heating Net GWh	Individual heating including permanent electrical heating Gross GWh
1998	3,023	10.0	20.2	...
2003	2,899	9.6	19.9	21.1
2020	2,389-2,559	7.5-8.2	15.4-18.7	16.7-20.5

Hydropower facilities

See annexes 07a and 07b		07.a	07.b	07.a+b	07.c	07.d	07.e-1	07.f
Name		Sø 358	Sø 520	Qapiarfusaap Sermia	Alangua	Søndre Isortup Isua	Tasersiaq	Umiivit
Category		B1	B1	B1	B2	A1	A1	A1
Planning stage		II	II	III	I	I	IV	III
Coordinates of power station		65°35'N 52°22'V	65°35'N 52°18'V	65°34'N 52°23'V	65°34'N 52°14'V	65°39'N 50°25'V	66°28'N 51°33'V	66°49'N 50°56'V
Nominal effect	MW	2,3	4,6	12+2,5	3,2	125*	300	100
Energy production ex works	GWh/a	9.6	19.1	55+13	13,6	1000	2500	900
Catchment area, precipitation	Km ²	21	25	26.5	74	235	1570	1425
Catchment area, ablation	Km ²	+	+	25.4	.	1080	+	1700
Mean annual run-off	Hm ³	17	23	75	67	1000	2160	1500
Reservoir size	Hm ³	14	16	75	30	1000	2240	1350
Damming	M	...	...	15	...	yes	25/8 ²⁶	Yes
Head	M	258	377	358	100	430	620	319
Horizontal distance from inlet to outlet	M	2000	990	4725	1400	12.000	25.000	9000
Distance from town	Km	35	35	34	30	.	.	.
Fjord crossings	Num- ber/m	2/...	2/...	2/6000 ²⁷	4/...	.	.	.
Documentation		2004 ^F	2004 ^F	1981 ^W 1995 ^D	2004 ^F	1995 ^D	1998 ^Z	1995 ^X 1995 ^D
Hydrological measurements		1974-86	1981-86	1974-86		1974-83	1975-	1975-83
Notes		28	28	28, 29			See description	
Data check		no	no	no	No	no	no	no

²⁶ To use catchment area II, a 10 metre high dam with overrun and bottom pit for sediments is required.

²⁷ Lake cable

²⁸ Potential 07.a and potential 07.b can be used in different ways, either individually or in combination. However, run-off volumes are not well documented, particularly as regards 07.b where the majority of the catchment area is covered with ice. There are only very few water flow measurements.

²⁹ Output and effect are stated for the lower power station (07.a+b) and the upper power station (07.a+b') respectively. All other figures related to the facility as a whole. Run off and output are as stated in [Nukissiorfiit 1995^D].

07.e Tasersiaq

The facility was first investigated in 1975, and an outline design was made in 1977 [ACG/VBB 1977^Y]. The project has subsequently been updated, most recently in 1998 [NNR/GB 1998^Z]. The values stated are taken from this updated version and include main catchment area I and catchment area II along Nordre Elv. The run-off is based on measurements made in 1975-1991. Catchment area A is an ice-dammed lake, which is emptied about once every ten years. It is uncertain whether this catchment can be transferred to catchment I, but if it is possible, an increase in output of 670 GWh/a is estimated [ACG/VBB 1977^Y].

In [Nukissiorfiit 1995^D] another location of the power station and the tunnel line is suggested; see 07.e-2. The same energy production is indicated, despite the small catchment area and head.

Likewise a power station running to the southwest towards Evigheds Fjord is suggested as proposal 07.e-3. Here the head can be increased to about 670 metres net, and the distance from inlet to outlet will be about 31 kilometres.

In 1999-2000 a research study entitled "Imersuaq" was carried out to improve the assessment of run-off from the ice cap [www.imersuaq.dk]. This study has not given rise to any reassessment of the potential.

The catchment areas around Tasersiaq make several different extensions possible, depending on output requirements. There is some uncertainty as to the extent of the potential, particularly about the inclusion of catchment II. Since run-off is still being measured from Tasersiaq, it will be possible to update the potential by means of new calculations.

See also the description in chapter 6.

07.f Umiiviit

This station was examined in the 1970s, and new studies were made in 1994. In 1995 a sketch project was prepared [Rambøll 1995^X]. The sketch project comprises a first extension which uses the natural catchment area of Tasersuaq and a second extension where water is led to the area from catchment II (Torssut River).

Water flows in Torssut were measured in the period from 1975 to 1983, and in 1993 a measuring station was established at Tasersuaq. However, the number of flow measurements made are insufficient to establish a q/h ratio.

The data stated concern use of both catchment I and catchment II. The first extension alone is estimated to generate an output of 285 GWh/a.

In the second extension the water will be dammed up by about five metres, and a 40-55 metre dam will be established in Torssut.

There is great uncertainty about the possibility of realising the sketch project. Tasersuaq is stated to be relatively shallow, and the hydrological conditions are uncertain. Furthermore tunnels and dams would have to be established in an area with permafrost.

Sisimiut

Town data

	Population	Light/power Net GWh	District heating including interruptible electric heating Net GWh	Individual heating including permanent electric heating Gross GWh
1998	5,195	16.0	23.1	...
2003	5,263	17.0	23.9	45.6
2020	5,263-6,283	17.0-20.3	23.9-30.0	45.6-56.2

Hydropower facilities

See annexes 08 and 07b		08.a	08.b	08.b'	08.c	08.d	08.f
Name			Tasersuaq	Tasersuaq		Amerloq	Kangerlussuaq
Category		B0	B1	B1	B0	B2	B0
Planning stage		I	VI	III	I	I	I
Power station coordinates		67°05'N 53°28'V	67°07'N 53°23'V	67°07'N 53°23'V	66°58'N 52°58'V	66°56'N 53°04'V	67°02'N 50°35'V
Nominal effect	MW	1.0*	14,2	7.8	2.0*	2.6	1.3
Energy production ex works	GWh/a	5.2	54	44.4	9.9	10.6	7.5
Catchment area, precipitation	km ²	8.1	862 ³⁰	865	30	85	...
Catchment area, ablation	km ²	.	-	-	.	.	...
Mean annual run off	hm ³	4	309	277.2	12	37	...
Reservoir size	hm ³	...	501	270	...	17.5	...
Damming	M	...	0	-	...	...	...
Head	M	550	79	78.5	350	129	...
Horizontal distance from inlet to outlet	M	3500	5200	4600	3500	...	2950
Distance from town	Km	23	27	27	35	...	...
Fjord crossings	Number/ m	-	...	1200/1300/ 300	-	-	-
Documentation		1981 ^E	1992 ^{AE}	1999 ^O	1981 ^E	2004 ^F	2004 ^F
Hydrological measurements			1977-	1977-			
Notes			See description			31	
Data check		no	No	no	no	no	no

08.b Tasersuaq

See also description in chapter 6.

³⁰ Catchments I and II

³¹ The facility also uses the catchment area for 08.c

Kangaatsiaq

Town data

	Population	Light/power Net GWh	District heating including interruptible electric heating Net GWh	Individual heating including permanent electric heating Gross GWh
1998	641	1.5	-	...
2003	660	1.7	-	7.2
2020	557	1.4	-	6.7

No hydropower potential

Aasiaat

Town data

	Population	Light/power Net GWh	District heating including interruptible electric heating Net GWh	Individual heating including permanent electric heating Gross GWh
1998	3,147	11.9	12.7	...
2003	3,142	11.2	12.8	40.0
2020	3,057-6,652	10.9-13.1	12.7-15.1	39.6-47.3

Hydropower potential: see Qasigiannuit

Qasigiannqut

Town data

	Population	Light/power Net GWh	District heating including interruptible electric heating Net GWh	Individual heating including permanent electric heating Gross GWh
1998	1,444	4.8	4.8	...
2003	1,342	4.6	5.1	23.1
2020	917-1,087	2.8-3.5	4.4-4.6	21.2-21.9

Hydropower facilities

See annex 11	11.a	11.b	11.c	11.d	11.e	11.f	11.g
Name	Salliup tasia			Akiamiut	Sarqarlleq	See next table	Kangersuneq
Category	B2	B0	B0	B0	B2		B2
Planning stage	III	I	I	I	I		I
Power station coordinates	68°51'N 51°05'V	68°49'N 50°52'V	68°50'N 50°47'V	68°54'N 50°41'V	68°57'N 50°33'V		68°49'N 5040'V
Nominal effect	MW	0.9	1.0*	0.6*	1,0*	1.9	2.3
Energy production ex works	GWh/a	3.7	4.8	2.9	4.7 ³²	8.1	9.6
Catchment area, precipitation	km ²	73	18.5	61	63	63	64
Catchment area, ablation	km ²	.	.	.	.	.
Mean annual run off	hm ³	22	5.6	15.3	15.8	16	19
Reservoir size	hm ³	8,5	...	...	...	5	5
Damming	M	...	...	...	...	...	...
Head	M	80	360	80	125	227	227
Horizontal distance from inlet to outlet	M	1600	2300	2900	2500	2600	...
Distance from town	Km	...	15	19	25	33	...
Fjord crossings	Number /m	-	-	-	-	-	-
Documentation		1980 ^A 2004 ^F	1981 ^E	1981 ^E	1981 ^E	2004 ^F	2004 ^F
Hydrological measurements		1979-82					
Notes				33	33		
Data check		No	No	No	no	no	no

(Continues on the next page)

³² [Nukissiorfiit 1995^D] indicates a catchment area of 90 km² when water is taken from SØ. The resulting output is in the region of 6 GWh/a.

³³ 11.d og 11.e uses the same catchment area.

Hydropower facilities, Qasigiannuit/Aasiaat (continued)

See annex 11		11.f-1 (A)	11.f-1 (B)	11.f-1+ f-2 (C)	11.f-1 (D)	11.f-1+ f-2 (E)
Name		Kuussuup tasia	Kuussuup tasia	Kuussuup tasia	Kuussuup tasia	Kuussuup tasia
Catchment area		I	I	I	I+II	I+II
Category		B1	B1	B1	B1	B1
Planning stage		IV	IV	IV	III	III
Power station coordinates		68°41'N 50°54'V		68°43'N 50°32'V		
Nominal effect	MW	22	22	22	22+5 ³⁴	22+10 ³⁴
Energy production ex works	GWh/a	83	86	110	150	170
Catchment area, precipitation	Km ²	160	160	160	160+?	160+?
Catchment area, ablation	Km ²	135	135	135	135+?	135+?
Mean annual run off	Hm ³	261	261	261	≈350	≈350
Reservoir size	Hm ³	200	245	360	600	600
Damming	M	15	3	3+10	3	3
Head	M	135	135	135	135+40	135+40
Horizontal distance from inlet to outlet	M	4200	4200	4200+ 2400	4200	4200+ 2400
Distance from town	Km	41 ³⁵	41 ³⁵	41 ³⁵	41 ³⁵	41 ³⁵
Fjord crossings	Number /m	1	1	1	1	1
Documentation		1984 ^{AA}	1984 ^{AA}	1984 ^{AA}	1984 ^{AA}	1984 ^{AA}
Hydrological measurements		1980-91	1980-91	1980-91	1980-91	1980-91
Notes		See description				
Data check		No	No	No	No	No

11.a Salliup tasia See also description in chapter 6.

11.f Kuussuup tasia The outline proposal [ACG/VBB 1984^{AA}] suggests several possible extensions:

- A: With reservoir at Kuussuup tasia and power station 11.f-1
- B: With reservoir at Qingap Ilulialeeraa and power station 11.f-1
- C: With reservoir at Qingap Ilulialeeraa and power stations 11.f-1 and 11.f-2
- D: As B, with transfer from catchment II
- E: As C, with transfer from catchment II

³⁴ The effect of the turbine in power station 10.f-2 varies between 0.1 MW and 5 MW because of varying heads.

³⁵ The distance to Aasiaat is 114 km including a short fjord crossing.

It is assessed that it would be a good idea to use Qingap Ilulialeeraa as a reservoir for drawdown and to establish a 3 metre dam at Kuussuup tasia (proposal B) instead of a 15 metre dam at Kuussuup tasia (proposal A). Kuussuup tasia cannot be drawn down because of barriers in the lake. In proposal C a 10 metre dam is established at Qingap Ilulialeeraa. In proposals D and E, both Qingap Ilulialeeraa and Tininnilik are used as drawdown reservoirs. Tininnilik is an ice-dammed lake with a variable water level between +160 and +220.

Ilulissat

Town data

	Population	Light/power Net GWh	District heating including interruptible electric heating Net GWh	Individual heating including permanent electric heating Gross GWh
1998	4,159	16.6	9.4	...
2003	4,525	18.3	11.1	53.0
2020	4,525-5,460	18.3-22.1	11.1-14.4	53.0-65.9

Hydropower facilities

See annex 12a		12.a	12.b	12.c	12.d-1	12.d-2	12.e	12.f
Name					Tasersuaq	Tasersuaq		
Category		B3	B0	B0	B0	B1	B0	B0
Planning stage		I	I	I	I	I	I	I
Power station coordinates		69°16'N 50°58'V	69°16'N 50°47'V	69°25'N 50°49'V	69°26'N 50°28'V	69°21'N 50°26'V	69°33'N 50°30'V	69°35'N 50°49'V
Nominal effect	MW	0.6*	0.8*	0.6*	1.6*	1.9	1.2*	1.9*
Energy production ex works	GWh/a	3.1	4.0	3.2	8.0	8.1	5.9	9.4
Catchment area, precipitation	Km ²	29	19	18	54	54	33	38
Catchment area, ablation	Km ²	.	.	.	.	.	.	.
Mean annual run off	Hm ³	8.7	5.7	5.4	13.5	14	8.3	11.4
Reservoir size	Hm ³	-	...	...	...	11	...	...
Damming	M	...	...	...	...	...	...	...
Head	M	150	300	250	250	261	300	350
Horizontal distance from inlet to outlet	M	1900	2900	1500	3000	2200	1000	1100
Distance from town	Km	9	18	30	42	...	53	55
Fjord crossings	Number /m	-	-	-	-	-	-	-
Documentation		1981 ^E	1981 ^E	1981 ^E	1981 ^E	2004 ^F	1981 ^E	1981 ^E
Hydrological measurements				1986-89				
Notes						36		
Data check		No	No	No	No	No	No	No

(Continues on the next page)

³⁶ [ACG 1981^E] shows a different location of the power station.

Hydropower facilities, Ilulissat (continued)

See annexes 12a and 12b		12.g	12.h	12.j			
Name		Paakitsup Aku.	Paakitsup Sarfaa	Nuussuaq			
Category		B2	B3	A1			
Planning stage		V	III	II			
Power station coordinates		69°29' 50°18'		70°04'N 51°16'V			
Nominal effect	MW	20	10-20	45*			
Energy production ex works	GWh/a	72.4	40-75	350			
Catchment area, precipitation	km ²	33	...	1000			
Catchment area, ablation	km ²	286	...	-			
Mean annual run off	hm ³	329	700-1600	600			
Reservoir size	hm ³	124	550-1100	...			
Damming	M	0	29-51	...			
Head	M	177/214	29-51	270			
Horizontal distance from inlet to outlet	M	8400	600	18.000			
Distance from town	km	52	38	.			
Fjord crossings	Number /m	1/650	-	.			
Documentation		1988 ^{BB} 2004 ^F	1982 ^{CC}	1995 ^D			
Hydrological measurements		1984-		1980-84			
Notes		See description	See description				
Data check		no	no	no			

12.g Paakitsup Akuliarusersua The studies of the hydropower potential at Paakitsup began around 1980 and ended with a draft proposal.

In parallel with the preparation of the national Energy Plan 1990-2005 a revised draft proposal [ACG/VBB/PAP 1988^{BB}] was prepared.

The hydropower station is specially designed because of permafrost in the areas around the tunnels and water temperatures close to 0°C in the reservoir, which is adjacent to a glacier.

When the Energy Plan was adopted in 1987, extended utilisation of hydropower potential was given high priority, one reason being a wish to achieve the greatest possible reduction of the import of oil. This resulted in a preliminary decision to focus on the towns of Ilulissat, Sisimiut, Nuuk and Paamiut, with Ilulissat as the location for the first power station.

Against this background, the preparations for the construction of the power station began, tender documents were prepared and tenders were called.

However, the preliminary decision was not followed by an actual decision to realise the projects and set aside the funds required in the national budget, which meant that it was initially necessary to carry out a temporary extension of the existing diesel-fired power station and subsequently to build a diesel-fired co-generation station. As a result of this, there was no economic benefit associated with a shift to hydropower for a long period of time.

In connection with a possible reconsideration of hydropower it is suggested that alternative extensions of the Paakitsup potential be investigated together with areas of smaller potential close to Ilulissat, which in terms of size match the energy requirements.

See also the description in chapter 6.

12.h Paakitsup Sarfaa

The power station is established by damming up a lake (Paakitsup ilorlia) with very high dams. The catchment area contains large ice-cap areas, e.g. 12.g, but no certain hydrological estimates are available. This project seems to be unrealistic.

Qeqertarsuaq

Town data

	Population	Light/power Net GWh	District heating including interruptible electric heating Net GWh	Individual heating including permanent electric heating Gross GWh
1998	1,059	3.2	-	...
2003	1,006	3.3	-	14.0
2020	836-921	2.5-2.9	-	13.2-13.6

Hydropower facilities close to the town

See annex 14		14.a	14.a'					
Name		Kuussuaq (Røde Elv)	Kuussuaq (Røde Elv)					
Category		B2	B3					
Planning stage		III	III					
Power station coordinates		69°15'N 53°29'V	69°15'N 53°29'V					
Nominal effect	MW	3	0.73					
Energy production ex works	GWh/a	4	2.2					
Catchment area, precipitation	km ²	...	83					
Catchment area, ablation	km ²	...	+					
Mean annual run off	hm ³	40	40					
Reservoir size	hm ³	5.5	0					
Damming	M	15	5					
Head	M	90	50					
Horizontal distance from inlet to outlet	M	...	1000					
Distance from town	km	1.5	1.8					
Fjord crossings	Number/m	-	-					
Documentation		1995 ^D	1999 ^{DD} 2004 ^F					
Hydrological measurements		1982-90	1982-90					
Notes		See description						
Data check		No	no					

Uummannaq

Town data

	Population	Light/power Net GWh	District heating including interruptible electric heating Net GWh	Individual heating including permanent electric heating Gross GWh
1998	1,481	5.0	1.6	...
2003	1,423	5.0	1.9	17.1
2020	1,087-1,253	3.5-4.2	1.8	15.8-16.4

The closest hydropower potential is 12.j Nuussuaq (see Ilulissat).

Maarmorilik

The possibilities of establishing a hydropower station in connection with the Maarmorilik Mine were investigated in 1978-1985. Hydrological measurements were made over a period of eight years, and a sketch project was prepared for a hydropower station able to generate an output of about 68 GWh/a. Tenders have been called from three companies, which have submitted Technical Proposals; see [ACG 1980^{EE}].

Upernavik

Town data

	Population	Light/power Net GWh	District heating including interruptible electric heating Net GWh	Individual heating including permanent electric heating Gross GWh
1998	1,126	4.0	0	...
2003	1,218	4.3	0.4	19.1
2020	1,133-1,218	4.0-4.4	0.4	17.6-18.1

No hydropower potential

Qaanaaq

Town data

	Population	Light/power Net GWh	District heating including interruptible electric heating Net GWh	Individual heating including permanent electric heating Gross GWh
1998	652	1.8	3.5	...
2003	648	2.1	4.4	4.3
2020	563	1.7	4.3	3.9

No hydropower potential

Ammassalik

Data for Tasiilaq

	Population	Light/power Net GWh	District heating including interruptible electric heating Net GWh	Individual heating including permanent electric heating Gross GWh
1998	1,688	3.8	0.1	...
2003	1,818	4.3	0	16.8
2020	1,563-1903	3.5-4.5	0	14.9-17.8

Hydropower facilities close to the town

		18.a	18.b				
Name		Aammangaag (Præstefjeld)	Qorlortoq				
Category		B2	B1				
Planning stage		VII	III				
Power station coordinates		65°37'N 37°40'V	65°39'N 37°38'V				
Nominal effect	MW	1,3	2,4				
Energy production ex works	GWh/a	6,0	11				
Catchment area, precipitation	km ²	25.6	89				
Catchment area, ablation	km ²	-	.				
Mean annual run off	hm ³	47.7	118				
Reservoir size	hm ³	14	107				
Damming	m	0	...				
Head	m	100	45				
Horizontal distance from inlet to outlet	m	1200	1400				
Distance from town	km	2.8	7				
Fjord crossings	Number /m	-	-				
Documentation		1999 ^{FF}	1981 ^{GG} 1995 ^D				
Hydrological measurements		1981-	1982-84				
Notes		See description					
Data check		No	no				

18.a Aammangaag

The Tasiilaq hydropower station was built under a general contract in 2002-2005 on the basis of a detail design prepared by Icelandic consultants based on a sketch project [Rambøll 1999^{FF}]

The potential was initially investigated in 1980-1984. The investigations concluded with the preparation of an outline proposal [H&S/P&S 1984].

The outline proposal illustrates four possible extensions using the existing hydrological heads and possibilities of creating reservoirs.

In connection with a forthcoming overall renovation of the diesel-fired power station at Tasiilaq, a decision-making process took place in 2001-2002, which resulted in a decision to realise a power station project that uses the hydrological head from the lowest of the lakes (Sø 100) and establishes small reservoirs both in Sø 100 and in Sø 160. A tunnel from Sø 160 has been established.

The predicted output of this hydropower station will be able to meet the light and power requirements of the town.

Ittoqqortoormiit

Town data

	Population	Light/power Net GWh	District heating including interruptible electric heating Net GWh	Individual heating including permanent electric heating Gross GWh
1998	529	1.4	-	...
2003	523	1.4	-	6.7
2020	438	1.1	-	6.3

No hydropower potential

6 The most promising facilities

Budgets With the exception of the budgets for Qorlortorsuaq and Tasersuaq/Sisimiut, all the budgets stated have been prepared on a very slender, preliminary project basis and should therefore only be used to compare potential and make a preliminary prioritisation.

6.1 Town projects

Nanortalik–Tasiusaarsuk (01.a)

The outline proposal from 1983 illustrates an alternative that uses the head from Sø 373 to an underground power station at level 25 with stream intake from Sø 390, which includes the catchment area of Sø 524.

Output has been calculated at 24 GWh/year on a relatively uncertain basis. This would be sufficient to cover lighting, power and heating needs in Nanortalik, which are estimated at a total of 14.6 – 17.0 GWh/year in 2020 in the Energy Plan.

Initiatives None of the alternatives suggested seems to ensure a good economic balance. Economic balance will probably not be achieved until a point in time when investment in hydropower solutions will replace investment in oil-based solutions. New hydrological simulations must be carried out on the basis of existing measurements made in the area over the past 4-7 years. Alternative extension possibilities must be recalculated.

Estimate	DKK '000
Construction work	73,500
Building work	7,000
Mechanical and electrical installations	41,000
Transmission line	16,000
Sum	137,500
Overheads, design and feasibility study	28,000
Total	165,500

Nanortalik–Narsap Sarqaa (01.e)

Another possible location which should be taken into account in future considerations is Narsap Sarqaa, which is located at a greater distance from Nanortalik, but features a considerably shorter water route.

Initiatives

The increased costs of the transmission line are clearly offset by the savings achieved because of the shorter water route.

The other advantages of this alternative are better possibilities of creating reservoirs and a bigger head.

None of the alternatives suggested seems to ensure a good economic balance.

Economic balance will probably not be achieved until a point in time when investment in hydropower solutions will replace major investment in oil-based solutions.

In order to confirm or disprove the perception of the advantages presented by Narsap Sarqaa, insofar as this is possible, it will be necessary to explore the reservoir potential and the possible transmission line track.

If the perception is confirmed, hydrological measurements must be made to document the production potential.

Estimate	DKK '000
Construction work	40,500
Building work	11,000
Mechanical and electrical installations	45,000
Transmission line	30,000
Sum	126,500
Overheads, design and feasibility study	29,000
Total	155,500

Qorlortorsuaq (03.f)

Following an international competition, a design and build contract for the construction of the Qorlortorsuaq Hydropower Station was signed in December 2004 for execution from early 2004 to late 2007.

The total costs including client costs and contingencies as well as an amount of DKK 15 million to ensure future expandability of the station amounted to DKK 237,800,00 (price level 01/2006).

The detailed budget for this power station constitutes the main basis for the budgets relating to the planned projects set out in chapter 6.

Estimate	DKK '000
Construction work	58,500
Building work	6,500
Mechanical and electrical installations	68,100
Transmission line	62,900
Sum	196,000
Overheads, design and feasibility study	41,800
Total	237,800

Paamiut – Iterlaa, alternative B (05.g-2)

In 1980 a sketch project was prepared for a hydropower station at Iterlaa. In a working paper issued in 1983, the layout suggested was called Alternative B.

A geological report from 1983 presents three alternatives: 1A, 1B and 1C.

An outline proposal dated December 1984 only treats Alternative 1A in greater detail, but no reason was given as to why Alternative 1B and Alternative 1C had been rejected. Subsequently a preliminary design for Alternative B was prepared (dated June 1986).

The preliminary design illustrates a solution according to which only one reservoir of about 50 million cubic metres for drawdown is established in Sø 306. Two possibilities of increasing the reservoir volume are described: by damming up Sø 306 or by regulating Sø 318, which is located at a higher level, by drawdown.

The design features a power station on the mountain with a 2 x 6.0 MW aggregate. The mean output is calculated at 48 GWh/year.

Within the past few years the potential close to Nigerdleq has been investigated. The investigations are based on heads from two different lakes (Sø 430 and Sø 165) in two separate feeder systems going to the same power station with a 2 x 2.4 MW aggregate and a mean output of about 14 GWh/year.

The total reservoir volume of about 15 million cubic metres is established by damming up five lakes:

Sø 430 – 5 x 350 m, Sø 158 – 3 x 15 m, Sø 158 – 8,5 x 25 m, Sø 165 – 14 x 60 m and Sø 180 – 16 x 90 m. At all the locations, remote-controlled regulation buildings must be established.

A comparative calculation of construction costs for Iterlaa (Alternative B) with a 2 x 2.4 MW aggregate with an output of about 19 GWh and construction costs for Nigerdleq shows that Iterlaa, Alternative B, is the economically most advantageous solution.

In addition, Iterlaa Alternative B offers the following advantages:

- In the basic extension, only drawdown will be necessary.
- Additional extension can be ensured by extending the power station and increasing the reservoir capacity by damming up Sø 306 and draw down Sø 318, which makes it possible gradually to increase the ‘maximum’ output of this potential to 48 GWh/year.

Initiatives

Since 1981 run-off measurements have been made in Sø 318, and in the period 1986-1988 also in Sø 306. Based on these measurements it is considered possible to carry out a simulation of operations with sufficient certainty. In this connection it should be borne in mind that the first extension described above will not utilise the full hydrological potential.

Supplementary feasibility studies:

- Surveys and seismic conditions in the intake area in Sø 306
- Final location of cross-tunnel connections
- Final location of point of discharge
- Possibly digitalisation of transmission line track; alternatively, preparation of map.

Time schedule

- Decision about feasibility studies, end 2005
- Feasibility studies, summer 2006
- Preparation of basis for call of tenders, 2006
- Detailed calculations
- Economic analyses
- Call of tenders, September 2006
- Submission of tenders, November 2006
- Contract, end 2006
- Commissioning, 2009

Estimate	DKK '000
Construction work	77,500
Building work	14,000
Mechanical and electrical installations	52,000
Transmission line	32,000
Sum	175,500
Overheads, design and feasibility study	42,000
Total	217,500

Sisimiut – Tasersuaq (08.b)

In 1992 an international design and build competition was held for the Tasersuaq Hydropower Station.

Based on completed contract negotiations, a number of calculations of societal effects and operating economy were made, the result being a recommendation of the realisation of the project submitted to the Greenland Home Rule authorities on 25 September 1992.

However, the Greenland Home Rule authorities decided to postpone the investment in the hydropower station in favour of investment in local airstrips.

The preliminary design and the project prepared by the winning consortium show a plant with a total output from catchment areas I and II of 49-53 GWh/year, which with a reasonable margin is compatible with the overall forecast for light, power and interruptible electrical heating of 41-50 GWh given in the Energy Plan for 2020.

It would be possible not to include catchment area II.

The hydrological measurements have continued and run-off measurements for a period of 267 years are now available.

Initiatives

- Hydrological simulation
- Simulation of operations
- Economic analysis in which investment in the hydropower model is based on updating of the outcome of the completed negotiations conducted with Scanpihl in August 1992.
- Operating economy analyses
- Basis for decision, August 2005

If the recommendation leads to a decision of implementation, an international competition may subsequently be held on the basis of the information at hand.

Estimate	DKK '000
Construction work	113,500
Building work	13,500
Mechanical and electrical installations	73,500
Transmission line	24,400
Sum	224,900
Overheads, design and feasibility study	57,000
Total	281,900

Qasigiannuit–Sagdliup Tasiaq (11.a)

In December 1984 an outline proposal was prepared for a hydropower station at Kuussuup Tasiaq, which, when fully extended, would be able to generate an output in the region of 150 GWh/year against an investment of about DKK 800 million (1984 prices).

This output is far above total requirements in Qasigiannuit and Aasiaat, which were the recipient areas originally selected.

The cost of building this power station was and still is much too high to ensure a good economic balance in relation to the investment.

In 1980 a sketch proposal was prepared for the use of the catchment area around Sagdliup Tasia.

The annual average output has been estimated at 2.7 GWh on a very slender hydrological basis, the light and power needs in Qasigiannuit being 4.6

GWh in 2003 and the needs estimated in the Energy Plan being 2.8–3.5 GWh by 2020.

Utilisation of this potential would thus mean only partial supply.

Given that the calculated construction costs amount to about DKK 89 million, most of which will go to the construction of the dam, the project would probably only be profitable from an economic point of view if the investment in the hydropower station would mean that major investment in oil-based projects would be avoided.

Initiatives

Before major investments in hydrological and construction feasibility studies are made it must be determined at the lowest possible cost whether the project is profitable from an economic point of view.

The uncertainty applying to the cost involved in the hydropower model mainly relates to the establishment of the necessary reservoir, which in the sketch project prepared is created partly by means of canals and partly by means of dams.

Following surveys of the area it will probably be possible to calculate the reservoir costs with sufficient certainty. Following calculations relating to other elements of the hydropower project and investments in the oil-based model it will be possible to calculate the economic profitability with reasonable certainty.

If the profitability is acceptable it will be necessary to invest in feasibility studies.

Hydrology:

- Hydrological run-off measurements to supplement existing measurements dating from the period from 1980 to 1984.

Construction:

- Seismic conditions at dam and duct locations.
- Mapping of power station area and transmission line route.

Estimate	DKK '000
Construction work	45,500
Building work	3,000
Mechanical and electrical installations	30,800
Transmission line	2,900
Sum	82,200
Overheads, design and feasibility study	7,000
Total	89,200

Ilulissat - Paakitsoq udbygning 1 (12.g)

The draft proposal from May 1988 illustrates a project with two feeder tunnels to a single power station from SØ 233 and SØ 187 respectively.

The calculated output from this power station is 79 GWh, which is significantly above the current energy needed to cover light, power and interruptible electric heating requirements, which in the Energy Plan are estimated at a maximum of 36.5 GWh by 2020.

Given this, a power station with only one feeder tunnel and a reservoir in SØ 187 is suggested.

If the reservoir is exclusively based on drawdown, the reservoir volume has previously been calculated at 52 million cubic metres, which provides a basis for an annual output of about 35 GWh/year.

This first extension would make it possible to increase output by subsequent extensions, e.g.:

- Damming of SØ 187 to HRV level 201 would increase the reservoir volume to about 100 million cubic metres and output to about 55 GWh/year.
- A transfer tunnel between SØ 187 and SØ 233 with a reservoir in SØ 233 would increase the reservoir volume to about 110 million cubic metres and output to about 60 GWh.
- Bigger dam in SØ 187.
- Long transfer tunnel from SØ 233 (as preliminary design of May 1988).

Initiatives

Initially it must be documented at the lowest possible cost that realisation of the project is reasonable from an economic point of view.

A crucial point in this respect is whether investment in a hydropower station would replace major investments in the oil-based model, just as the size of the investments in supply systems and electro-boilers at Illissat must be calculated and taken into account in the overall calculations.

In connection with the preparation of the preliminary design in May 1988 it was assessed that a drawdown solution rather than a solution based on damming would present the smallest risk of critical movement of the ice front.

In order to confirm the assessment that there will be no critical movements of the ice front within the facility's lifetime, other initiatives must be taken and surveys must be conducted together with a glaciologist to determine, among other things, whether the ice front has continued to withdraw, as was assumed in 1988.

The other available hydrological surveys, construction surveys and mapping surveys are considered to be sufficient to realise the project.

Estimate	DKK '000
Construction work	124,000
Building work	26,000
Mechanical and electrical installations	70,000
Transmission line	58,000
Sum	278,000
Overheads, design and feasibility study	32,000
Total	310,000

6.2 Industrial facilities

Industrial potential

A specific order of priority does not make any sense, as long as it is unknown which industrial plants are to be supplied and which energy requirements are involved.

If a mine is to be supplied, the distance between the mine and the potential site is of course very important. If the location is not bound by any specific factors, the cost of extending the hydropower facility itself and the scope of the potential as compared with requirements will be crucial.

In this report we have decided to describe three potential sites offering relatively low extension costs, with output capacities in the region of 500, 1000 and 2500 GWh/year respectively:

- Taserssuaq at Godthåb Fjord
- Buksefjord/Ista
- Tasersiaq at the bottom of Evighedsfjord.

Maniitsoq – Tasersiaq (07.e-1)

The Tasersiaq potential is the greatest known potential that has been mapped on a preliminary basis in Greenland.

As early as in 1975, the first hydrological measurements were made. Measurements are still being made. In 1977 an Intermediate Project Report was prepared. It was updated in October 1980.

Another updating of the hydrology and construction estimate based on the original layout from 1977 was made in January 1998.

In 1995 reconnaissance was made with a view to identifying alternative layouts, including one which discharges into Evighedsfjord – as opposed to all previously suggested alternatives, which discharge into the Paradise Valley.

The advantage of discharge into Evighedsfjord is that the entire fall height down to sea level (+ about 55 metres) will be used.

The following estimate is based on the alternative where discharge is into Evighedsfjord.

Initiatives

One purpose of the proposed initiatives is to identify the design which is the most attractive from an overall point of view.

- Quality assurance of hydrological data and production simulation based on the total series of measurement (1975 – 2005).
- Detailed feasibility studies, including geological reconnaissance by engineers for dams, tunnels, transmission line and other infrastructure
- Permafrost survey

Estimate	DKK '000
Construction work	1,757,000
Building work	80,000
Mechanical and electrical installations	545,000
Transmission line	330,000
Sum	2,712,000
Overheads, design and feasibility study	270,000
Total	2,982,000

Nuuk Buksefjord/Ista – Possible extension

Stage II (06.a)

The least far-reaching possible extension, called Stage II, is the already prepared extension to include a third turbine of app 15 MW, for which the existing power station hall, tunnels, transmission line, etc have been prepared.

In the first ten years of operation (1993-2003) an average of 85 million m³ overflow per year has been measured, which means that it would be possible to increase output by 65 million kWh/year if a third 15 MW turbine is installed.

From the outset of the planning of the Buksefjord Hydropower Station, such output was considered to be sufficient to cover increased consumption of light, power and permanent electrical heating in Nuuk.

Estimate 3 – Aggregate	DKK '000
Construction work	1,000
Building work	0,000
Mechanical and electrical installations	60,000
Transmission line	0,000
Sum	61,000
Overheads, design and feasibility study	500
Total	61,500

Extensions 2 and 3

An extension of the size of extensions 2 and 3 will only be relevant within the next few years if one or more power-consuming industries are attracted to the area.

In connection with the sketch proposal for a zinc refinery in Nuuk, an outline design for extensions 2 and 3 was prepared, which used the catchment area for Isortuassup Tasia (Ista) to the south, including the ice-dammed lake 710.

Extension 20 (6.b-1)

In extension 2, the facility is extended with a 70 MW aggregate in a separate power station located next to the existing power station, which brings the total MW installed up to 100 MW, which – with 7,800 full-load hours (which an industrial enterprise with 24-hour operations may well reach) – will generate an annual output of 780 GWh.

The increased water volume will be provided by the construction of a 16 km tunnel to transfer water from Ista.

Estimate – Extension 2	DKK ‘000
Construction work	216,000
Building work	300,000
Mechanical and electrical installations	178,000
Transmission line	15,000
Sum	709,000
Overheads, design, feasibility study and contingencies	253,000
Total	962,000

Extension 30 (6.b-2)

In extension 3, the fall of 160 metres between ISTA and the current KANG reservoir is used in a new 2 x 45 MW power station 3 located at the transfer tunnel. Following construction of this power station, the total energy output of the entire facility will be at least 1,160 GWh/year.

To transfer the energy to Nuuk it will be necessary to construct a transmission line for power station 3 to the Buksefjord facility, and along the stretch from Buksefjord to Nuuk the existing transmission line will have to be doubled.

The estimate for extension 3 is based on the assumption that the extension will be realised separately following completion of extension 2.

If extensions 2 and 3 are made at the same time, savings can be achieved.

Estimate – Extension 3	DKK ‘000
Construction work	258,000
Building work	0,000
Mechanical and electrical installations	259,000
Transmission line	220,000
Sum	737,000
Overheads, design, feasibility study and contingencies	220,000
Total	957,000

ISTA (06.f)

It is possible to use the ISTA catchment area directly by constructing a tunnel system connected with a power station using the 430 m fall from ISTA to the sea level in the Alanngorlia fjord arm.

The energy output of this facility will be 740 GWh.

The access route to this facility, through the very narrow fjord arm and the very long and difficult transmission line track to Nuuk may be prohibitive to the realisation of this alternative.

Tasersuaq discharging at Fiskefjord (06.h')

A previous description of this potential said that it could be used with a non-submerged discharge into a side fjord of Godthåbsfjord.

However, feasibility studies made in 1995, including extensive soundings in the reservoir lake, showed that the reservoir tapping possibility is very limited, as the water depth in the southern end of the lake is very low, for which reason a solution based on discharge into Godthåbsfjord would require damming at a length of about 20 metres in order to create the necessary reservoir.

At a suitable damming location at the discharge point at Taserssuaq, a 20-metre damming area would imply a dam height of about 25 metres with a crown length of at least 250 metres.

Furthermore, the 20-metre dam would also require two dams in the neighbouring Narssarsuaq valley with heights of about 10 metres and 15 metres respectively, both having crown lengths of about 900 metres.

The sounding of the reservoir lake showed that the water depth was considerably deeper at the centre of the lake and that there seemed to be a suitable place for tapping at depths down to 40 metres in the western part of the lake.

The reconnaissance also showed that conditions for the establishment of a tunnel system with submerged discharge in Fiskefjord seemed to be ideal.

The tunnel between Taserssuaq and Fiskefjord is 19,000 metres long, or about 9,000 metres longer than the solution based on discharge into Godthåbsfjord. However, the cost of the longer tunnel is believed clearly to be set off by the additional cost involved in establishing the large dams required if the solution to the south is chosen.

The estimate includes a transmission line going all the way to Godthåbsfjord. The distance is equivalent to the distance to the olivine deposit in Fiskefjord.

Initiatives

- Resumption of hydraulic measurements
- Detailed sounding and seismic studies at inlet at Taserssuaq and at outlet in Fiskefjord
- Facility sketch project
- Mapping of land between inlet and outlet, including geological mapping

- Sounding and survey of navigation conditions in the innermost part of Fiskefjord (sounding has been conducted up to the olivine deposit site at Tasiussarssuaq).

Estimate	DKK '000
Construction work	520,000
Building work	40,000
Mechanical and electrical installations	206,000
Transmission line	51,600
Sum	817.600
Overheads, design and feasibility study	120,000
Total	937,600

7 Hydrological measuring stations

Historical overview

Run-off measurements to determine hydropower potential started at the initiative of Kryolitselskabet Øresund in 1974 and were first conducted in the area to the north of Godthåb Fjord where eight measuring stations were installed. In the following year, GTO installed measuring stations in some high-potential areas along the west coast.

In the 1980s and 1990s several measuring stations were established to register water levels in connection with the measurement of water flows for use in assessments of hydropower potential. In 1994, fifteen measuring stations were still operating, while 53 stations had been closed down [GFU 1994^{HH}].

Current measuring stations

Today only nine measuring stations are still in operation. The table below shows all the stations that are currently used or have been used to measure water levels for hydropower purposes.

Hydropower potential	Station number	Station Established	Station closed down	Station Active status	Name of station
01.a	124	28-Apr-81	05-Sep-90	No	Tasiussaarsuk, sø 373
01.a	418	26-Apr-80	07-Jul-84	No	Tasiussaarsuk, Sø 179
01.a	428	27-Apr-81	17-Aug-88	No	Tasiussaarsuk, Sø 523
01.f	452	12-Oct-87	04-Sep-90	No	Tasersuaq
03.a	419	11-Jul-80	04-Jul-84	No	Killavaat, Sø 589
03.c	130	09-May-81	27-Jun-84	No	Kvane River
03.c	317	09-Jun-80	01-Jul-84	No	Taseq, outlet
03.c	318	18-Aug-80	01-Jul-84	No	Narsaq River
03.c	431	05-Maj-81	03-Sep-92	No	Taseq, outlet
03.c	432	18-Nov-02		Yes	Taseq
03.c	444	30-Jun-84	19-Aug-88	No	Dyrnfs valley, Nrq river
03.e-1	453	17-Apr-88	24-Aug-90	No	Ukkusip Tasia
03.e-3	504	06-Oct-87	23-Aug-90	No	Qallimiut/KTU
03.f	451	01-Oct-87		Yes	Qorlortorsuaq
03.f	461	05-Sep-92		Yes	Vig sø
03.f	462	30-Apr-92		Unknown	Ulve sø
03.h	102	20-Aug-78		Unknown	Nordbo sø outlet
03.h	301	17-Jun-76	01-Jul-84	No	Nordbosø, outlet
03.h	302	16-Jun-78	01-Jul-84	No	Thorsø outlet
03.h	441	04-Jul-84		Unknown	Thorsø, outlet

Hydropower potential	Station number	Station Established	Station closed down	Station Active status	Name of station
05.b	450	08-Oct-04		Yes	Nigerdleq
05.g	420	11-Jun-80	10-Jan-91	Yes	Iterlaa, Sø 318
05.g	447	19-Jun-86	13-Aug-88	No	Iterlaa Sø 306
06.a	422	26-Apr-81	16-Jul-92	No	Buksefjord, outlet/sø250
06.a	434	05-May-82	28-Aug-83	No	Pingorssuaq
06.a	458	16-Oct-89		Unknown	Catchment 2 Sø 370
06.a	459	07-Mar-90		Unknown	Kang catchment 2 Sø 458
06.a	460	26-May-90		Unknown	Catchment 5 Sø 750
06.a	463	17-Jul-92		Unknown	Buksefjord, dam
06.e	104	22-Aug-78	25-Aug-86	No	Grædefjord, sø 348
06.e	111	22-Jul-80	15-Aug-88	No	Grædefjord, sø 448
06.e	303	14-Jun-76	01-Sep-84	No	Grædefjord, sø 348
06.e	304	21-Jun-78	01-Sep-84	No	Grædefjord, sø 448
06.e	316	05-Jul-79	01-Sep-84	No	Grædefjord, sø 480
06.f	305	13-Jun-76	29-Jun-85	No	Isortuarsuup tasia
06.f	321	25-Sep-96		No	Sø 710 – ISTA
06.f	438	11-Jan-84	05-Sep-89	No	Isortuarsuup, sø 851
06.f	443	29-Jun-85		Yes	Isortuarsuup Tasia
06.g	3M10	17-Aug-76	05-Dec-81	No	Tarsartoq tasia
06.g	3M3	27-May-74	25-Jun-87	No	Sø481
06.g	3M4	30-May-74	14-Sep-74	No	Sø610
06.g	3M5	27-May-74	28-Jun-90	No	Sarqap Sermerssua
06.g	3M7	25-May-74	03-Oct-76	No	Taserssuaq
06.g	3M8	18-Jun-78	06-Apr-85	No	Sø772
06.g	3M9	25-Jun-74	08-Aug-83	No	Qaamasup tasia
06.g	446	05-Jul-85		Unknown	Qaamasup tasia, sø450 (3m8)
06.h	3M6	24-May-74	31-Dec-83	No	Tuvssap Tasia
07.a	113	26-Aug-79	20-Jul-86	No	Qapiarfiup, sø 358
07.a	307	22-Jun-78	01-Sep-84	No	Qapiarfiup, sø 358
07.b	423	18-Aug-81	20-Jul-86	No	Qapiarfiup, sø 517
07.d	3M1	01-Jun-74	30-Jul-83	No	Sø415
07.d	3M2	06-Jan-74	01-Jul-83	No	Sø792
07.e	105	27-Aug-78		Yes	Tasersiaq outlet
07.e	308	08-Jul-75	18-Jul-75	No	Tasersiaq outlet
07.e	309	10-Aug-76	01-Jan-83	No	Tasersiaq, sø 859
07.f	310	14-Jul-75	01-Jun-80	No	Torssut
07.f	320	29-Jun-80	01-May-83	No	Torsuut
08.b	106	28-Aug-78		Yes	Tasersuaq sø
08.b	311	10-Jul-77	01-Jul-84	No	Tasersuaq, outlet
08.b	464	25-Aug-92		Yes	Pisissarfik
11.a	315	01-Jan-79	18-Nov-82	No	Salliup, Tasia
11.f	421	07-Jul-80		Unknown	Kuusuuup Tasia
12.g	142	03-Sep-84	15-Aug-92	No	Paakitsup akuliarusersua
12.g	312	11-Jun-77	01-Aug-79	No	Paakitsaq, Nordøst
12.g	319	06-Jul-80	31-Dec-86	No	Paakitsup, sø 187 udl
12.g	437	04-Sep-83		Yes	Pakitsaq, sø 187

Hydropower potential	Station number	Station Established	Station closed down	Station Active status	Name of station
12.g	445	04-Sep-84	25-Sep-93	No	Pakitsoq, sø 234
12.g	454	29-Jun-88	02-Jul-89	No	Paak fjord
12.h	116	28-Jul-80	29-Aug-84	No	Nuussuaq
12.h	314	04-Jul-80	01-Aug-84	No	Nuussuaq
14.a	436	10-May-82	05-Sep-90	No	Kuussuaq, Røde elv
18.a	401	15-Jun-81	11-Sep-88	No	Præstefjeld, Sø 168
18.a	426	15-Jun-81		Yes	Præstefjeld/Aammangaaq, Sø 168
18.a	4646	15-Jun-81		Unknown	Præstefjeld, Sø 168

Source: Extract of ASIAQ list of stations, 12 November 2004

The location of the measuring stations appears from the maps enclosed and from [GFU 1994^{HH}]

8 Glossary

Ablation	Melting of ice-covered areas. The ablation zone is the part of the ice cap or local glaciers where melting occurs. The catchment area for ablation is indicated where there is run off from the ice cap or from local glaciers that are not completely included in the catchment area, i.e. areas to which frozen ice arrives and then melts. It is often difficult to state the size of ablation catchment areas, partly because the ablation boundary, i.e. the height of ablation, is not known, and partly because there is an unknown amount of run-off below the ice.
Annual regulation	A regulation degree where water from years with plenty of water can be stored for years in which water volumes are low.
Decision-making basis	Report prepared on the basis of a draft proposal, containing all financial analyses necessary to make a decision concerning the initiation of construction work.
Degree of regulation	The ratio of reservoir volume to mean annual run-off.
Design basis	Any kind of report, investigation, survey, etc that forms part of the basis on which the design and dimensioning of a hydropower station is performed. See sketch project, outline proposal, draft proposal and hydrological basis.
Draft proposal	A report that gives an account of all matters relating to the construction of a hydropower station. It generally contains a C-estimate, operating simulations, etc. A draft proposal may form the basis for regulatory approval and calls for design and build tenders.
Efficiency	A power station's efficiency is the ratio between the energy supplied by the power station after the point of a transformer, if any, and the energy of the water at its entry into the power station. Losses occurring in turbines, generators and transformers are taken into account in the calculation of the efficiency.
Energy potential	The theoretically calculated energy that a hydropower station can generate. The energy potential is often stated 'ex works', which means at departure from the transformer. The energy volume available to a town is calculated by deducting transmission line and possibly transformer losses along the route to the town's distribution system, which is stated as 'at town gate'.
Head	The gross head is the difference between the water level at the intake and the water level at the point of discharge. The net head is the gross head less the pressure loss along the water routes.

Hydrological catchment area	The geographical area from which the flow of water to the hydropower station takes place. The flow may either be in the form of precipitation or in the form of ablation from the main ice cap or from local ice caps and glaciers.
Industrial hydropower	Hydropower stations of a size that makes them suitable for the supply of power to mines, energy-intensive industries, etc. Such hydropower stations are often located far from towns and can consequently only be used to supply towns in connection with the establishment of energy-intensive industries.
Outline proposal	Report based on feasibility studies, often containing several proposals for solutions as well as an estimate of construction costs.
q/h ration	Ratio of water flow to water level at a hydrological measuring station. The water flow is measured by means of a number of successive flow measurements, while water levels are measured continuously. This makes it possible to calculate the continuous water flow and consequently the run off in a specific area.
Regulation factor	The ratio of the unused (regulated) water volume to the mean annual run off.
Regulated volume of water	The part of the run off that can be used in a hydropower station. The regulated volume of water is total run off less water loss. The water loss is the volume of water that runs out of the reservoir without being used. 'Regulated volume of water' is also called 'unused volume of water'.
Reservoir	A natural or artificial lake used to store water from periods with excess run off for use in periods where the run off is insufficient to meet consumption requirements. Also called 'storage'.
Run-off	The quantity of water running off from a hydrological catchment area to the reservoir or intake basin from which water is tapped into the hydropower station.
Seasonal regulation	A regulation degree where the reservoir is not sufficiently large to store run off from years with an abundance of water to years with scarcity of water.
Settlement hydropower	Small, generally unregulated hydropower stations close to settlements.
Storage size	Storage (reservoir) volume.
Unregulated	A hydropower station is unregulated if there is no reservoir where water can be stored.
Urban hydropower	Hydropower stations of a size and location that make them suitable to supply existing towns with power.

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