Household Energy Supply and Use in Yemen: Volume II, Annexes

Report

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JOINT UNDP / WORLD BANK
ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

PURPOSE

The Joint UNDP/World Bank Energy Sector Management Assistance Program (ESMAP) is a special global technical assistance partnership sponsored by the UNDP, the World Bank and bi-lateral official donors. Established with the support of UNDP and bilateral official donors in 1983, ESMAP is managed by the World Bank. ESMAP's mission is to promote the role of energy in poverty reduction and economic growth in an environmentally responsible manner. Its work applies to low-income, emerging, and transition economies and contributes to the achievement of internationally agreed development goals. ESMAP interventions are knowledge products including free technical assistance, specific studies, advisory services, pilot projects, knowledge generation and dissemination, trainings, workshops and seminars, conferences and roundtables, and publications. ESMAP work is focused on three priority areas: access to modern energy for the poorest, the development of sustainable energy markets, and the promotion of environmentally sustainable energy practices.

GOVERNANCE AND OPERATIONS

ESMAP is governed by a Consultative Group (the ESMAP CG) composed of representatives of the UNDP and World Bank, other donors, and development experts from regions which benefit from ESMAP's assistance. The ESMAP CG is chaired by a World Bank Vice President, and advised by a Technical Advisory Group (TAG) of independent energy experts that reviews the Programme's strategic agenda, its work plan, and its achievements. ESMAP relies on a cadre of engineers, energy planners, and economists from the World Bank, and from the energy and development community at large, to conduct its activities under the guidance of the Manager of ESMAP.

FUNDING

ESMAP is a knowledge partnership supported by the World Bank, the UNDP and official donors from Belgium, Canada, Denmark, Finland, France, Germany, the Netherlands, Norway, Sweden, Switzerland, and the United Kingdom. ESMAP has also enjoyed the support of private donors as well as in-kind support from a number of partners in the energy and development community.

FURTHER INFORMATION

For further information on a copy of the ESMAP Annual Report or copies of project reports, please visit the ESMAP website: **www.esmap.org**. ESMAP can also be reached by email at **esmap@worldbank.org** or by mail at:

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Abbreviations and Acronyms

ARC	Aden Refinery Company
BPL	below-poverty-line
cif	cost insurance freight
CPC	Ceylon Petroleum Corporation
CPI	Consumer Price Index
CSO	Central Statistical Organisation
DFID	Department for International Development, UK
ERR	economic rate of return
ESMAP	Energy Sector Management Assistance Programme
fob	free on board
FRR	financial rate of return
GAREWS	General Authority of Rural Electrification and Water Supply
GDP	Gross domestic product
GOY	Government of Yemen
HH	household
HBS	Household Budget Survey (1998)
HES	Household Energy Survey (ESMAP 2003)
IRR	internal rate of return (to equity investors)
LPG	liquefied petroleum gas
LRMC	long run marginal cost
MDG	Millennium Development Goals
MoF	Ministry of Finance
MOM	Ministry of Oil and Minerals
MOPIC	Ministry of Planning and International Cooperation
MRC	Marib Refining Company
NGO	Non-government Organization
PEC	Public Electricity Company
PPP	purchase power parity
PRA	Participatory Rapid Assessment (ESMAP 2003)
PRSP	Poverty Reduction Strategy Program
SWF	Social Welfare Fund
YGC	Yemen Gas Company
YOGC	Yemen Oil and Gas Company
YPC	Yemen Petroleum Company
YR	Yemeni Rial

Annex 1

The Household Energy Survey

The Consultation Process in Survey Design

A1.1 The Chairman of the CSO requested that the Household Energy Survey (HES) be implemented in co-operation with the CSO. This cooperation took the form of technical advice provided to the local consultants and use of the CSO facilities for data entry. The sampling frame was prepared from a database provided by the CSO. Maps prepared by the CSO were used to define the location of the primary sampling units. The local consultants consulted with Dr. Mohamed Al-Mansoub, the statistics expert in the Poverty Alleviation Unit of MOPIC and with Mr. Bakhbazi (Survey Research Specialist at the CSO) on several occasions to discuss the survey methodology.

A1.2 Workshops were organized by MOPIC at which participants from other sector ministries and NGOs were invited to contribute to the design of the HES. They were held on July 17 and 29, 2003[1].

Survey Coverage and Sample Frame

A1.3 The survey was conducted in both urban and rural areas of the country covering all governorates except for Al-Jawf, Marib, and Al-Marah for reasons of the expense of surveying in these areas. The population frame was constructed from the 1994 census that contains a list of all villages by governorate, district, sub-district, and urban and rural areas.

[1] Participants included representatives of the Ministry of Electricity, Public Electricity Corporation, PEC General Dept for Rural Electricity Projects, Ministry of Oil and Minerals, Yemen Gas Corporation, Yemen Petroleum Corporation, the Central Statistical Organisation, Ministry of Planning and International Cooperation (MOPIC), Local Government.

Table A1.1: Total Number of Households in the Survey (Population Frame)

Name of Governorate	*Number of Households*	
	Covered in the Survey	*Excluded From the Survey*
Ibb	298,662	
Abyan	48,086	
Sana'a City	140,483	
AL-Baida	56,661	
Taiz	294,591	
AL-Jawf	-	38,747
Hajja	155,796	
AL-Hodeida	267,641	
Hadramout	148,779	
Dhamar	211,494	
Shabwh	46,671	
Saadah	67,901	
Sana'a Governorate	154,711	
Aden	65,651	
Lahj	86,540	
Mareb	-	22,138
AL-Mahwit	57,990	
AL-Mahrah	-	8,475
Amran	100,694	
Ad-dala	46,822	
Total Number of Households	2,249,173	69,360

Source: Census 1994

Sample Size and Sample Design

A1.4 The total sample size for the household survey was 3,625 households. In addition to the household interview, another 135 interviews were also conducted with the village head of the sampled village in the rural areas to collect additional village level data. The sample design is based on a stratified two-stage random sampling technique. The stratification is based on the following geographical classification.

A1.5 Urban areas

- Sana'a city - considered to be a major urban area
- Aden city - considered to be another major urban area
- Other urban areas - including households in the main city of every governorate except Sana'a and Aden

A1.6 Rural areas - grouped into five regions

Table A1.2: Urban/Rural Categories

Area No.	*Areas*	*Categories*	
1	Capital Secretariat	Urban	__
2	Aden	Urban	__
3	Saddah, Sana'a, Amran	Urban	Rural
4	Hajja, Hodeida, Dhamar, Mahwait	Urban	Rural
5	Ibb, Taiz	Urban	Rural
6	Abyan, Al-Baida, Lahj, Al-Dhala	Urban	Rural
7	Hadramout, Shabwa	Urban	Rural

A1.7 These classifications were adopted because it is assumed that variability in energy usage among households within the two main and sub-strata is small. Within each stratum, a two-stage random sampling technique was employed. The first stage of sample selection involved selecting villages within each stratum at random. Due to the fact that the list of villages is based on the 1994 census, the total number of households in each village is assumed to be outdated and is recognized as a shortcoming. Therefore, at the second stage, a fixed number of households within each sampled village were randomly selected from a current list of households in the village obtained from village or neighborhood head.

A1.8 For the rural strata and urban strata (other than Sana'a and Aden), 15 households per stratum were randomly selected. A larger number of households per selected neighborhood were randomly selected from Sana'a and Aden. This is because it is believed that there is a larger variability of energy usages among households within neighborhoods in major urban areas than in the villages in rural areas. A total number of 20 households were randomly selected from each sampled neighborhood in Sana'a and Aden.

A1.9 Given the fixed sampling rate and fixed number of households to be sampled in the final stage and to ensure that every sampled household within each stratum would have an equal chance of being selected – each sampled element in the final stage has equal probability of selection method (epsem) property – the number of villages (or neighborhoods) sampled from each stratum will vary from stratum to stratum. Using the following formula for sampling rate, the number of villages (or neighborhoods) to be sampled (b) can be solved:

$$f = f_a \times f_b = n/N = (a/A) \times (b/B)$$

N = Total number of household within the strata

n = Sample size

A = Total number of villages within the strata

a = Number of villages to be sampled

B = Total number of households within the village

b = Number of households within the village to be sampled

A1.10 Tables A1.3 and A1.4 show the planned sample design including sample size, sampling rate, total number of village and households expected to be sampled from each sampled village. Table A1.5 shows the actual sample size collected from the field.

Table A1.3: Sample Design for Rural Strata

	Total Number of					***Planned***	
Name of Governorate	***House-holds***	***Villages***	***Avg. no. of HHs per Village***	***Sample Size***	***Sampling Rate***	***No. of HH per Village***	***No. of Villages***
Saadah	60,097	1,139	53	86		14	6
Sana'a	151,898	3,006	51	217		15	14
Amaran	85,540	1,552	55	122		15	8
Region 1	*297,535*	*5,697*		*425*	*0.00143*		*28*
Hajjah	141,609	3,709	38	106		15	7
Al Hodiedah	184,783	2,255	82	138		15	9
Dhamar	188,631	3,252	58	141		16	9
Al-Mahwit	54,354	1,176	46	41		14	3
Region 2	*569,377*	*10,392*		*425*	*0.00075*		*28*
Ibb	265,008	2,707	98	223		15	15
Taiz	240,168	1,907	126	202		17	12
Region 3	*505,176*	*4,614*		*425*	*0.00084*		*27*
Abyan	38,125	2,369	16	72		14	5
Al-Baida	47,961	1,404	34	90		15	6
Lahj	82,939	3,733	22	156		16	10
Adalah	43,738	1,286	34	82		16	5
Region 4	*212,763*	*8,792*		*400*	*0.00188*		*26*
Shabwh	41,884	2,842	15	109		16	7
Hadramout	111,172	3,387	33	291		15	19
Region 5	*153,056*	*6,229*		*400*	*0.00261*		*26*
Total				2,075			135

Table A1.4: Sample Design for Urban Strata

Governorate Name	*Total Number of*		*Avg. No. of HH per Village*	*Sample Size*	*Sampling Rate*	*Planned*	
	House-holds	*Urban Villages*				*No. of HH per Village*	*No. of Villages*
Saadah	7,804	15	520	13		13	1
Sana'a	2,813	16	176	5		5	1
Amaran	15,154	20	758	26		13	2
Region 1	*25,771*	*51*	*505*	*44*	*0.00172*		*4*
Hajjah	14,187	27	525	24		12	2
Al Hodiedah	82,858	28	2,959	143		14	10
Dhamar	22,863	9	2,540	39		13	3
Almahwit	3,636	8	455	6		6	1
Region 2	*123,544*	*72*	*1,716*	*213*	*0.00172*		*16*
Ibb	33,654	19	1,771	58		14	4
Taiz	54,423	20	2,721	94		12	8
Region 3	*88,077*	*39*	*2,258*	*152*	*0.00172*		*12*
Abyan	9,961	9	1,107	17		17	1
Al-Baida	8,700	11	791	15		15	1
Lahj	3,601	4	900	6		6	1
Adalah	3,084	4	771	5		3	2
Region 4	*25,346*	*28*	*905*	*44*	*0.00172*		*5*
Shabwh	4,787	7	684	8		8	1
Hadramout	37,607	14	2,686	65		8	8
Region 5	*42,394*	*21*	*2019*	*73*	*0.00172*	*8*	*9*
Other urban-combined	**305,132**	**211**	**1446**	**525**	**0.00172**		**46**
Sana'a City	**140,483**	**46**	**3,054**	**625**	**0.00445**	**19**	**33**
Aden (combine all)	**65,651**	**19**	**3,455**	**400**	**0.00609**	**45**	**19**

Table A1.5: Total Number of Households Surveyed

Governorate	*Urban*	*Rural*	*Total*
Sana'a City	600		600
Aden City	400		400
Sa'da	14	86	100
Sana'a Gov.	9	212	221
Amran	28	122	150
Region 1	50	422	472
Hajjah	27	100	127
Al-Hudayda	149	138	287
Dhamar	42	140	182
Al-Mahwit	7	41	48
Region 2	225	419	644
Ibb	60	224	284
Taiz	98	202	300
Region 3	158	426	584
Abyan	18	72	90
Al-Bayda	15	91	106
Lahij	6	156	162
Ad-Dala	6	82	88
Region 4	45	401	446
Hadramawt	96	265	361
Shabwa	10	109	119
Region 5	106	374	480
Total	1585	2040	3625

A1.11 Table A1.6 shows the distribution of sample households across income deciles and across governorates. Since each income decile has (roughly) the same number of households, it follows that the sample weights show large variation. For example, there are only 240 households sampled in the lowest income decile, so, on average, one sampled household represents around 1,000 actual households; but in the top decile, one sampled household represents only 500 households. Interpretation of results cross-tabulated by income decile *and* governorate therefore requires caution, particularly where access rates are small.

Table A1.6: Distribution of Households by Region and Income Decile

Monthly income	***0 -9000***	***9,001 - 12,000***	***12,001 - 15,000***	***15,001 - 19,800***	***19,801 - 22,500***	***22,501 - 27,000***	***27,001 - 33,000***	***33,001 - 42,700***	***42,701 - 61,000***	***61,001 >***	
decile YR/month	***bottom***	***D[2]***	***d[3]***	***d[4]***	***d[5]***	***d[6]***	***d[7]***	***d[8]***	***d[9]***	***top 10%***	
Ibb	68	55	40	16	38	26	14	7	13	6	283
Abyan	4	2	3	4	3	11	8	2	23	30	90
Sana'a City	14	30	31	24	42	49	79	77	111	141	598
Al-Baida		3	7	2	8	15	5	18	21	26	105
Taiz	32	30	32	29	38	30	31	36	21	21	300
Hajjah	10	8	11	15	10	11	23	13	16	15	132
Al-Hodeida	54	79	21	23	27	23	26	13	9	12	287
Hadramout	4	7	20	27	29	52	31	38	51	23	282
Dhamar	10	13	32	22	23	23	20	21	10	8	182
Shabwah	3	2	2	6	10	27	13	19	23	13	118
Sa'adah	1	8	9	13	15	16	13	10	7	8	100
Sana'aGovern	16	13	29	14	24	17	24	21	24	38	220
Aden	8	28	26	29	38	41	51	67	78	33	399
Lahj	2	9	22	25	25	23	17	15	11	11	160
Al Mahweet	5	3	3	6	2	4	6	15	1	2	47
Amaran	9	12	21	13	15	9	15	30	14	11	149
Adelah		3	5	5	6	11	11	14	26	7	88
Total	240	305	314	273	353	388	387	416	459	405	3540

International Comparisons

A1.12 The results of the 2003 Yemen HES are compared to the eight countries examined by a 2003 ESMAP study.[2] This study examined a diverse set of countries – Brazil, Vietnam, South Africa, Ghana, Vietnam, Guatemala, India and Nepal – with a view to drawing general conclusions about the determinants of household energy use and fuel substitution patterns. The countries studied did not include any from the Middle East – an omission that the Yemen survey can now rectify.

A1.13 When making international comparisons, it is proper to note at the outset the main cultural characteristics and differences, and the degree of development and urbanization. Table A1.7 shows how Yemen compares to the other countries in degree of urbanization and household size.

[2] ESMAP, *Household Energy Use in Developing Countries: A Multi-country study*, Washington, October 2003.

Table A1.7: Urbanization and Household Size

	Urbaniz–ation	*Persons/HH*			*2003 HDR Poverty Index for developing countries*
income decile	*[%]*	*urban*	*rural*	*all*	
0-9000	9.4	5.9	5.5	5.6	
9001-12000	16.4	6.6	6.2	6.3	
12001-15000	14.6	6.9	6.6	6.6	
15001-19800	20.3	6.7	7.2	7.1	
19801-22500	19.4	6.7	6.7	6.7	
22501-27000	25.4	6.9	7.2	7.2	
27001-33000	28.9	7.4	8.4	8.1	
33001-42700	28.9	7.2	8.9	8.4	
42701-61000	32.3	7.6	9.6	9.0	
61001>0	33.1	10.0	11.3	10.8	
average, Yemen	**22.7**	**7.4**	**7.6**	**7.5**	**40.3**
Brazil	80.7	3.7	4.3	3.9	11.8
Nicaragua	56.7	5.2	5.7	5.4	18.3
South Africa	53.3	3.9	5.1	4.5	31.7
Vietnam	24.1	4.4	4.8	4.7	20.0
Guatemala	43.1	4.7	5.7	5.2	22.5
Ghana	36.7	3.9	4.5	4.3	26.0
Nepal	7.3	5.4	5.7	5.7	41.2
India	27.3	4.5	5.0	4.9	31.4
Average	*41.2*	*4.5*	*5.1*	*4.8*	

Source: ESMAP. Poverty Index from 2003 Human Development Report

A1.14 Average household size across all income deciles is significantly higher in Yemen than in any other country. Indeed, household size *increases* with income decile, and there is little difference between urban and rural households in this regard. (As explained further in Annex 2, this correlation of income and family size is largely determined by the number of wage earners per family: the average in the bottom decile is one wage earner per household, while the average in the top decile is 2.7.) The overall average of 7.5 persons per household is significantly greater than the average of the other countries, which explains one of the reasons why energy consumption per household (and in particular LPG consumption) is much greater than elsewhere. Yemen is also less urbanized than most of the comparative countries: only Nepal is less urbanized. Yemen is also among the poorest countries: only Nepal has a comparable level of poverty.

Completion of Fieldwork

A1.15 Fieldwork was carried out between 7 and 22 December 2003. 3,625 forms were returned to the offices of NHL Consulting by January 27, 2004 where the international and local consultants carried out quality control procedures (e.g. the records of supervisors were used to add missing village identifier codes in the case of a small number of forms).

Questionnaire Design and Field Survey

A1.16 The draft questionnaire was designed by local consultants with the international survey consultant in an advisory role. A preliminary field test of the questionnaire was carried out by the local and international consultants in the Taiz area between July 13 & 15, 2003. Subsequently further field testing of the survey was integrated into the training program of supervisors and enumerators. The field testing led to modifications in the questionnaire. The main modifications related to phrasing of the questions. The field testing also suggested changes to interview techniques that were incorporated in the instructions for supervisors and enumerators. The finalized questionnaire was transmitted to MOPIC by the local consultants on October 7, 2003.

Training of Supervisors and Enumerators

A1.17 Supervisors were recruited from Sana'a and Aden universities, the faculty of Hajjah and other third-level educational institutes. They were associate professors, lecturers, researchers and postgraduates. Enumerators were students recruited from the universities. In all 15 supervisors and 116 enumerators were recruited.

A1.18 Training documents No. 1 and No. 2 were provided by the local consultants to supervisors and enumerators. (These documents are contained in the project file). Training document No. 1 contains the methodological basis of the survey, a general background of the project, sample size and the contents and characteristics of the questionnaire form.

A1.19 Training document No.2 contains a detailed explanation of the following:

- Objectives of the questionnaire form.
- Supervisor's tasks.
- General instructions concerning the form completion.
- Instructions about how to select households to be surveyed.
- Statement about how to fill the questionnaire form question by question.
- Instructions related to certain questions that require explanations.
- Instructions related to dealing with problems that surface during field implementation and how to overcome them.
- Instructions about how to make use of the relevant parties and councils.
- Instructions related to preparation of field reports.
- Instructions about how to deal with information not required by the form.

A1.20 Maps were provided to enumerators and supervisors.

A1.21 The training program covered:

- General background, major objectives and methodology basis of the project.
- Presentation and discussion of the economic and social characteristics and relation to each of the questionnaire chapters.

- Detailed presentation and discussion of the questionnaire form by using modern technology means (PowerPoint).
- Identification of the locations of the randomly selected villages on maps prepared for this purpose.

A1.22 The training consisted of five stages:

- Preliminary two-days' training for supervisors at the World Bank building with participation of the international survey expert and the local consultant team on July 12, 2003. The training focused on presentation and discussion of the project objectives and the questionnaire form in its preliminary version.
- All workers of the field survey were trained in Taiz Governorate for one day prior to undertaking the first experimental survey in the presence of the international survey expert.
- Extensive training for supervisors and surveyors in small groups at different locations by the local consultants.
- Workshops for each survey group with its supervisor.
- Final meetings with certain supervisors prior to implementation.

Table A1.8: Training

Governorate	*Place of Training*	*No. of Trainees*
Sana'a + Al-Mahweet + Amran	Sana'a	20
Capital Secretariat	Sana'a	24
Hadramout + Shabwa	Al-Mukalla	14
Aden + Lahj	Aden	19
Taiz + Abyan	Aden	15
Hajjah + Al-Hodeida	Al-Hodeida	17
Ibb + Dhamar + Al-Baida	Dhamar	18

Data Processing

A1.23 The data entry program was programmed using Microsoft Access software. The Terms of Reference of the local consultant called for the use of an SPSS data entry program. When the local consultant was unable to obtain a copy, the international survey consultant gave permission to use MS Access. The local consultant had prepared a draft program by January 12, 2004. This was tested in trials at the CSO and was further developed by the international consultant. The program was finalized on January 24, 2004.

A1.24 The international consultant supervised training of the data entry staff at the CSO on January 24 & 25 2004, and the data entry was done at the CSO laboratory and supervised by designated staff from the CSO.

Remarks and Lessons Learned

A1.25 As noted above, the sampling frame for the HES is based on the 1994 census. Since 1994, new villages will have been established and the population in villages existing at the time of the 1994 census will have changed. The population of Yemen is thought to have grown from 15 million 1994 to over 19 million at the time of the HES. Any bias introduced into the survey results by not taking account of new villages in the sampling frame will only be significant if energy use by households in the new villages has unique characteristics. The potential bias of using outdated lists of households in villages from the 1994 census was addressed by obtaining a current list of households in the village from the village or neighborhood head. This, rather than the list from the 1994 census, was then used in the second stage of sampling a fixed number of households within each sampled village.

A1.26 Another source of bias arises since each income decile contains (roughly) the same number of households and it follows that the sample weights show large variation. For example, there are only 240 households sampled in the lowest income decile, so, on average, one sampled household represents around 1,000 actual households; but in the top decile, one sampled household represents only 500 households.

A1.27 Other potential sources of error in the reported data derive from difficulty in ensuring accurate responses from respondents, careful completion of questionnaires by enumerators and punctilious data entry and data cleaning. While there are some aspects, mainly relating to questionnaire design, that would be done differently with the benefit of hindsight, data quality assurance showed that data entry and data cleaning were of a high standard.

A1.28 With hindsight, the design of the HES questionnaire and the conduct of the survey could have been improved in the following ways.

- Respondents had better recall of the expenditure amounts on purchases of electricity and various fuels than of the quantities consumed (very few households were able to show the enumerator their electricity bill). Additional questions on expenditures made by households might have been useful (e.g. by querying last month's expenditures as well as average expenditures per billing period). In addition, questions on energy expenditures could have been included in the expenditure section of the questionnaire as a way of cross-checking energy expenditures in the individual fuel and electricity modules.
- Questions to probe the seasonality of fuel use may have been useful in the HES as the PRA findings indicated that energy purchases are seasonal with winter spikes of heating fuels in the highlands and increased use of fans during summer in the lowlands as well as increased use during religious festivals.
- The survey was too long. Questions which turned out to be of peripheral interest included, for example, the purchase of gensets (i.e. amount and payment terms of loan) and on their condition when purchased and characteristics of the household dwelling. It is thought that more reliable

data on quantities of fuels and electricity consumed would be obtained from respondents if the questionnaire were of shorter length and if these questions were towards the front of the questionnaire.

- Training of field interviewers was carried out over two days in several locations. This may not have been sufficient time for interviewers to fully familiarize themselves with the questionnaire and to gain experience in testing it under field conditions. A larger budget for training would have allowed for more time for all interviewers to test the questionnaire in the field and for the training consultants to fully satisfy themselves as to the proficiency of all interviewers.
- The PRA that provided qualitative information and the HES that provided quantitative data of household energy use are complementary instruments. The PRA, for example, is a better instrument to explore attitudes to fuel use and the inclusion of attitude questions in the HES is now considered superfluous. It is noted that it is important that the PRA results be written up and fully assimilated prior to undertaking the design of the household survey.
- The local cost of implementing the HES was approximately $150,000 and for the PRA was approximately $50,000. With a larger budget, a longitudinal HES would have permitted collection of more detailed information from households (for example by more use of electricity bills) and more detailed study of seasonal changes in household energy demand.
- The survey work was delayed on several occasions because of political events. From January through June 2003, it was not possible for World Bank staff to visit Yemen. In addition, for several months in the run-up to the general election in Yemen in April 2003 it was not possible to carry out survey field work. In planning similar surveys, it is important to take account of the political calendar that may impact on the timetable of implementation.
- Specialized energy surveys (such as the HES), which are mainly interested in fuels and electricity use for lighting and cooking, have not usually queried gasoline use as it is not normally used within the household for these purposes. Gasoline subsidy removal however will undoubtedly have an impact on household expenditure through the increased cost of gasoline purchased by households and indirectly through the increased cost of transport services used by households. In the case of poor households, it is assumed that the indirect impact would be dominant. Whereas direct use of gasoline by households could have been queried in the HES (and it is recommended that this be done in future surveys of this type), it is not a well adapted survey instrument to probe use of transport services by households. For this, a separate specialized transport survey would have been required.

Annex 2

Participatory Rapid Assessment

Research Sites and Methodology

A2.1 Using a purposive sampling method, twelve sites were selected in coordination with the CSO. The criteria for selecting the sample included the following key indicators that shape energy consumption:

- geographic variation: (i) Western Coastal Zone, (ii) Eastern Plains, (iii) Highlands, (iv) Southern Plains (v) urban & rural locations
- level of poverty (range of extremely poor and medium poor areas distributed across the four key geographic zones)
- electricity availability (areas with and without any grid access and local/cooperative off-grid service)
- physical accessibility (areas with no road access, dirt roads and paved roads)
- presence or absence of fossil fuels
- presence or absence of biomass

A2.2 *A stratified sample frame*: The above criteria were applied to the CSO's sampling frame for the 1998 Household Budget Survey to ensure diversity of national conditions. The sample was stratified on the basis of geographic representation as defined by the government's Strategy for Rural Development. That strategy divided the country into four main geographic areas, based on common socio-economic features, rather than the arbitrary political boundaries of administrative units (i.e. governorates). The areas are Western Coastal Zone, Eastern Coastal Zone, Highlands, Southern Plains. The eastern and southern coasts are lowlands with high temperatures and desert conditions; but some areas also have rich agriculture, mostly fruits and vegetables, fishing and livestock. With mild to cold temperatures, the Highlands are the bread basket of Yemen, renowned for terraced agricultural fields which grow cereals and vegetables. The research areas also included an equal number of sites from the former socialist south and the former north which had developed distinct political economic systems that continue to operate today. Table A2.1 summarizes the characteristics of each of the study sites.

A2.3 Within each of these geographic areas the poorest and average income districts were identified using the results of the CSO's 1998 Household Budget Survey. Since the CSO only had data at the district level, the research team then consulted with the district's Local Council to further identify villages on the basis of the availability of electricity, roads and biomass. The research was conducted in 12 locations (nine rural and three urban) in the four main geographic zones of the country.

Table A2.1: Summary of Location Characteristics

	District and Governorate	*Poverty*	*Electricity*	*Accessibility of the District*	*Petroleum products*	*Collected Biomass*
Western Coastal Zone	Marawa, HOUDEIDAH	Poor	Not available	Highly accessible	Available	Available
	Bajil, HOUDEIDAH	Medium	Not available	Medium accessibility	Available	Scarce
	Meena, HOUDEIDAH CITY	Medium	Grid	Highly accessible	Available	Scarce
Eastern Plains	Qatn, HADRAMOUT	Medium Poor	Grid	Medium accessibility	Available	Available
	Sah, HADRAMOUT	Poor	Rural cooperativ e	Medium accessibility	Available	Scarce
Highlands	Utmah, DAMAR	Poor	Not available	Medium accessibility	Scarce	Available
	Jabl yal yazid, AMRAN	Medium	Not available	Highly difficult to access	Scarce	Available
	Mutheikhra, IBB	Poor	Not available	Highly difficult to access	Scarce	Available
Southern Plains	Mozaa, TAIZ	Poor	Not available	Highly difficult to access	Scarce	Available
	Musseimeer, LAHJ	Poor	Not available	Medium accessibility	Scarce	Available
Urban	Alnuba, LAHJ	Poor	Grid	Medium accessibility	Available	Scarce
	Alhuk, LAHJ	Poor	Not available	Highly accessible	Available	Scarce

Figure A2.1: Map of the Study Areas

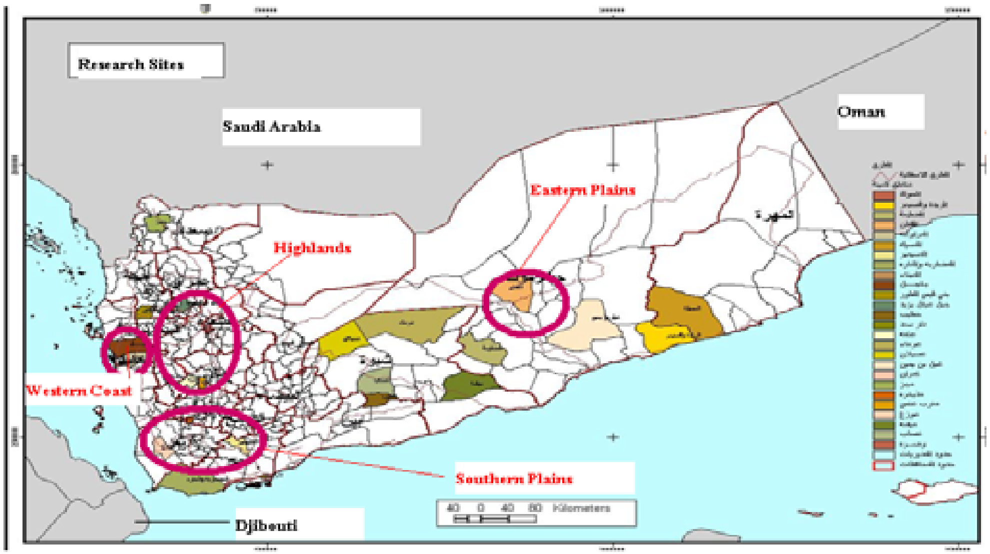


Table A2.2: PRA Instruments and Objectives

PRA Instruments	*Objectives and expected output*
1. Rapport building: meeting the sheikhs, local council members and community leaders	▪ Preliminary community profile established ▪ Socio-economic groups identified ▪ Preliminary identification of energy-related stakeholders
2. Community data sheet	▪ Community-wide quantitative information collected, such as population size, number of boys and girls enrolled in schools, type of social services available in the village (schools, health centers etc), number of energy-related service
3. Guided visit of village with key informant	▪ Key community institutions and energy services identified and geographically located ▪ Socio-economic groups geographically located
4. Community-wide meeting and stakeholder analysis using a guide prepared for the purpose	▪ Community profile finalized ▪ Identification of socioeconomic groups finalized ▪ Profile of community institutions finalized ▪ Key stakeholders identified ▪ Preliminary assessment of quality of energy services for community service providers (schools, health centers, public institutions, private businesses, etc)
5. Mapping exercise	▪ Map of the village drawn by community members identifying key energy related landmarks (energy suppliers, wood fuel collection sites), social services (schools, health centers etc), private businesses using energy (grain mills, shops etc).
6. Semi-structured interviews with males: one-on-one interviews with key male informants identified during stakeholder analysis and using interview guides prepared for the purpose	▪ Energy uses, supply and constraints described by members of the local councils, suppliers and users of energy sources.
7. Semi-structured interviews with women: one-on-one interviews from each of the three social groups, using interview guides prepared for the purpose	▪ Gain an in-depth understanding of household energy related behaviors, coping strategies and attitudes. Special attention given to division of labor within the household for supplying energy sources and its associated constraints. More detailed assessment of cooking practices and constraints faced at the household level.
8. Men's focus groups: meetings with men organized separately for each of the three socioeconomic categories	▪ Gain an in-depth understanding of household energy-related behaviors, coping strategies and attitudes faced by households from a male perspective. ▪ Assess quality of energy services for community service providers (schools, health centers, public institutions, private businesses etc) from a male perspective.
9. Women's focus groups: meetings with women organized separately for each of the three socioeconomic groups	▪ Gain an in-depth understanding of household energy-related behaviors, coping strategies and attitudes faced by households from a female perspective. ▪ Assess quality of energy services for community service providers (schools, health centers, public institutions, private businesses etc) from a male perspective.

A2.4 Twelve teams composed of four researchers (two men and two women), led by a Yemeni consulting firm, NHL, were deployed in each of the locations. They conducted focus group and in-depth interviews with both men and women and carried out geographic and poverty mapping exercises, stakeholder analysis and participant observation. Prior to the field work, they tested and refined the instruments. The teams lived in each of the research locations for four days. In each village they held at least one community-wide meeting, where communities defined their notions of well-being and grouped themselves in to three categories: **well-off**, **poor** and **very poor**. Following the initial community-wide meetings, gender segregated focus group interviews were held with each of the three social categories. In-depth interviews were conducted with key men and women informants representing different social categories, sheikhs, community leaders, elected representatives, shop owners, other energy suppliers, teachers, health workers, etc. The study also examined energy use by local institutions, such as health centers and schools, and locally-based private businesses. It also assessed constraints that energy providers and decision-makers faced at the local level in making different energy sources more widely accessible.

A2.5 In total, approximately 795 individuals were interviewed in the PRA survey. The large number of interviews, combined with data gathered through the different instruments above and the field teams' own observations, permitted triangulation of information.

Table A2.3: Total Number of Interviewees

	Focus groups with community energy users			Total Number of Focus Groups
	Women	Men	Total	
Well-off	108	123	231	12
Poor	115	125	240	12
Very poor	126	115	241	12
Total	349	363	712	36

In-depth interviews	**Totals**
Women users of energy services	36
Community leaders	15
Energy service suppliers (shop owners, LPG distributors etc)	32
Total	83

A2.6 *Data Analysis*: The field data were coded and entered into a Microsoft Access and Excel database which allowed information to be compared by gender, research site and socio-economic group. This report thus presents data which reflect both consistency and variation by gender, research site and socioeconomic group.

Socio-Economic Context and Household Eenergy Use in Yemen

Understanding Poverty

A2.7 The research places energy use within the social and economic context of the household and also the community within which it is located. An attempt was made to understand the meaning of poverty from the perspective of the people living in the research locations. In nearly all locations there was a consensus that people could be categorized into three wealth or income groups, the "well-off," "poor," and "very poor." Perceptions of the characteristics of these three groups were also remarkably consistent in the 12 locations. These categorizations are used throughout the paper.

How Did Communities Define Who is Well-Off?

A2.8 In rural areas, households considered **well-off** typically own their own homes and have land or livestock to rent to others. They also have one or more of the following resources: (i) fixed income through public or private sector employment which provides a predictable and consistent cash flow to households in cash poor areas (ii) a commercial activity (iii) remittances from abroad or (iv) several employed members of the household. Well-off households have assets and a diversity of income sources that enable them to mitigate risks and uncertainties. On average, they constitute 10-20% of the total population of a research site.

> *"Being **well-off** means shifting completely from wood to LPG and from kerosene to electricity."* Poor woman from Nuba

How Did Communities Define Who is Poor?

A2.9 Those considered **poor** do not own the house they live in, have limited land ownership and livestock and have no assets to rent out. In some areas, returnees of the 1990 Gulf War who remain unemployed are included in this category. Poor households rely on a single source of income. In the urbanized areas of the Eastern and Southern Plains, low-ranking government employees, especially those without job-related benefits (such as teachers who have no housing allowance), are considered poor. They constitute between 30-60% of a village population in the research sites.

How Did Communities Define Who is Very Poor?

A2.10 The **very poor** are utterly destitute and generally depend on others to meet their basic needs. They have no steady source of income. In general, they have at least one or often more of the following attributes: (i) the main provider (generally male) is either dead or disabled; (ii) they are female headed households; (iii) they have no land or livestock; (iv) they work as agricultural sharecroppers; (v) they have no means of production; (vi) they are unskilled; (vii) they are recipients of social security or other alms; (viii) they are elderly with no source of support; (ix) they are daily wage laborers; (x) they are nomads without livestock, homeless or beggars. They represent anywhere between 30-60% of a village population.

Implementation of the PRA Field Research: What Worked?

A2.11 First, special attention was paid to the composition of the field research team. The importance of ensuring that teams have men and women interviewers cannot be emphasized enough, given significant gender segregation in Yemen. Recruiting women field workers though is a challenge given the country's gender inequalities and the cultural restrictions on women's mobility. Fortunately, there are well-qualified women field workers, but finding them requires a conscious effort. This paid off in the wealth of information that was amassed from women respondents (which could not have been collected by male interviewers due to cultural restrictions on the interaction between men and women). Field workers from the same rough geographic areas were selected, taking Yemeni social relations into account, in order to generate trust and collect reliable information. Second, a one week training and pilot exercise were conducted, in view of the multiplicity of research instruments even though the field teams were generally familiar with PRA methods. This was especially important since the energy issue was entirely new to them. To ensure the collection of valid results, for instance, field workers were trained in encouraging all focus group participants to speak; the teams also learned techniques for politely limiting those who dominate conversations (for example, one technique includes inviting such individuals to the side for one-on-one interviews while the focus group meetings are being conducted). Third, research sites were selected using specific criteria applied to a sample frame for a nationally representative household budget survey with the assistance of the National CSO and further refined through consultations with the district offices of the CSO and local councils. An added lesson from this PRA is that the method can indeed by used as a monitoring and evaluation tool if sites are selected through a combination of statistical methods and purposive sampling to identify localities that are nationally representative. The PRA research instruments can then be used for data collection from which larger inferences can be drawn.

Instruments for Field Research

A2.12 (i) Field instruments – since energy touches upon a wide array of issues (poverty, human development, natural resource management, community cohesion, etc) survey instruments that collect such diverse data need to be designed. The most effective instruments for capturing the energy-related constraints that people face were the case studies using semi-structured interviews with key informants and focusing on a particular energy-related issue. These provided powerful illustrations of coping mechanisms in the face of energy-related constraints. Since they were open ended and one-on-one, they also allowed respondents to tell their personal stories in their own way and encouraged them to speak openly. The interview guides for the focus groups were excessively long and some questions, therefore, went unanswered or were incomplete. In particular, questions dealing with income or the history of the village, designed to identify changes over time that may impinge on energy use, were often only partially answered. In part this was because historical reflection, especially in the south, was perceived as straying into political territory and was therefore sensitive. There is a challenge in designing field instruments that capture diverse data needs yet remain simple and concise.

A2.13 (ii) Training of field staff – so they understand the significance of each category of questions and learn to distinguish relevant from irrelevant data. A lot of marginally relevant data were collected and promising information that could have been documented through probing techniques was neglected.

A2.14 (iii)Nature of the questions – some energy-specific questions need to be deepened: for instance, the PRA has shown that interviewees recognize the negative health impacts of indoor smoke from wood fuel, however, it did not explore if people also realized that it shortens life expectancy.

Data Analysis

A2.15 The most significant challenge in undertaking the PRA was conducting the data analysis in a way that was rigorous, particularly for data entry and interpretation. Should it be aggregated and disaggregated? Although analysis forms were designed in parallel with the questionnaires, these proved unwieldy and cumbersome when it came to using them for treating field data. For future work, data entry and analysis programs should also be tested as part of the piloting of the field instruments. The analysis focused on information that was triangulated, i.e. data which were found to be consistent across social category and space; consistent across different social categories within the same locality; or consistent within the same social categories but different across space. However, it would have also been important to analyze data that were not confirmed, ie. non-conclusive findings. One such example is the frequent discrepancy in the price, quantity consumed and frequency of use as reported by men and by women. There was discrepancy too in data collected through focus groups and semi-structured interviews with both men and women. These were not significant variations, but a discrepancy nonetheless. The information used in the report is that where there was consistency across different instruments.

Annex 3

Kerosene

Consumption Patterns

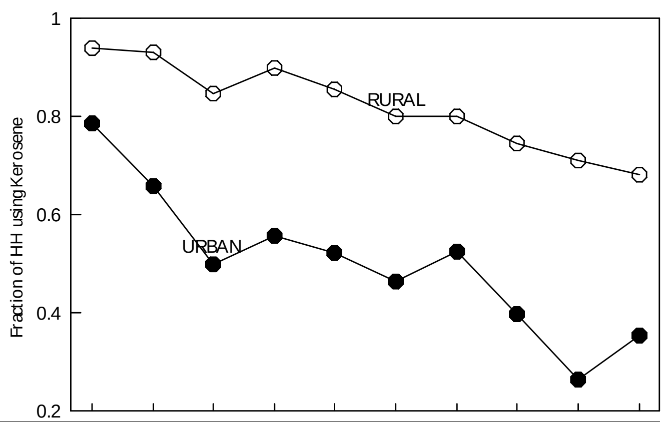
A3.1 Kerosene is used primarily by the household sector, and there is little use by industry and commerce. About one third is used for cooking and two-thirds for lighting. However, the expectation that kerosene is used primarily by the poor is not confirmed by the 2003 HES. 92% of the poorest households report kerosene use, but 57% of the richest decile also report kerosene use. Indeed, as shown in Table A3.1, monthly consumption of households using kerosene varies very little across income deciles (between 8 and 11 liters/month)[3].

Table A3.1: Kerosene Use by Income Decile

	Income per decile (YR/month)	***%HH reporting use***			***Consumption [liters/month]***			***Total Consumption [10^6 liters/year]***		
		Urban	Rural	All	Urban	Rural	All	Urban	Rural	All
1	0-9000	79%	94%	92%	8	10	10	1	17	18
2	9001-12000	66%	93%	89%	10	11	11	2	16	18
3	12001-15000	50%	85%	80%	10	11	11	2	16	17
4	15001-19800	56%	90%	83%	6	11	11	1	12	13
5	19801-22500	52%	86%	79%	6	9	8	1	11	12
6	22501-27000	46%	80%	71%	7	10	9	1	11	12
7	27001-33000	52%	80%	72%	9	11	11	2	12	14
8	33001-42700	40%	74%	64%	8	11	10	1	10	11
9	42701-61000	27%	71%	57%	7	11	10	1	9	10
10	61001>0	35%	68%	57%	7	11	10	1	9	10
	average	46%	83%	75%	8	10	10	14	121	135

[3] As in the case of LPG, the quantities reported in the survey significantly exceed the total reported as supplied by YPC. Quantities have therefore been adjusted in order to reconcile with the YPC total, and which is used as the basis for calculating subsidies. If one assumes that the expenditure data is reasonably reliable, the corollary is that reported prices are significantly underestimated. Again a variety of possible explanations could be given, including use of smaller 750ml water bottles sold as "litres". (see Annex 6 for a full discussion of this problem in the case of LPG)

Figure A3.1: Kerosene Use by Income Decile



	d[1]	d[2]	d[3]	d[4]	d[5]	d[6]	d[7]	d[8]	d[9]	d[10]
● URBAN	79%	66%	50%	56%	52%	46%	52%	40%	27%	35%
⊖ RURAL	94%	93%	85%	90%	86%	80%	80%	74%	71%	68%

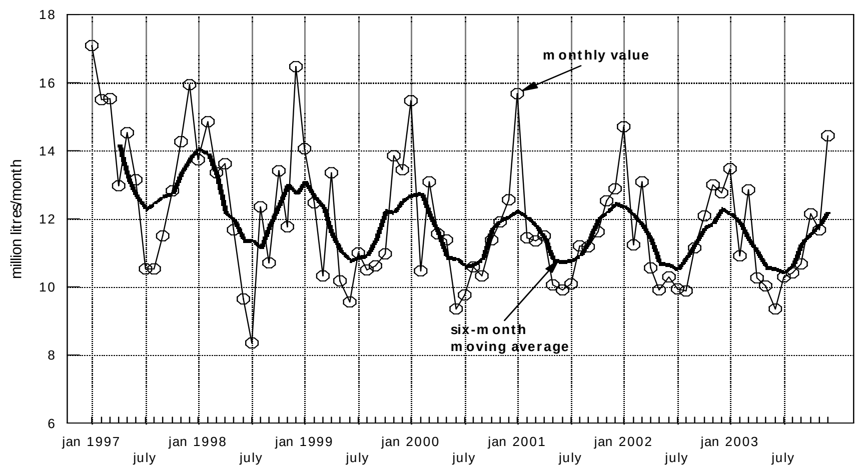
A3.2 As shown in Table A3.2, the key insight is that what varies by income decile is not the quantity of kerosene used, but the percentage of households using kerosene. Thus, for example, 40% of households in the bottom decile use kerosene for cooking, but only 25% of households in the top decile do so. But for those households that do use kerosene for this purpose, monthly consumption increases only from 11 liters/HH/month in the bottom decile, to 13 liters/HH/month in the top decile.

Table A3.2: Kerosene End-uses (Liters/HH/month)

	Cooking & Baking		*Lighting*		*Home Business*		*Other*	
		[%ofHH]		*[%ofHH]*		*[%ofHH]*		*[%ofHH]*
bottom Decile	11	[40%]	12	[80%]	2	[0.5%]	3	[1.9%]
ALLincome	12	[33%]	12	[59%]	5	[1.0%]	7	[4.6%]
top decile	13	[25%]	11	[45%]	32	[0.5%]	12	[4.7%]
URBAN								
bottom Decile	11	[48%]	7	[68%]	2	[4.9%]	1	[8.3%]
ALLincome	11	[22%]	8	[32%]	6	[1.8%]	6	[10.6%]
top decile	6	[12%]	10	[25%]	32	[1.4%]	9	[10.6%]
RURAL								
bottom Decile	11	[39%]	13	[82%]		[0.0%]	4	[1.2%]
ALLincome	12	[37%]	12	[67%]	4	[0.8%]	8	[2.9%]
top decile	14	[31%]	12	[56%]		[0.0%]	19	[1.8%]

A3.3 The demand for kerosene is highly seasonal, as shown in Figure A3.2. Kerosene consumption peaks in winter, with a sharp peak in December. Over the past few years, Ramadan has fallen in January (1997, 1998), gradually receding by one week or so each year: in 2003, Ramadan was from October 25-November 25, the month immediately before the survey was taken. Estimates of the total annual consumption for 2003 have therefore been adjusted for this seasonal effect.

Figure A3.2: Monthly Kerosene Demand

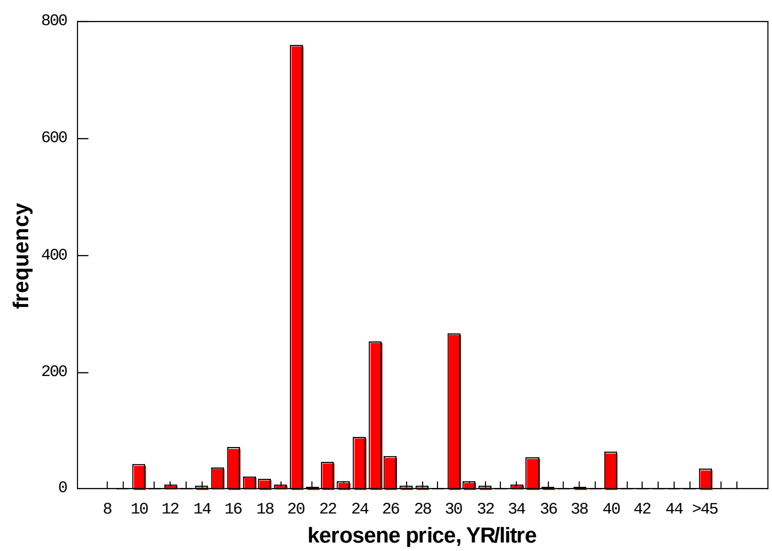


Source: Ministry of Oil and Minerals, Planning and Statistics Department.

The Retail Price of Kerosene

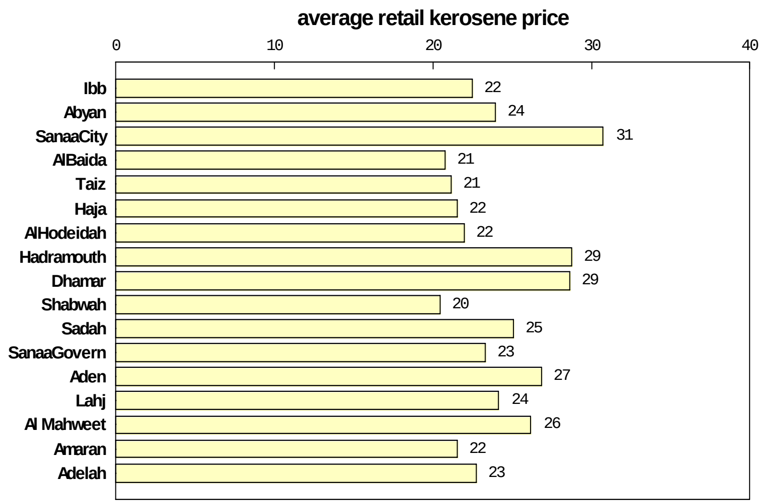
A3.4 The PRA reports kerosene retail prices ranging from 20 YR/liter in urban areas and in rural areas with easy access (paved road, close to district capital) to 25-35 YR/liter in less accessible rural areas (with poor roads or far from a district capital), to 30-35 YR/liter during the rainy season in rural areas. The overall national average retail price reported in the 2003 HES is 23 YR/liter, some YR7 more than the nominal ex-YPC price of 16 YR/liter: the most common price is 20 YR/liter (Figure A3.3).

Figure A3.3: Frequency Distribution of Retail Kerosene Prices



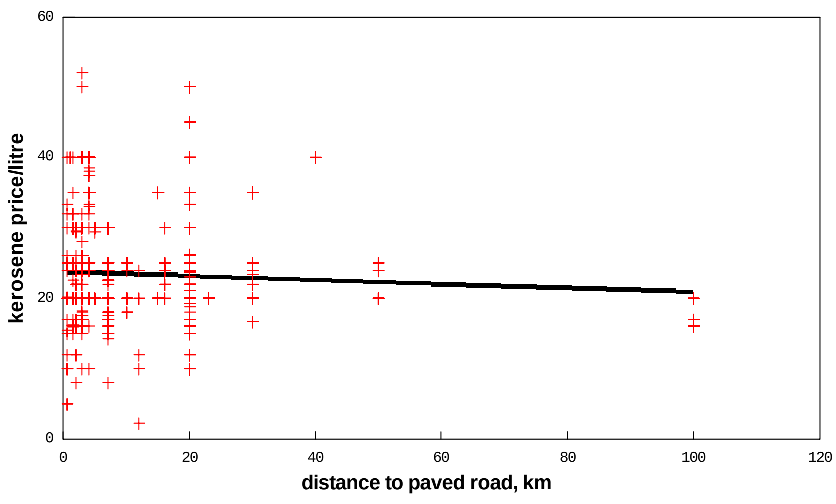
A3.5 The national 2003 HES data reveal no significant difference in retail price paid across the national income deciles, which range from 22 to 24 YR/liter. However, regional differences are more pronounced, as shown in Figure A3.4: Sana'a has the highest at 31 YR/liter, and Shabwah the lowest at 20 YR/liter.

Figure A3.4: Average Kerosene Price by Governorate



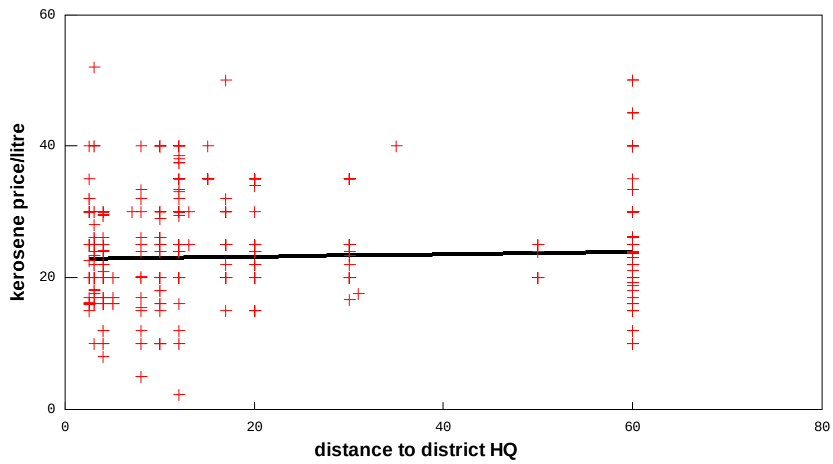
A3.6 The hypothesis that kerosene prices increase with increasing distance from paved roads or district capitals is intuitively plausible and was a finding of the PRA survey. However, it is not confirmed by any statistical evidence, as shown in Figures A3.5 and A3.6. The least-squares fit is not statistically significant.[4]

Figure A3.5: Kerosene Price v. Distance of Village to Nearest Paved Road



[4] However, there are problems with the dataset used for these regressions: only half of the rural households sampled have distance data that could be extracted from the village database.

Figure A3.6: Kerosene Price v. Distance to Nearest District HQ (km)



Kerosene Expenditure

A3.7 As shown in Table A3.3, survey reported kerosene prices show relatively little variation, either by income group or by urban/rural location. Consequently, monthly expenditures closely track consumption (shown in Table A3.1): rural households spend about 33% more than urban households. Both kerosene consumption and expenditure are dependent upon electricity access. The reported average retail price of 24 YR/liter compares to the official ex-distributor price of 17 YR/liter, and reflects local retail markups.

Table A3.3: Kerosene Expenditure (For Households Using Kerosene)

Income per decile (YR/month)	*Expenditure [YR/month]*			*Reported price [YR/liter]*		
	Urban	Rural	All	Urban	Rural	All
1 0-9000	282	394	386	24	22	22
2 9001-12000	368	446	436	23	24	24
3 12001-15000	313	433	422	22	23	23
4 15001-19800	233	475	442	20	24	23
5 19801-22500	268	367	354	23	28	27
6 22501-27000	259	397	374	23	24	24
7 27001-33000	360	415	404	23	24	24
8 33001-42700	304	418	398	24	22	23
9 42701-61000	230	377	354	27	25	25
10 61001>0	303	406	384	24	23	23
average, all deciles	297	414	397	23	24	24

A3.8 The PRA reported monthly kerosene expenditures as indicated in Table A3.4 and observed that: “in nearly all geographic districts, poor and very poor households outspent the well-off on monthly kerosene consumption: this is because the well-off use electricity and generator power for lighting.”

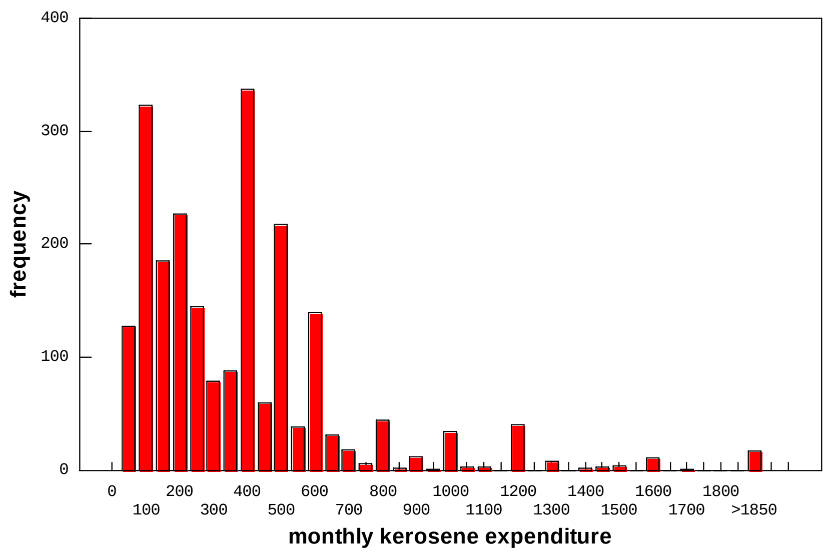
Table A3.4: Monthly Kerosene Expenditure Reported by the PRA

	DISTRICT, village	*Very poor*	*Poor*	*Well-off*
Western Coastal Zones	MARAWA Altour - Rural	500	500	400
	BAJIL - Rural Al Kharsha	640	800	500
	average	**570**	**650**	**450**
Eastern Plains	QATN Batina	800	500	
	SAH Sah	900	600	300
	average	**850**	**550**	**300**
Highlands	JABAL YAL YAZID Beit Al Harethi	500	500	750
	UTMAH Khiara	200	200	200
	MUTHEIKHRA Saaha	500	500	625
	average	**400**	**400**	**525**
Southern Plains	MOZAA Al Hud	1000	800	700
	MUSSEIMEER Mareeb	1080	1400	
	TIBN AlNuba	1100		
	ALHUK Al Rabsa	1800	1500	200
	MEENA - Alziadiah Al Shamaliya	1800	1500	1350
	average	**1356**	**1300**	**750**

Source, PRA.

A3.9 However, as suggested by Figure A3.7, the kerosene expenditures reported by the PRA for the Southern Plains are not representative; while there are indeed some households that report monthly kerosene expenditure of 1,500 YR/month, these account for only 1.5% of the sampled households.

Figure A3.7: Distribution of Monthly Kerosene Expenditure



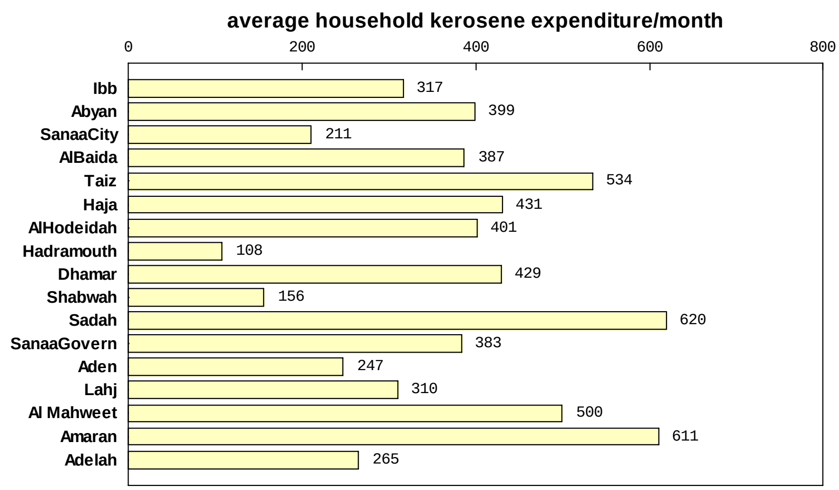
A3.10 Table A3.5 shows the monthly kerosene expenditure by income decile and Governorate (for households using kerosene). The average monthly expenditure by decile is fairly flat (386 YR/month in the bottom decile, 384 YR/month in the top decile)

Table A3.5: Monthly Kerosene Expenditure by Income Decile and Governorate

Income [YR/month]	*0 -9000*	*9,001 -12,000*	*12,001 -15,000*	*15,001 -19,800*	*19,801 -22,500*	*22,501 -27,000*	*27,001 -33,000*	*33,001 -42,700*	*42,701 -61,000*	*61,001 >*
	bottom	***d[2]***	***d[3]***	***d[4]***	***d[5]***	***d[6]***	***d[7]***	***d[8]***	***d[9]***	***top 10%***
Ibb	262	365	249	342	304	419	323	483	319	963
Abyan	110	224	230	166	80	553	169	250	388	520
Sana'aCity		80		80	78	120	1354	160	63	114
Al-Baida		386	357	320	224	638	113	423	464	458
Taiz	733	528	665	616	435	414	415	429	379	341
Hajjah	254	250	377	327	389	366	455	464	958	470
Al-Hodeida	383	408	395	489	382	430	431	341	296	351
Hadramout	8	101	105	91	76	138	103	137	126	80
Dhamar	306	960	445	377	25	362	492	427	414	352
Shabwah	68	60	110	67	200	191	147	153	130	144
Sa'adah	1300	540	517	549	602	643	898	486	630	496
Sana'aGovern	259	326	299	564	349	316	374	540	315	504
Aden	202	164	288	122	383	201	243	244	168	433
Lahj	231	422	335	480	266	287	298	162	296	261
Al Mahweet	856	509	417	459	750	413	434	570		
Amaran	368	588	644	812	364	634	835	628	605	626
Adelah			500	331	331	276	226	455	152	120
Total	386	436	422	442	308	374	404	398	354	384

A3.11 However, there is great regional variation, as shown in Figure A3.8, ranging from as little as 108 YR/month in Hadramout to 620 YR/month in Sa'adah.

Figure A3.8: Average Monthly Household Kerosene Expenditure



A3.12 Table A3.6 compares the PRA kerosene expenditure results with those of the 2003 HES. The results for the Southern Plains are notably different, with the PRA estimates over twice that of the HES. In two of four cases, the HES shows increasing expenditure with increasing income (Eastern Plains and Highlands) – exactly the opposite pattern to that noted in the PRA.

Table A3.6: Comparison of PRA and 2003 HES Kerosene Expenditures

	Very poor	*Poor*	*Well-off*
RPA Western Coastal Zone	570	650	450
2003HES: Al Hodeida	396	433	330
RPA: Eastern Plains	850	550	300
2003 HES: Sabwah	79	151	142
RPA: Highlands	400	400	525
2003 HES: Sana'a Governorate	294	401	453
RPA:Southern Plains	1356	1300	750
2003 HES: Taiz	642	470	383

A3.13 At present, there is little incentive to add kerosene to diesel fuel. But experience in other countries shows that where a significant price differential does exist, kerosene is often added to diesel fuel for transportation use. Therefore, if the diesel price is increased and that of kerosene is not, an increasing share of kerosene consumption can be expected to be diverted away from household use. For unelectrified rural households, kerosene is the only source of lighting (other than candles and dry cells): richer households tend to use LPG for non-electric lighting.

Who Benefits from the Kerosene Subsidy?

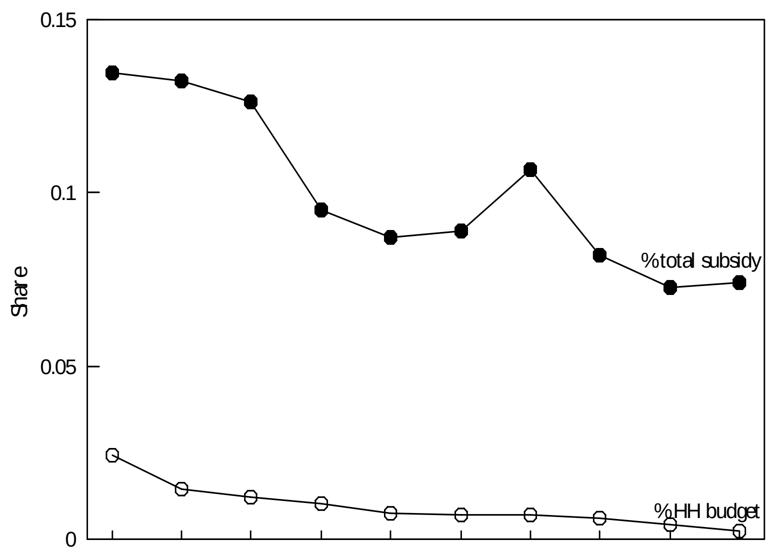
A3.14 As shown in Table A3.7, as a percentage of household income, the subsidy is more important to the poorest decile (13% of income) than to the richest (7%). However, the variation across deciles is relatively small (unlike that for diesel, where 43% of the total is captured by the richest decile).

Table A3.7: Kerosene Subsidies by Income Decile (2003).

Income by decile (YR/month)		*Subsidy*		*For HH reporting use:*		
	consumption	total	captured by each decile	subsidy	total expenditure	subsidy
	[10^6 liters/year]	[10^6 YR]	[%]	[YR/month]	[YR/month]	[% of total expenditure]
1 0-9000	18	382	13%	208	8481	2.5%
2 9001-12000	18	377	13%	230	16021	1.4%
3 12001-15000	17	359	13%	224	18389	1.2%
4 15001-19800	13	270	9%	224	21365	1.0%
5 19801-22500	12	248	9%	178	22990	0.8%
6 22501-27000	12	253	9%	194	27591	0.7%
7 27001-33000	15	303	11%	230	32867	0.7%
8 33001-42700	11	233	8%	210	33326	0.6%
9 42701-61000	10	206	7%	209	49248	0.4%
10 61001>0	10	211	7%	206	91469	0.2%
Total	137	2842	100%	212	31997	0.7%

A3.15 The variation in the corresponding share of total household budget is much greater: the subsidy is equivalent to 2.5% of the total expenditure of the poorest decile, but only 0.2% of the top decile (Figure A3.9).

Figure A3.9: Fraction of Total Kerosene Subsidy to Households Captured by Each Income Decile



	d[1]	d[2]	d[3]	d[4]	d[5]	d[6]	d[7]	d[8]	d[9]	d[10]
● %total subsidy	13%	13%	13%	9%	9%	9%	11%	8%	7%	7%
⊖ %HH budget	2.5%	1.4%	1.2%	1.0%	0.8%	0.7%	0.7%	0.6%	0.4%	0.2%

Direct Effects

A3.16 Table A3.8 shows the impact of bringing the kerosene subsidy to its economic price of YR 36.8/liter). The additional expenditure (assuming no price response, e.g., no switching to fuelwood for cooking) represents 2.5% of total household expenditure for the lowest decile and 0.2% for the richest decile.

Table A3.8: Impact of Bringing Kerosene Price to its Economic Value (YR 36.8/liter)

Income per decile (YR /month)	*Present expenditure*	*Additional expenditure*	*Total HH budget*	*Additional expenditure*
	[YR/month]	[YR/month]	[YR/month]	[%]
0-9000	386	208	8179	2.5%
9001-12000	436	230	15592	1.5%
12001-15000	422	224	17882	1.3%
15001-19800	442	224	20869	1.1%
19801-22500	354	178	22427	0.8%
22501-27000	374	194	26976	0.7%
27001-33000	404	230	32166	0.7%
33001-42700	398	210	32751	0.6%
42701-61000	354	209	48479	0.4%
61001>0	384	206	90548	0.2%

A3.17 Table A3.9 summarizes the impact of increasing prices to 60%, 80% and 100% of the 2003 economic price, corresponding to increases of 6, 13 and 21 YR/liter respectively.

Table A3.9: Impact of Reducing Kerosene Subsidies

Price level	*[% of economic price]*		*43%*	*60%*	*80%*	*100%*	*average effect on decile*
Price increase	[YR/liter]		0.0	6.1	13.4	20.8	
Economic price	[YR/liter]		36.8	36.8	36.8	36.8	
Retail price	[YR/liter]		16.0	22.1	29.4	36.8	
Subsidy	[YR/liter]		20.8	14.7	7.4	0.0	
Consumption							
Price elasticity	-0.2						
Consumption	[million liters]		137	128	121	116	
Impact on Government							
Subsidy	[YRbillion]		2.8	1.9	0.9	0.0	
Net gain to government	[YRbillion]			1.0	2.0	2.8	
Impact on households using Kerosene							
		%HH affecte d					
Poorest decile	[% of total present HH expenditure]	92.4%	0.0%	0.7%	1.6%	2.5%	2.4%
Middle decile	[% of present expenditure]	75.3%	0.0%	0.2%	0.5%	0.8%	0.6%
Richest decile	[% of present expenditure]	57.4%	0.0%	0.1%	0.1%	0.2%	0.1%

A3.18 How would households be likely to respond to increases in the kerosene price? One might assume that the poor would revert to fuelwood for that part of kerosene used for lighting, but at the moment, purchased fuelwood is the most expensive form of cooking fuel, as shown in Table A3.10. LPG has the lowest variable costs per meal, but high upfront fixed costs (for purchase of the cylinder and stove).

Table A3.10: Energy Costs Per Meal

	Unit	***Cost (YR)***	***Number of meals***	***Cost per meal***
Logs	Hamla (60 kilos)	3,500	30	116
Wood chips	Bag full	65	1	65
Kerosene	2 liter	40	1	40
LPG	1 cylinder	280	30	9

Source: Participatory Rapid Assessment

Indirect Effects

A3.19 In the case of kerosene, one might hypothesize two reasons why not all kerosene consumption goes to households. First, given the extent of subsidy, some quantity of kerosene may be smuggled abroad. Second, it is conceivable that some amount of kerosene is used to dilute transportation fuels. Because the kerosene price is very close to that of diesel (16 YR/liter as opposed to 17 YR/liter for diesel), the incentive to adulterate diesel is small. However, with a gasoline price at 35 YR/liter, in theory the incentive to adulterate gasoline is strong. However, this would cause maintenance (and emission) problems related to the fact that kerosene does not burn as easily, and it is not believed this is practiced in Yemen. The incentive to convert gasoline vehicles to LPG is much greater.

Annex 4

Diesel

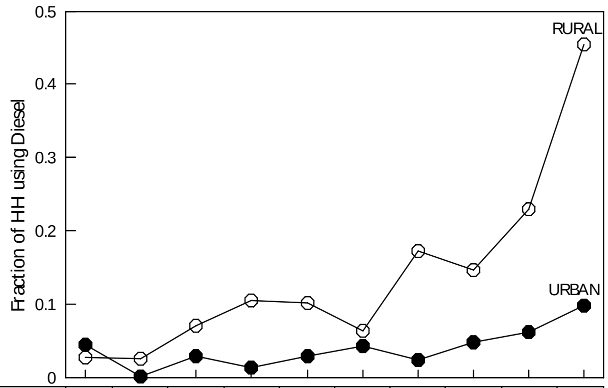
Household Consumption Patterns

A4.1 Direct consumption of diesel reported by households in 2003 was 486 million liters per year, or 21.6% of the total (the rest is used in transportation and by commerce and industry). However, only 11% of all households reported direct use of diesel – and of the households that do use diesel, 52% are in the two top income deciles. More remarkably, 34% of the households in the top decile use diesel (and 45% in the *rural* top decile), as opposed to 1-9% of households in the bottom 50% of households. In short, (direct) diesel use by households is sharply concentrated in the well-off households.

Table A4.1: Diesel Use by Decile

	Income per decile (YR/month)	*%HH reporting use*			*Consumption [liter/month]*			*Consumption [10^6 liters/year]*		
		Urban	Rural	All	Urban	Rural	All	Urban	Rural	All
1	0-9000	4%	3%	3%	172	35	55	2	3	5
2	9001-12000	0%	3%	2%	274	40	43	0	2	3
3	12001-15000	3%	7%	6%	3	119	111	0	21	21
4	15001-19800	1%	11%	9%	71	96	95	0	18	18
5	19801-22500	3%	10%	9%	26	130	124	0	29	29
6	22501-27000	4%	6%	6%	86	98	96	2	13	15
7	27001-33000	2%	17%	13%	45	169	163	1	56	57
8	33001-42700	5%	15%	12%	143	203	196	5	57	62
9	42701-61000	6%	23%	18%	184	175	176	10	74	84
10	61001>0	10%	45%	34%	185	217	214	16	176	192
	average	4%	13%	11%	139	167	164	38	448	486

Figure A4.1: Proportion of Households using Diesel



	d[1]	d[2]	d[3]	d[4]	d[5]	d[6]	d[7]	d[8]	d[9]	d[10]
● URBAN	4%	0%	3%	1%	3%	4%	2%	5%	6%	10%
⊖ RURAL	3%	3%	7%	11%	10%	6%	17%	15%	23%	45%

A4.2 The largest reported use of diesel is for agriculture: 22.1 million liters of the total of 45 million liters per month is used for this purpose (Table A4.2). Diesel for self-generation is the second largest use, accounting for 14 million liters/month.

Table A4.2: Distribution of Household Energy Consumption by Use, Per Month

	Purchased Firewood	*Charcoal*	*Electricity*	*LPG*	*kerosene*	*gasoline*	*diesel*
	1000t	*1000t*	*GWh*	*1000t*	*10^6 liters*	*10^6 liters*	*10^6 liters*
Cooking & Baking	48	1		53	9		
Lighting				6	16		
Fridge				0			
Ironing		0					
Space heat	7	1					
Water Heat							
Electric appliances			140			3	14
Home Business	0	0			0		1
Agriculture							22
Water Pumping							1
Transport							3
Other	1	3			1		4
Total	56	5	140	59	25	3	45

Note: diesel and gasoline use for "appliances" represents fuel for self-generation

A4.3 Indeed, this use of diesel for agriculture is highly concentrated in the two top income deciles (Table A4.3): for example, in rural areas, 29.8% of households in the top decile report diesel use for agriculture (and who use 200 liters a month for this purpose), as opposed to only 1.7% of rural households in the poorest decile (who use only 25 liters a month). The rationale that diesel requires subsidy in order to assist agriculture and farmers may be correct, but in fact this benefits well-off farmers, not poor farmers.

Table A4.3: Diesel End-uses: Liters Per Household Per Month [In Households Using the Fuel for the Stated Use]

	Appliances	*Home Business*	*Agriculture*	*Water Pumping(a)*	*Transport*	*Other*
	[%ofHH]	*[%ofHH]*	*[%ofHH]*	*[%ofHH]*	*[%ofHH]*	*[%ofHH]*
bottom Decile	207 [0.4%]	[0.0%]	25 [1.6%]	[0.0%]	55 [0.1%]	47 [1.0%]
ALL income	218 [2.8%]	105 [0.5%]	143 [6.9%]	45 [0.7%]	80 [1.8%]	98 [1.9%]
top decile	284 [8.9%]	97 [3.0%]	202 [21.8%]	61 [2.6%]	85 [9.4%]	85 [5.6%]
URBAN						
bottom Decile	207 [4.4%]	[0.0%]	[0.0%]	[0.0%]	40 [0.1%]	[0.0%]
ALLincome	120 [0.9%]	224 [0.3%]	189 [1.6%]	21 [0.2%]	66 [1.0%]	60 [1.4%]
top decile	60 [1.0%]	[0.0%]	261 [5.5%]	7 [0.7%]	72 [2.8%]	61 [2.4%]
RURAL						
bottom Decile	[0.0%]	[0.0%]	25 [1.7%]	[0.0%]	57 [0.1%]	47 [1.1%]
ALLincome	226 [3.3%]	82 [0.5%]	140 [8.5%]	47 [0.8%]	82 [2.0%]	106 [2.0%]
top decile	292 [12.8%]	97 [4.4%]	197 [29.8%]	66 [3.6%]	87 [12.7%]	89 [7.2%]

Note: (a) water pumping for domestic water supply only (pumping for irrigation purposes is shown under "agriculture")

A4.4 Table A4.4 shows the proportion of households reporting diesel consumption for the various categories. 6.9% of all households report diesel use for agriculture, but only 2.8 for self-generation.

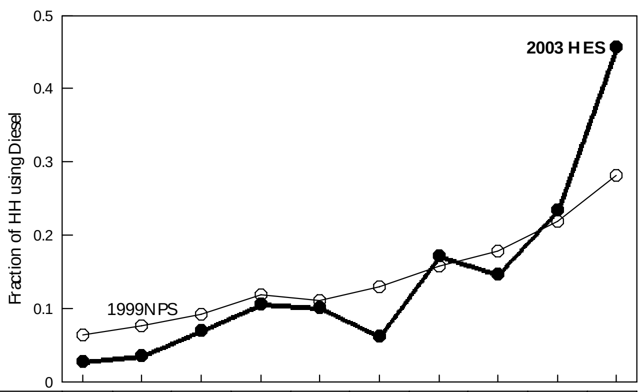
Table A4.4: Proportion of Households Reporting Diesel Use

		Transportation	*Water pumping*	*Agriculture*	*Business*	*Other*	*Self-generation*	*Any diesel use*
1	0-9000	0.1%	0.0%	1.6%	0.0%	1.0%	0.4%	3.0%
2	9001-12000	0.0%	0.1%	1.7%	0.0%	0.3%	0.0%	2.1%
3	12001-15000	0.6%	0.1%	3.5%	0.0%	2.9%	1.8%	6.4%
4	15001-19800	0.0%	0.2%	6.5%	0.5%	1.6%	1.4%	8.7%
5	19801-22500	0.5%	0.2%	5.0%	0.5%	2.3%	2.9%	8.7%
6	22501-27000	0.9%	0.1%	4.2%	0.3%	0.7%	0.6%	5.8%
7	27001-33000	1.5%	0.9%	7.0%	0.1%	1.2%	4.1%	12.9%
8	33001-42700	2.0%	1.2%	6.6%	0.0%	1.4%	5.0%	11.9%
9	42701-61000	3.1%	1.5%	12.2%	0.3%	1.9%	3.0%	17.6%
10	61001>0	9.4%	2.6%	21.8%	3.0%	5.6%	8.9%	33.6%
average		1.8%	0.7%	6.9%	0.5%	1.9%	2.8%	11.0%

Box A4.1: Comparison with results of 1999 Nationa

The 1999 National Poverty Survey estimated the % of households that had access to diesel and who irrigated with an artesian well (as cited in the Dec 2002 World Bank Poverty Update).

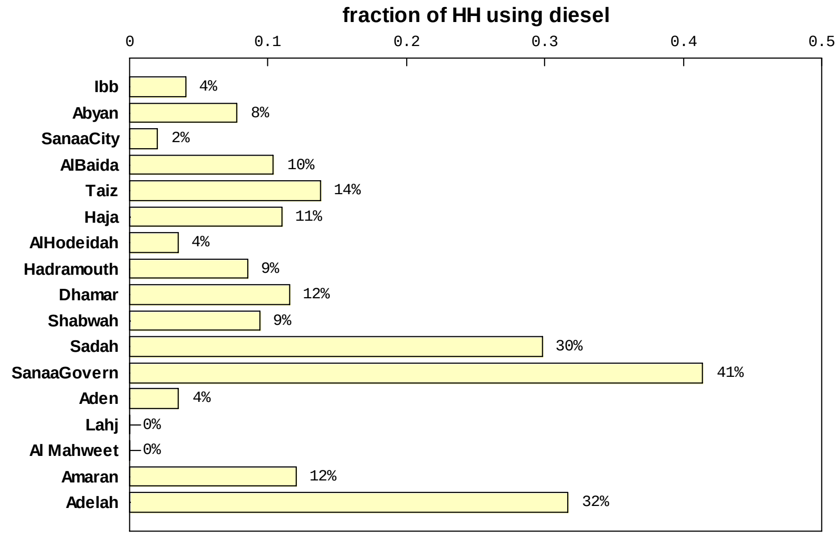
	Income per decile (YR / month)	*HH reporting diesel use for self-gen*		*HH reporting diesel use for Agriculture*		*Total HH reporting diesel use*	
		Rural	***urban***	***rural***	***urban***	***rural***	***urban***
1	0-9000	0.0%	4.4%	1.7%		2.8%	
2	9001-12000	0.0%	0.1%	3.2%	0.1%	3.6%	
3	12001-15000	2.1%	0.0%	4.1%	0.0%	7.0%	3.0%
4	15001-19800	1.6%	0.5%	7.9%	0.9%	10.6%	1.4%
5	19801-22500	3.6%	0.2%	6.1%	0.5%	10.1%	3.9%
6	22501-27000	0.8%	0.1%	5.3%	0.8%	6.3%	4.2%
7	27001-33000	5.7%	0.0%	9.8%		17.3%	2.3%
8	33001-42700	6.2%	1.9%	8.4%	2.2%	14.7%	4.8%
9	42701-61000	3.5%	2.0%	17.0%	2.1%	23.4%	6.8%
10	61001>0	12.8%	1.0%	30.1%	5.5%	45.6%	9.9%
average		3.3%	0.9%	8.6%	1.6%	13.1%	4.6%
1999 NPS		**2.4%**	**0.4%**	**9.7%**	**2.8%**	**13.9%**	**6.5%**



	d[1]	d[2]	d[3]	d[4]	d[5]	d[6]	d[7]	d[8]	d[9]	d[10]
1999NPS	6.4%	7.7%	9.2%	11.9%	11.1%	13.0%	15.8%	17.8%	21.9%	28.1%
2003 HES	2.8%	3.6%	7.0%	10.6%	10.1%	6.3%	17.3%	14.7%	23.4%	45.6%

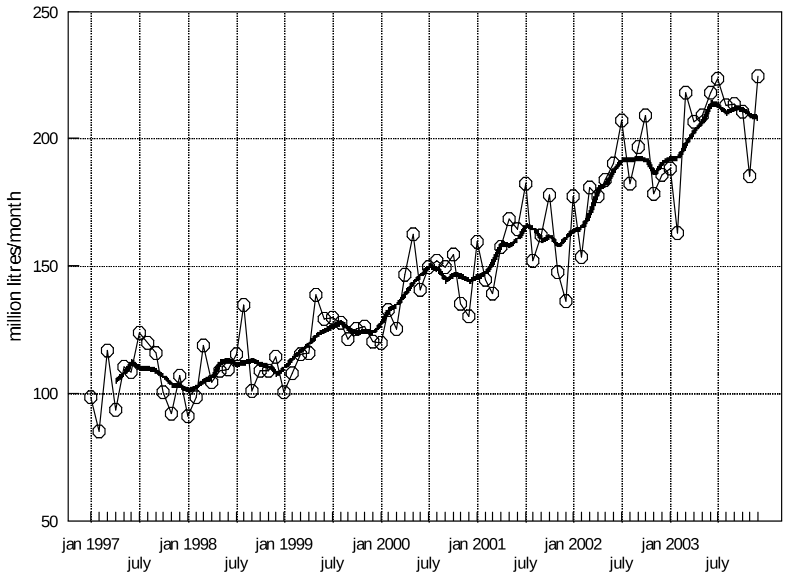
A4.5 Three governorates show a large percentage of households using diesel: Sana'a Governorate, Sa'adah and Adelah (Figure A4.2).

Figure A4.2: Percentage of Households in Each Governorate Reporting Diesel Use



A4.6 Diesel demand also shows regular seasonal variation, with the annual peak observed in July (Figure A4.3).

Figure A4.3: Monthly Diesel Consumption (All Uses, Including PEC and Non Households)



Diesel Expenditure

A4.7 Table A4.5 shows monthly expenditure on diesel fuel (for households reporting diesel use). Rural expenditure is significantly greater. Annex 8 discusses further diesel expenditures for self-generation.

Table A4.5: Monthly Diesel Expenditures (For Households Reporting Diesel Use)

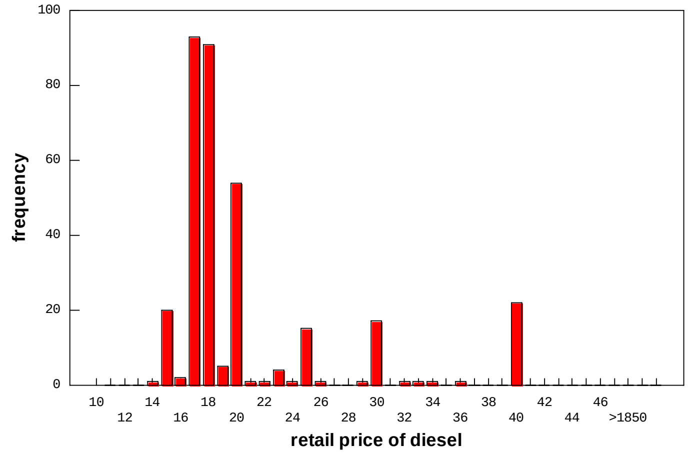
Income per decile (YR / month)	*%HH reporting use*			*Expenditure, [YR/month]*		
	Urban	Rural	All	Urban	Rural	All
1 0-9000	4%	3%	3%			
2 9001-12000	0%	3%	2%			
3 12001-15000	3%	7%	6%		2337	2186
4 15001-19800	1%	11%	9%		2193	2202
5 19801-22500	3%	10%	9%		2957	2814
6 22501-27000	4%	6%	6%		1832	1912
7 27001-33000	2%	17%	13%		3389	3259
8 33001-42700	5%	15%	12%	2651	4101	3880
9 42701-61000	6%	23%	18%	3142	6453	6066
10 61001>0	10%	45%	34%	2930	4262	4107
average, all deciles	4%	13%	11%	2533	3779	3652

Note: expenditure where less than 5% of HH report diesel use is not reliable, and is omitted

The Retail Price of Diesel

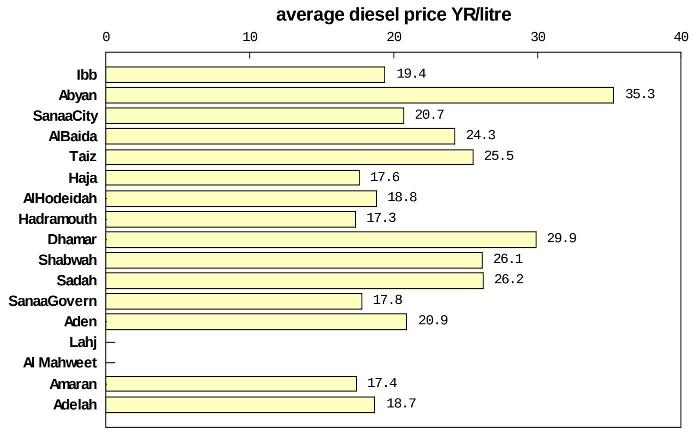
A4.8 With a wide network of filling stations where diesel is sold at the official price of 17 YR/liter throughout the country, reported retail diesel prices vary little: 70% of respondents report a price of between 17 and 20 YR/liter (Figure A4.4). Where there are no gas stations, diesel is sold in village shops in small quantities at higher prices.

Figure A4.4: Distribution of Reported Diesel Prices, YR/liter



A4.9 Figure A4.5 shows the average price of diesel by governorate. Abyan and Dhamar appear to have an unusually high average price to households (but with few households reporting diesel use in these provinces, this may not be not statistically significant).

Figure A4.5: Average Price of Diesel, by Governorate



A4.10 Nevertheless, as shown in Table A4.6, such variation as is observed in diesel prices is income dependent: the bottom quintile reports average purchase prices of 23 YR/liter, as opposed to YR18 in the top quintile (or 19 YR/liter overall).

Table A4.6: Diesel Prices

Income per decile (YR /month)	*Reported price [YR/liter]*		
	Urban	Rural	All
1 0-9000	18	23	23
2 9001-12000	13	23	23
3 12001-15000	24	19	20
4 15001-19800	25	20	20
5 19801-22500	19	21	21
6 22501-27000	20	21	20
7 27001-33000	16	19	19
8 33001-42700	15	16	16
9 42701-61000	16	19	18
10 61001>0	19	18	18
average, all deciles	18	19	19

Diesel Smuggling

A4.11 It is widely reported that considerable quantities of diesel (and LPG) are smuggled to neighboring countries, notably across the Red Sea, motivated by the sharp difference between the domestic price in Yemen and the international price. Estimates of as much as 30% of total diesel consumption being smuggled have been quoted. As shown in Table A4.7, Yemen diesel prices are substantially below those of neighboring countries, so there is substantial incentive for smuggling.

A4.12 However, as suggested in Box A4.2, while the economics of petty smuggling suggest significant incentives, it is hard to see how this could amount to 30%, which, given 2003 consumption of 2,260 million liters of diesel, implies some 700 million liters, or 670,000 tons.

Table A4.7: Diesel Price Comparison, in US cents/liter

	1998	*2000*	*2002*
Yemen	**7**	**6**	**10**
Eritrea	23	33	25
Somalia(a)			
Djibouti	40	53	54
Saudi Arabia	10	10	10
UAE	18	26	30
Oman	29	29	26

Source: World Bank Development Indicators, 2002; GTZ
(a) No official information; according to press reports, diesel prices in Mogadishu are around 30 US cents/liter, but supply is erratic (mainly by tanker from UAE to the port at El-Ma'an, and often reach 80 US cents to $1/liter). Smuggling is also reported from Djibouti (where retail prices are high) into northern areas of Somalia. It is a reasonable assumption that Somali is a substantial market for smuggled fuels.

Box A4.2: The Economics of Petty Smuggling

While smuggling in the face of large differentials between domestic and international prices is plausible, the evidence for the magnitudes involved appears to be entirely anecdotal: no reliable quantitative study of the subject has been found. Smuggling must either involve an exchanged commodity such as fish or cattle or dollars.

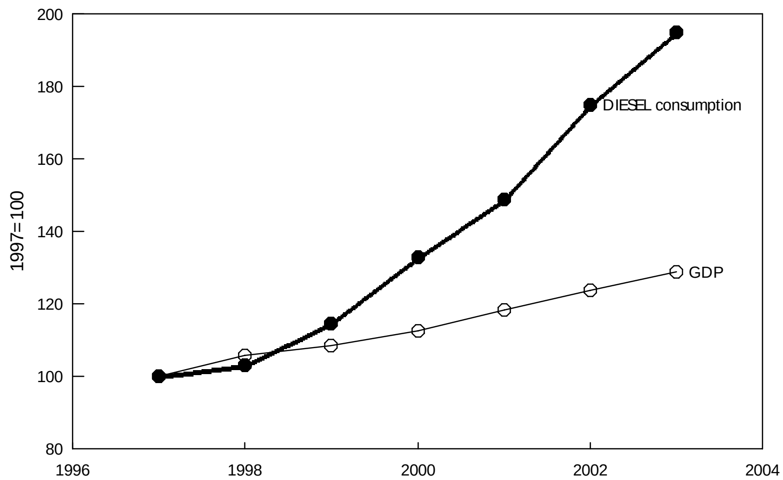
The economic consequences of smuggling can be illustrated by simple example. The economic cost of diesel is 37 YR/liter, but can be bought by a smuggler in Yemen for 17 YR/liter. The smuggler's transportation cost to bring the diesel to a neighboring country is, say, 2 YR/liter (which is spent in Yemen). Assume the retail price of diesel at a coastal location in the neighboring country is also (the equivalent of) 37 YR/liter. It is reasonable to suppose that the available rent (37-(17+2)= 18) is shared based on a negotiation that is based on an allocation of the risks to the parties involved: assume that 4 accrues to the party in the neighboring country, and 14 to the Yemeni smuggler. The diesel could be exchanged for a commodity with a market value in the neighboring country of 33 YR, that can be sold back in Yemeni markets for the same price; the smuggler's expenses for bringing back the produce to the Yemeni market is 1YR (spent in Yemen). The winners and losers in this transaction are as follows:

- Government of Yemen: -20 YR/liter (cost of subsidy)
- Neighboring country party: +4YR/liter (obtains diesel worth 37 YR/liter for 33 YR/liter)
- Economy of Yemen +3 YR/liter (smuggler's expenses)
- Yemeni smuggler +13 YR/liter (revenue from produce sale 33 YR/liter, less costs of 17+2+1=20 YR/liter)

Unless the diesel is sold for dollars and deposited in an offshore banking account, the likelihood is that the Yemini smuggler's surplus is spent in the Yemeni economy. Therefore, the only actual economic loss to the Yemeni economy as a whole is that (probably relatively small) share of the rent that accrues to the party in the neighboring country: the main effect is a *transfer payment from the government to the smuggler* (and the sectors that benefit from the smuggler's expenditures), and some (small) leakage to the foreign party.

A4.13 It has been suggested by other commentators that high growth rates of diesel consumption in Yemen, substantially in excess of the growth rate in GDP, support the proposition of large quantities of diesel smuggling. Figure A4.6 also supports this proposition.

Figure A4.6: Diesel Consumption and GDP



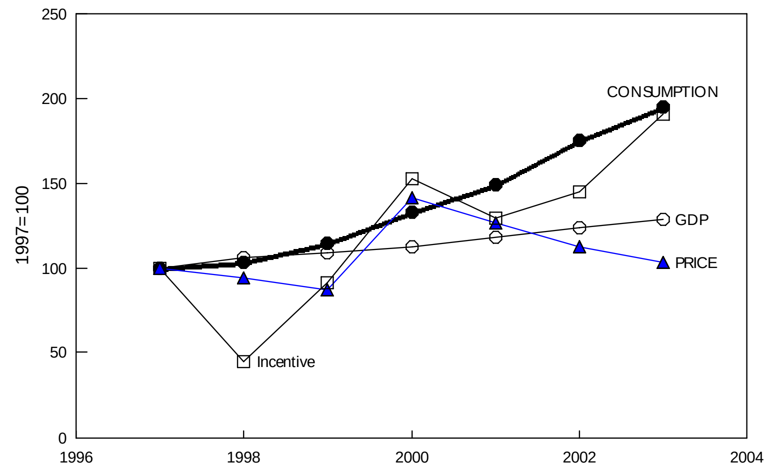
A4.14 One needs to exercise great care when drawing such conclusions. First, one of the main reasons why diesel consumption has increased sharply over the past few years is increased consumption by PEC for electricity generation (as well as diesel purchases by industries and households for self-generation). As shown in Table A4.8, when PEC consumption is subtracted out, the 2002 increase in diesel consumption is 16%.

Table A4.8: Diesel Consumption, GDP and Price Differential

		1997	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*
Total diesel consumption	[10^6 liters]	1271	1310	1458	1689	1891	2222	2474
Growth rate	[ ]		3%	11%	16%	12%	18%	11%
PEC consumption	[10^6 liters]			60	127	203	257	334
Non-PEC consumption	[10^6 liters]	1271	1310	1398	1562	1688	1965	2140
Growth rate	[ ]		3%	7%	12%	8%	16%	9%
Differential (economic price-actual price)	[YR/liter]	11.9	5.4	10.9	18.2	15.4	17.3	22.8
Change	[YR/liter]		-6.6	5.6	7.3	-2.8	1.9	5.5
As % change	[ ]		-55%	104%	67%	-15%	12%	32%
Non-oil real GDP growth rate	[ ]	6.2%	5.8%	2.7%	3.5%	5.2%	4.6%	4.0%

A4.15 Second, the main conclusion of Figure A4.6 is not necessarily that the difference in diesel consumption and GDP is driven by smuggling. Indeed, many countries at Yemen's stage of economic development (and particularly rapid growth in road traffic) exhibit high income elasticities for diesel consumption, and one would *expect* that diesel consumption grows faster than GDP growth. While it is true that a large price differential between border price and domestic price is an incentive for diesel smuggling, a falling real (domestic) diesel price also induces additional diesel consumption. Indeed, when real price and price differential are added to Figure A4.6, as shown in Figure A4.7, a very different picture emerges: the falling real price of diesel has driven diesel consumption just as much as increasing price differential.

Figure A4.7: Diesel Consumption v. GDP and Diesel Prices



A4.16 With so short a time series, one may be reluctant to read too much into a simple regression model. Nevertheless, when one estimates the model

$$\delta Diesel = k\ \delta GDP^{a}\ \ \delta PRICE^{b}\ \ \delta PX^{c}$$

the income elasticity calculates as 2.4, the own-price elasticity as –0.2, and the elasticity with respect to the price differential as 0.1 (all statistically significant, signs and magnitudes of elasticities very much as expected, overall R^2=0.99). Based on this (admittedly simplistic) model, when one sets δPX=0, i.e., if the border and retail price were equal and thus no longer an incentive for smuggling, then the 2003 consumption reduces from 2,474 million liters to 2,300 million liters, a reduction of 7%. This reduction of 173 million liters calculates to one million barrels/year, or 145,000 tons per year.

A4.17 Smuggling on a larger scale is also plausible. Assuming a full load of diesel, a 100 A1 oil tanker with six oil tanks totaling a 2,760 DWT vessel could move about 18,000 bbls or 2.8 million liters. The gross margin (difference between Yemen domestic and international price) is 22.8 YR/liter (see Table 5.9, Volume 1), for a total of YR62 million, or $320,000. To account for the entire 7% estimate of smuggled diesel of 145,000 tons, 56 loads in this type of tanker would be required, generating a potential gross margin of 56 x $320,000 = $19 million. Smuggling on this scale seems both plausible and profitable.

Reducing the Diesel Subsidy: Direct Effects

A4.18 Experience from other countries indicates that when diesel is so far below its opportunity cost, the consequences include loss of tax revenues to the Government, smuggling and corruption, and wasteful consumption. In addition, in Yemen under-pricing of diesel leads to over-pumping of groundwater for water-intensive crops (fruit, vegetables and Qat) and depletion of aquifers, whose costs are borne by *all* water users.

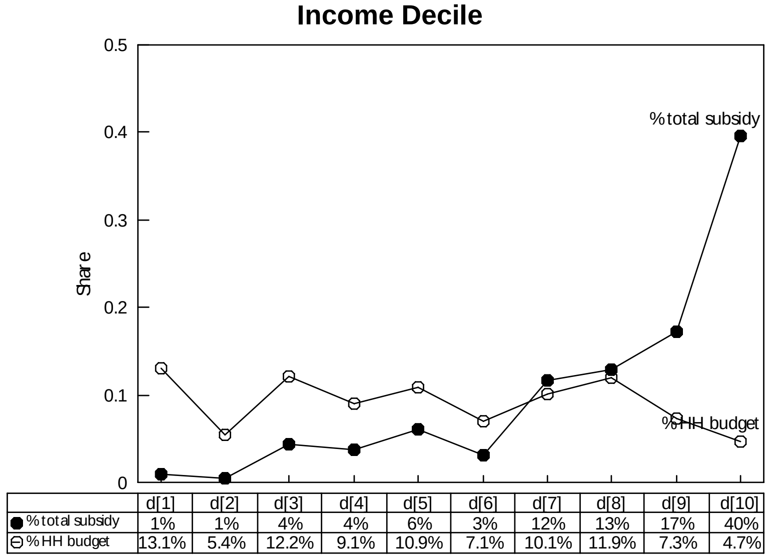
A4.19 Households would experience the effect of a rise in diesel price in two ways. The first is the *direct* effect of higher prices on the diesel fuel purchased by households. The second is the *indirect* effect of higher diesel prices on other household expenditures: for example, since diesel is used for irrigation pumping and transport of food, food prices would increase as producers and distributors pass on the cost of *their* higher diesel prices. Similarly, where diesel is used for power generation, the cost of electricity would also increase.

A4.20 Table A4.9 and Figure A4.8 show subsidies by income decile. 57% of the total subsidy (associated with direct use) is captured by the two top deciles: the bottom three deciles capture 6% of the total – a simple reflection of the low direct diesel use in the low deciles.

Table A4.9: Subsidies by Income Decile.

		Subsidy			***for HH reporting use:***		
		consumption	total	captured by each decile	subsidy	Total expenditure	subsidy
	Income decile (YR / month)	[10^6 liters/year]	[10^6 YR]	[%]	[YR/month]	[YR/month]	[% of total expenditure]
1	0-9000	5	93	1%	1114	8481	13.1%
2	9001-12000	3	52	1%	870	16021	5.4%
3	12001-15000	21	427	4%	2247	18389	12.2%
4	15001-19800	18	375	4%	1935	21365	9.1%
5	19801-22500	29	597	6%	2507	22990	10.9%
6	22501-27000	15	305	3%	1952	27591	7.1%
7	27001-33000	57	1147	12%	3304	32867	10.1%
8	33001-42700	62	1266	13%	3982	33326	11.9%
9	42701-61000	84	1699	17%	3581	49248	7.3%
10	61001>0	192	3899	40%	4335	91469	4.7%
	total	486	9861	100%	3331	31997	10.4%

Figure A4.8: Fraction of Total Diesel Subsidy to Households, Captured by Each Income Decile



A4.21 Table A4.10 shows the direct effect of raising the diesel price to 60%, 80% and 100% of the economic price. For example, if raised to the economic price, the effect on diesel users in the poorest decile is 13.6%, and only 4.8% in the richest decile. However, since only 3% of households in the poorest decile use diesel, the average across all households is only 0.4%, while for the richest decile it is 1.6%.

Table A4.10: Effect of Diesel Price Increases on Direct Diesel Use by Household

Price level	*[% of economic price]*		*46%*	*60%*	*80%*	*100%*	*Average effect on decile*
Price increase	[YR/liter]		0.0	5.4	12.8	20.3	
Economic price	[YR/liter]		37.3	37.3	37.3	37.3	
Retail price	[YR/liter]		17.0	22.4	29.8	37.3	
Subsidy	[YR/liter]		20.3	14.9	7.5	0.0	
Consumption							
Price elasticity	-0.1						
Consumption	[million liters]		486	473	459	449	
Impact on Government							
Subsidy	[YRbillion]		9.9	7.1	3.4	0.0	
Net gain to government	[YRbillion]			2.8	6.4	9.9	
Impact on households using Diesel							
		%HH affected					
Poorest decile	[% of total present HH expenditure]	3.0%	0.0%	3.6%	8.6%	13.6%	0.4%
Middle decile	[% of present expenditure]	7.3%	0.0%	2.4%	5.8%	9.2%	0.7%
Richest decile	[% of present expenditure]	33.6%	0.0%	1.3%	3.0%	4.8%	1.6%

Reducing Diesel Subsidies: Indirect Effects

A4.22 The main concern of poor households regarding indirect effects of increasing diesel prices is the potential effect on food prices, given the role of diesel fuel for food production (water pumping), and food transportation (diesel trucks). Similarly great concern has been expressed that the poor would be hit by higher costs of purchased water (again because of diesel used for pumping groundwater, and diesel fuel used in bowsers operated by water sellers). The PRA notes, for example, that

> *Respondents expressed strong opposition to paying higher diesel prices, even those who do not purchase it. They fear that an increase in diesel prices will mean an increase in the cost of transporting basic goods. Already, remote areas have significantly higher prices largely attributable to transportation costs. Respondents explained that increasing diesel prices would elicit a stronger negative public reaction than the recent increase in bread due to the far-reaching implications of diesel consumption.*

A4.23 It is noted (Annex 10) that the poor devote a much higher proportion of their income to food than the non-poor, so if indeed food prices rise as a consequence of higher diesel prices, the poor would be affected disproportionately: food accounts for 54% of the household expenditure in the poorest decile, but only 36% of the richest decile.

A4.24 Ideally, to estimate the indirect effect of a diesel price increase on the CPI requires an input-output table. This is not available for Yemen, and therefore it is only possible to estimate an upper bound of the potential impact based on certain assumptions that are conservative from the standpoint of estimating distributional impacts.

A4.25 The calculations are shown in Table A4.11. Of the total 2003 diesel consumption, 334 million liters was used by PEC, and 486 million liters was purchased directly by households; and for the moment assume no diesel is smuggled. The remaining quantity of diesel will be used by a variety of sectors, but in the absence of an I/O table and lacking information about how much diesel is used in transportation, by industry, by Government, etc., the most conservative assumption that can be made with regard to the potential impact on the poor is that the entire residual diesel consumption, i.e. 1,655 million liters, goes into the production, transportation and distribution of food and water. Since the poor consume a much higher fraction of their income on food than the non-poor and are particularly concerned about the potential impact on water costs, this is the most conservative assumption one can make. Thus, under this assumption, the sector food and water would incur increased costs of YR33.6 billion.

Table A4.11: Impact of Diesel Subsidy Elimination

	Diesel expenditure			*Baseline expenditure*	*Price increase*
	quantity	*current*	*incremental*		
	[million liters]	[YR billion]	[YR billion]	[YR billion]	[%]
Total	2475	42.1	50.2		
PEC consumption	334	5.7	6.8	49.3	13.8%
Smuggled	0	0.0	0.0		
Direct use by HH	486	8.3	9.9		119.4%
Export goods		0.0	0.0		
Government consumption		0.0	0.0		
Investment		0.0	0.0		
Non-HH private consumption		0.0	0.0		
All other items in CPI		0.0	0.0		
Food&Water					
diesel	1655	28.1	33.6		
electricity			3.0		
total			36.6	417	8.8%

A4.26 With regard to diesel use by PEC, elimination of the diesel subsidy would increase PEC costs by YR6.8 billion. PEC's total costs in 2003 were YR49.3 billion, so if the diesel price increase were passed to consumers (as a fuel adjustment in the tariff), its price would increase by 13.8% (assuming no adjustment of electricity consumption by consumers in the face of a price increase, or fuel switching by PEC, as discussed below).

A4.27 Some of this electricity is purchased directly by consumers – in 2002, households consumed 55% of electricity sold by PEC.[5] Therefore, assuming all

[5] In 2002, the distribution of PEC sales by sector was as follows

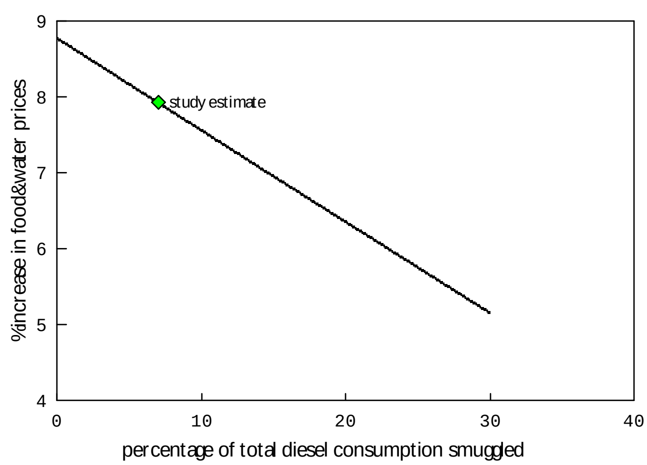
	GWh	
Domestic	1380	55.8%
Commercial	382	15.4%
Industrial	281	11.4%
Agricultural	39	1.6%
Government	365	14.8%
Mosques	27	1.1%
Total	2474	100.0%

tariffs are equally adjusted, the remaining 45% is sold to the rest of the economy (which is here assumed to be just food). Therefore, the food and water sector faces price increases of YR28.8 million due to more expensive diesel, and YR3.0 billion due to more expensive electricity, for a total of YR36.6 million. From the 2003 household survey, total food and water expenses amounted to YR417 billion, and therefore the food prices would increase by 8.8%.

A4.28 As noted, this is a very pessimistic calculation from the standpoint of the poor, and therefore should be interpreted as an *upper bound* of the potential increase in food and water prices. First, one of the main reasons why PEC uses diesel rather than fueloil is price: in 2002, PEC paid 17 YR/liter for diesel, but 28.50 YR/liter for fueloil, so were diesel to rise to more than 28.50 YR/liter, some fuel switching would be likely to occur. Moreover, with power generation switching to gas, the importance of diesel to generation costs will in any event decline.

A4.29 Second, the calculation shown in Table A4.11 assumes that no diesel is smuggled. As shown in Figure A4.9, the greater the fraction of diesel that is now smuggled, the smaller the impact on food prices: if 7% were smuggled (as estimated above), then the price increase would fall from 8.8% to 7.9%.

Figure A4.9: Impact of Diesel Smuggling on Food Price Increases



A4.30 With the estimates of price increases of Table A4.11 in hand, one may then estimate the overall impact of removal of the diesel subsidy on households. As shown in Table A4.12, the distribution across deciles is remarkably flat – at least under the assumptions made here, notably that the entire indirect impact is concentrated in food.

Table A4.12: Direct and Indirect Impacts of Increasing Diesel to Economic Price, All Households

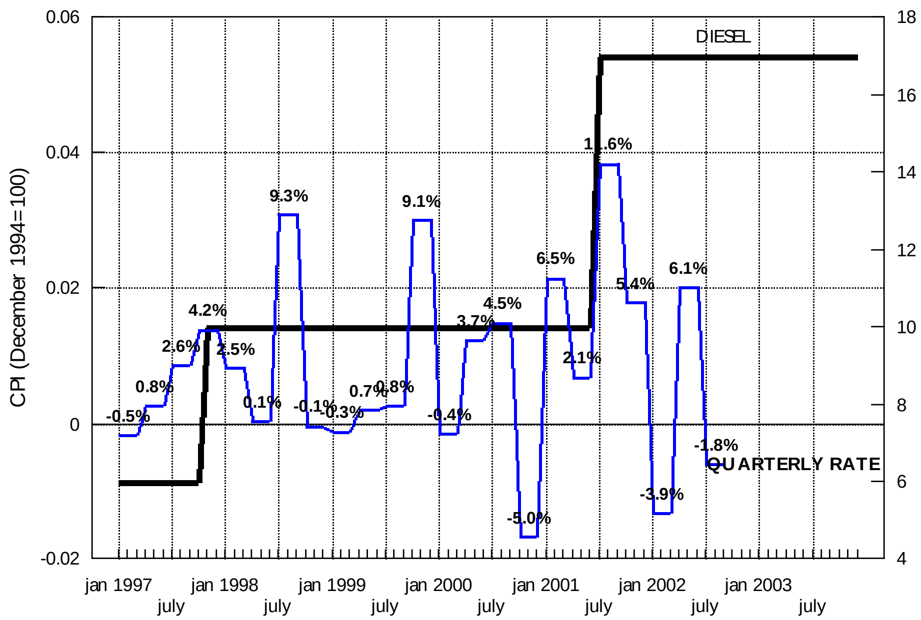
		Indirect effects				Direct effects					
Income per decile (YR/month)		***Food***		***Electricity***		***Diesel***		***Diesel Self-gen***		***Total increase***	
	Total HH expenditure	present	increase 8.8%	present	increase 13.8%	present	increase 119.4%	present	increase 119%		as % of total E
0-9000	8179	4650	408	92	13	18	21	14	17	460	5.6%
9001-12000	15592	8342	732	223	31	26	31	1	1	795	5.1%
12001-15000	17882	9025	792	240	33	120	144	21	25	994	5.6%
15001-19800	20869	9879	867	400	55	150	180	63	76	1177	5.6%
19801-22500	22427	11456	1005	346	48	176	210	82	98	1360	6.1%
22501-27000	26976	13650	1198	575	79	116	138	7	9	1424	5.3%
27001-33000	32166	14583	1280	736	101	273	326	173	207	1914	5.9%
33001-42700	32751	15061	1322	577	79	283	338	221	264	2003	6.1%
42701-61000	48479	19739	1732	985	136	586	700	589	703	3271	6.7%
61001>0	90548	32641	2864	1375	189	1252	1495	220	263	4812	5.3%
total	32401	13843	1215	550	76	298	355	138	165	1811	5.6%

Impact of Past Increases in the Diesel Price

A4.31 The main report examines the impact of the diesel price increases in 2001 by looking at trends in the overall monthly CPI and aggregate expenditures, and concludes that the likely impact on the CPI was about 2%. The small impact of past diesel price increases can also be confirmed by examination of the quarterly averages and by examining the 1997 price increase as well.

A4.32 As shown in Figure A4.10, in the case of the first diesel price increase in mid-October 1997, the quarterly inflation rate immediately preceding the diesel price increase showed an increasing trend, from -0.5% in the first quarter of 1997 to 2.6% in the fourth quarter. In the fourth quarter, i.e. immediately following the price increase in mid-October, it increased to 4.2%, but then dropped to 2.5% and 0.15% by mid-1998. It would be hard to argue that the increase in the third quarter of 1998, to 9.3%, was connected to the diesel price increase of the previous year. In short, the only discernable evidence of the 70% increase in diesel price in 1997 is an increase in the fourth quarter rate that is 1.6% higher than the quarterly rate immediately preceding and immediately following.

Figure A4.10: Quarterly Inflation Rates (CPI) v. Diesel Price



A4.33 In the case of the diesel price increase in the third quarter of 2001, the inflation rate does indeed increase sharply in this quarter with an 11.6% rise.[6] But in the two previous years when there was no diesel price increase, the third quarter inflation rates were 9.3% and 9.1%. Note that in the subsequent quarters, the inflation rates drops to 5.4% and -3.9% in the first quarter of 2002 – a clear indication of seasonal variation and that increased food prices attributed to "diesel price increases" are computed away over time.

A4.34 An examination of the detailed monthly increases in the major components of the CPI also shows little evidence of dramatic effects (Table A4.13). August shows a sharp increase of 3.5% for transport (but which only has a weight of 4.25% in the CPI). September shows sharp increases in food and qat prices, but these, as noted above, occur almost every year due to normal seasonal fluctuations.

[6] The Cabinet Decree increasing diesel prices was passed on July 26th, 2001. Tariffs for electricity, water and telephone were also increased on August 1, 2001, together with domestic air fares (5%) and international air fares (15%).

Table A4.13: Monthly Inflation Rates in 2001

	Weight in CPI	*Jan01*	*Feb*	*Mar*	*April*	*May*	*June*	*July*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*
All items	**10000.0**	**0.5%**	**-0.7%**	**1.8%**	**1.2%**	**0.0%**	**1.2%**	**0.8%**	**2.4%**	**8.1%**	**1.0%**	**2.7%**	**1.7%**
Food and non-alcoholic beverages	4381.2	1.7%	-0.3%	2.9%	1.8%	-0.3%	1.8%	-0.2%	1.2%	**8.3%**	1.3%	4.1%	-4.0%
Tobacco, cigarettes and Qat	1484.5	-3.3%	-4.9%	2.3%	2.1%	0.0%	1.2%	1.6%	4.3%	**25.7%**	2.2%	4.0%	19.8%
Clothing and footwear	871.5	-0.4%	0.8%	0.1%	-0.5%	0.6%	0.6%	1.5%	1.8%	2.8%	0.3%	0.8%	0.5%
Housing and related items	1327.2	2.1%	0.5%	0.1%	-0.2%	0.1%	0.0%	2.3%	5.6%	0.1%	-0.0%	0.0%	-0.1%
Household furnishings and appliances	405.1	-0.8%	0.0%	0.6%	0.5%	0.9%	0.5%	0.7%	1.2%	0.7%	0.4%	0.6%	-0.1%
Health	267.3	-1.6%	0.9%	2.9%	0.4%	-0.1%	2.5%	3.0%	3.2%	1.8%	-0.2%	0.2%	0.3%
Transport	425.6	0.5%	0.0%	0.1%	0.7%	0.0%	0.2%	0.1%	**3.5%**	1.1%	-0.0%	0.0%	-0.0%
Communications	18.9	-1.0%	0.2%	0.8%	0.1%	1.4%	0.0%	0.0%	3.5%	1.3%	1.3%	0.0%	-0.3%
Recreation and culture	84.1	0.1%	0.0%	0.0%	-0.2%	0.4%	0.1%	1.3%	1.1%	1.3%	0.1%	0.0%	-0.1%
Education	52.1	1.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.0%	24.2%	0.0%	0.0%	0.0%
Restaurants & Hotels	283.3	4.0%	-1.0%	0.5%	1.0%	0.9%	2.8%	1.9%	0.0%	-0.2%	-0.8%	1.5%	-0.4%
Misc. goods and services	399.3	-0.1%	0.5%	0.2%	0.8%	0.9%	0.2%	0.5%	0.2%	2.9%	-0.1%	0.1%	0.0%

Annex 5

Impact of Diesel Subsidies on Water, Qat and Food Prices

Water

A5.1 Only 32% of the population has access to drinking water from a public supply system and therefore large sections of the population are dependent upon purchased water, which in turn is dependent upon diesel both for groundwater extraction and for bulk transportation. The impact on purchased water prices will therefore be one of the critical issues in the political economy of reducing subsidies.

A5.2 The 2003 HES included a question on water purchases. As shown in Table A5.1, households (that buy water) spend 5% of their expenditure on water. 89% of urban households, and 53% of rural households purchase water: particularly in rural areas, the proportion of households that purchase water rises sharply with income.

A5.3 In some areas, mosques play an important role in distributing water to the poorest households free of charge. The study team visited a mosque in Sana'a in a poor area (of the old city), where children came with wheelbarrows and were filling 5, 10 and 20 liter plastic containers with water. The mosque purchases water from a water seller enabled by contributions made by the better-off adherents, a practice said to be widespread and in accordance with the *zakat* traditions of Islam.

A5.4 Elimination of the diesel subsidy will result in the cost of wholesale (bulk) water increasing by 10-15%. But demand for *bulk* water is likely to be elastic: it is relatively easy to use 10-15% less for washing, bathing, etc. if one wants to adjust to higher prices by reducing consumption. The survey shows the *average* urban purchased water bill is 3,000 YR/HH/month and thus the average household will face an increase of 300-450 YR/month.

A5.5 However, much of the bulk water supply is consumed by the non-poor: for example, the top urban income decile spends 6,750 YR/month on purchased water. But if these groups adjust to higher prices by conservation, that can only be to the good of Yemen.

Table A5.1: Expenditure on Purchased Water

Income per decile (YR/month)		***%HH reporting use***			***Expenditure, [YR/month]***			***purchased water as % of total HH***		
		Urban	Rural	All	Urban	Rural	All	Urban	Rural	All
1	0-9000	73%	29%	33%	621	215	253	6%	3%	3%
2	9001-12000	79%	39%	45%	976	293	405	5%	2%	3%
3	12001-15000	81%	36%	42%	1119	514	602	6%	3%	3%
4	15001-19800	82%	43%	51%	1613	420	663	5%	2%	3%
5	19801-22500	90%	58%	64%	2016	829	1059	8%	4%	5%
6	22501-27000	94%	62%	70%	1871	984	1209	7%	4%	4%
7	27001-33000	95%	58%	69%	2445	1359	1673	8%	4%	5%
8	33001-42700	86%	60%	68%	3242	1586	2064	10%	5%	6%
9	42701-61000	94%	74%	80%	4418	2317	2996	9%	5%	6%
10	61001>0	96%	85%	89%	6747	4608	5316	7%	5%	6%
	average	89%	53%	61%	3002	1208	1616	8%	4%	5%

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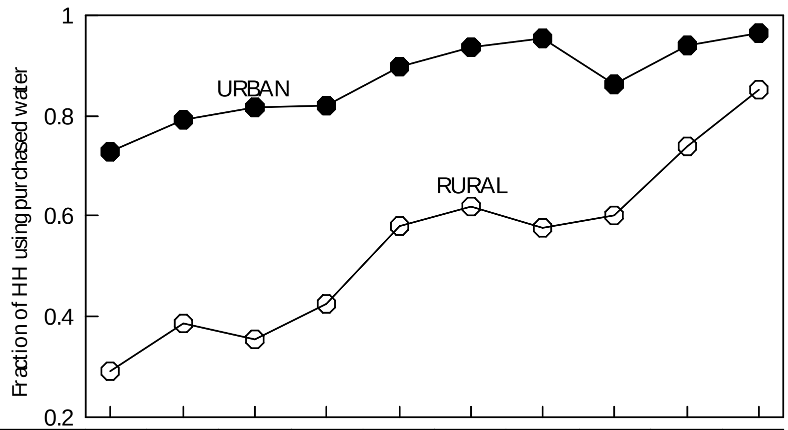

	d[1]	d[2]	d[3]	d[4]	d[5]	d[6]	d[7]	d[8]	d[9]	d[10]
URBAN	73%	79%	81%	82%	90%	94%	95%	86%	94%	96%
RURAL	29%	39%	36%	43%	58%	62%	58%	60%	74%	85%

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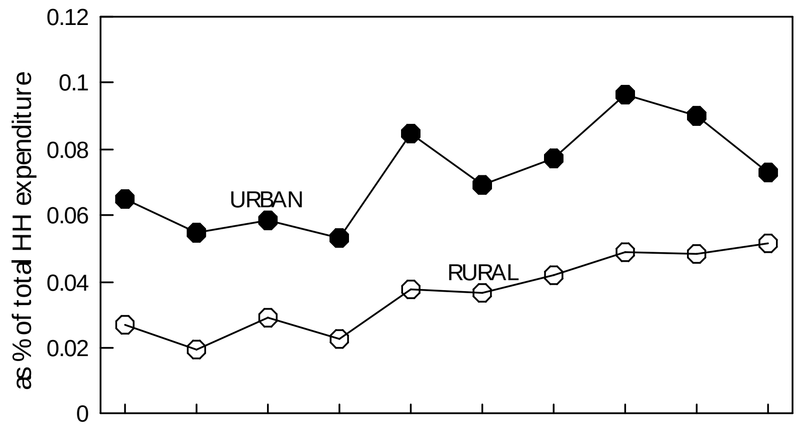

	d[1]	d[2]	d[3]	d[4]	d[5]	d[6]	d[7]	d[8]	d[9]	d[10]
URBAN	6%	5%	6%	5%	8%	7%	8%	10%	9%	7%
RURAL	3%	2%	3%	2%	4%	4%	4%	5%	5%	5%

Box A5.1: Impact on Diesel Price Increases on Water Sellers

In January 2003 the study team visited two private urban water operations in the Haddah area of Sana'a (a wealthy suburb). One was pumping water from a 170-meter depth, the other from a 200-meter depth and selling water to water sellers who came to the pumping stations with bowsers. The table below shows a calculation of the probable impact of a diesel price increase (from the present price to the 2003 economic price of 37 YR/liter) on the selling price. While the information collected relied on the operators' statements and could not be verified, the indicated calculations provide an order of magnitude estimate of the probable price impact.

			Water wholesaler A (30HP pump)	***Water wholesaler #2 (40 HP pump)***
	Water wholesaler (& storage)			
1	wholesale water price	[YR/tanker]	200	200
2	total daily revenue	[YR/day]	20,000	14,000
3	tankers/day	[#]	100	70
4	capacity	[m3]	3.5	4
5	total quantity of water	[liters/day]	350,000	280,000
6	diesel consumption	[liters/day]	120	140
7	diesel cost	[YR/liter]	17.5	17.5
8		[YR/day]	2100	2450
9	wholesale water price	[YR/liter]	0.057	0.050
10	of which diesel	[YR/liter water]	0.006	0.009
11		[%]	11%	18%
12	incremental diesel cost	[YR/liter]	20.3	20.3
13		[YR/liter water]	0.007	0.010
14	increase in wholesale price	[%]	**12%**	**20%**
	Water seller			
15	transportation distance	[km]	3	3
16		[km/liter]	3	3
17	diesel use per round trip	[liters]	2.0	2.0
18		[YR/trip]	35.0	35.0
19	seller's price of water	[YR/tanker]	600	600
20		[YR/trip]	5.8%	5.8%
21				
22	seller's incremental diesel price	[YR/liter]	20.3	20.3
23		[YR/trip]	40.6	40.6
24	increase in wholesale price	[YR/trip]	24.4	40.6
25	total increase	[YR/trip]	65.0	81.2
26		[ ]	10.8%	13.5%

The calculation suggests a price increase of 10-15%, depending on assumptions. It may be noted that this modality of private water supply is quite inefficient.

Box A5.2: Impact on Water Prices

A significant portion of urban water supply is in the form of bulk deliveries supplied by small bowsers. These fill up from groundwater pumping stations. Water is also widely sold in 10-liter plastic containers at most neighborhood food shops: this water is ozone-treated, and suitable for drinking purposes. The sample calculations presented here are based on information obtained from a sample of such operations visited in 2003.

WHOLESALE WATER (Water Pumping)
Assumptions:

- Water pumping business serving 100 tankers/day, each @ 3.5m^3
- Present wholesale water price: 200 YR/tanker
- Diesel consumption: 120 liters @ 17.5 YR/liter
- Present diesel cost: 2,100 YR/day
- Total sales revenue: 20,000 YR/day

Then if diesel price increases by 20 YR/liter

- Diesel cost increases by 2,400 YR
- Water cost increases by 12%
- Cost per 3.5m^3 tanker increases from 200 YR to 224 YR = 24 YR

URBAN BULK WATER DELIVERY
Assumptions:

- Delivery distance: 3km;
- Diesel fuel consumption: 3km/liter; 2 liters/round trip @ 17.5 YR/liter
- Diesel cost: 35 YR/trip
- Selling price of water: 600 YR/tanker (3.5m^2)
- Delivered cost per liter: 0.2 YR per liter!

If diesel price increases by 20 YR/liter

- Wholesale water cost increases by YR24
- Diesel fuel cost increases by 20 YR x 2 liters = YR40
- Total cost increase 24 + 40 = YR64
- Delivered cost increases from YR600-664

DRINKING WATER: (10-liter container in food shop)
Assumptions

- Present shop price 40 YR for 10 liters = 4 YR/liter (plus a refundable YR200 for the container)

If diesel price goes up by 20 YR/liter

- Water *extraction* cost increases by YR24 for 3500 liters, and the water *delivery* cost increases by YR40 per 3 km per 3,500 liters;
- Hence for, say, 15 km distance, delivery cost increases by YR200 for 3,500 liters
- Total cost increase for 3,500 liters = YR224 (=0.064 YR/liter)
- Cost increase for a 10-liter container = 0.64 YR/bottle.

A5.6 On the other hand, *drinking* water demand is *inelastic* and a basic human need. 79% of poor urban households buy water, spending 900 YR/month on water. If diesel increases 20 YR/liter, their water costs will increase by 10-15% (assuming they access a bulk water supply), or 90-140 YR/month. This increase represents about 1% of their total household expenditure. Similarly, 35% of poor rural households buy water, spending 330 YR/month. If diesel increases by 20 YR/liter, their water costs will increase by 10-15%, or 33-66 YR/month. This increase represents 0.5% of their household expenditure.

A5.7 Thus the impact of diesel price increases on (purchased) drinking water is small (Box A5.2). The most significant impact is on the urban poor, because a much smaller proportion of the rural poor purchase water. However, even for the urban poor, the impact is only about 1% of their monthly income.

Box A5.3: Cost of Water Pumping

The cost of water pumping can be derived from the basic equation for the power, in ***kW***, required to lift a given flow, namely

$$kW = \frac{9.81Qh}{1000 e_{pump} e_{motor}}$$

where Q = pumping rate in liters/second
h = hydraulic head, in meters
e_{pump} = efficiency of the pump
e_{motor} = efficiency of the motor

Given that 1 kWh is equivalent to 0.35 liters of diesel, then the daily diesel requirement, ***d***, follows as

$$d = 0.35\ kW\ ophours$$

Where ***ophours*** is the number of hours the pump is in operation per day.

This may be applied to the data for the first water seller reported in Box A5.1. For the data given, for and for the stated amount of water per day, the hydraulic head calculates to 200 meters if the pump and motor efficiencies are taken at 75%.

Number of tankers served per day		[ ]	100
Tanker size		cu meters	3.5
Water pumped		cubic m/day	350
		liters/day	350000
Operating hours		hours/day	15
Flow		liters/sec	6
Head		meters	200
Pump efficiency	[ ]	effpump	0.75
Power unit efficiency	[ ]	effpower	0.75
Gross capacity	kW	capacity	23
	HP		30
	kWh	kWh/day	339
Diesel	0.35 liters/kWh	liters/day	119
		liters/cuMetre	0.34

Thus for 1 cubic meter to be brought from 200-meter depth requires 0.34 liters of diesel fuel – a value that is used below for the calculation of the diesel input into a sample of water-intensive fruit and vegetables (Box A5.4).

Box A5.4: Assumptions and Calculations of Qat Price Increases

Qat Production Costs

Production costs per ha of Qat under well irrigation

- Water requirement 700-1400mm/year = 10,000cubic meters/ha
- Assume entire water requirement from groundwater (not trucked)
- diesel requirement 8,000 liters/year
- diesel cost/ha = 8,000 @ 17 YR/liter = 136,000 YR/year (=9.5% of revenue)
- Output/ha: 7,200 bundles [1200 trees/ha; 2 harvest/year; 3 bundles/tree/harvest: 1 bundle=0.5kg]
- Revenue @ 200 YR/bundle (ex-farm price, lower quality) = YR1,440,000

If diesel price increases by 20 YR/liter

- Increased diesel cost = 160,000 Year for 7,200 bundles= 22 YR/bundle

Qat Production Using Trucked Water

Assumptions

- 10% of water requirement (i.e. 1000m^3)brought by truck
- Higher quality Qat, ex-farm price 300 YR/bundle
- Water brought by truck over a 20km distance
- Fuel consumption 3km/liter = 13 liters/trip
- 1400 m^3 requires 400 truck loads, hence 400x13=5,200 liters of diesel

If diesel price increases by 20 YR/liter

- Diesel cost for transportation increases by 20 x 5,200 = YR104,000
- Cost increase per bundle = 104,000/7,200 = 14 YR/bundle =5% of 300 YR ex-farm price

Qat: Sana'a Price

Assumptions for transportation

- Qat transported 40km by diesel vehicle at 5km/liter = 16 liters (very conservative, average distances much lower)
- Present diesel cost per round trip @ 17 YR/liter = YR272
- Assume 500 bundles per trip
- Retail price 500 YR/bundle (lower quality)
- Total market value per trip YR500 x 500 = YR250,000

If diesel price increases by 20 YR/liter

- Transportation cost increases by YR320 for total trip, or about 1 YR/bundle
- Farm price increases by YR22
- Hence total price increase 1 + 22 = YR23

Food

A5.8 A detailed assessment of the impact of diesel subsidy removal requires an input-output model, which is not available for Yemen. The best that can be done is to estimate the increase in diesel price required for water pumping,[7] and express this as a

[7] The water inputs required per ha were taken from the 1993 Agriculture Sector Study, which contains detailed calculations of production costs for a selection of water intensive crops. While the prices for the non-diesel inputs (labour, pesticides, fertiliser, seeds, land preparation, etc.) have obviously changed significantly since the early 1990s in response to general inflation, the estimates of water requirement itself per ton (or planted area) of crop would have changed much less (and would be limited to the response to changes in the *relative* prices of the inputs).

fraction of the retail price. Even this calculation is subject to uncertainty, given lack of information about groundwater depths. Here we assume a conservative depth of 200 meters: if the actual depth is only 100m, the impact is halved. Moreover, this calculation does not include the additional impact of the transportation of crops from the farm to the consumer: however, based on the analysis of Qat transport, in the previous section, the diesel input in production far exceeds the diesel input in transportation (per unit of retail market value), and therefore the additional price increase attributable to transportation would be a few percent at most. In addition the calculation does not take into account second round effects.

A5.9 The calculations are shown in Table A5.2. The increase as a fraction of the retail price lies between 6% (for tomato) and 13% (for coffee). These are significant increases, and therefore require that the diesel price be increased over a period of a few years, rather than in a single step to allow households and farmers reasonable time to adjust.

Table A5.2: Impact of Diesel Price Increases on Water Intensive Fruit and Vegetables

		Tomatoes	*Potato*	*Grapes*	*Coffee*
Water requirement	m3 per ha	7,600	11,000	22,000	16,600
Yield	tons/ha	14	12.0	15	0.8
Retail price	YR/kg	60	70	126	1050
Retail yield	YR/ha	840,122	839,978	1,889,983	840,005
Diesel requirement	liters/m3	0.34	0.34	0.34	0.34
	liters/ha	2,584	3,740	7,480	5,644
Diesel cost increase	YR/liter	20	20	20	20
	YR/ha	51,680	74,800	149,600	112,880
Retail price impact	[ ]	6.2%	8.9%	7.9%	13.4%
	YR/kg	3.7	6.2	10.0	141.1

Sources:
Sana'a retail prices: Central Bank Annual Report 2003
Water requirements and yields: World Bank, Republic of Yemen, Agriculture Sector Study, Annex 1I, comparative economic analysis for crops.

A5.10 Despite the large uncertainties in this calculation, the impact must necessary be bounded by what is known about the overall level of diesel use in the economy. If the total national expenditure on food is YR600 billion (the survey indicates YR417 billion, which may be understated by about one third, hence YR600 billion may be a better estimate of actual 2003 expenditure) and the total use of diesel in agriculture is, say, 1,000 million liters (total household diesel consumption is 486 million liters, plus an equal amount, say, by commercial farming enterprises not captured in the survey), then a YR20 increase in diesel price increase on the 1,000 million liters represents YR20 billion, equivalent to an increase in retail prices of just 3.3%. Fruit and vegetables are the most water (and hence diesel) intensive of all crops, so one would expect these to be more sensitive to diesel prices than *all* food (that includes a significant amount of imports whose production cost is not affected by Yemen diesel prices, and whose sole diesel input is for transportation.

Annex 6

LPG

Consumption Patterns

A6.1 Over the past decade there has occurred a dramatic transformation of household energy use for cooking, with a major shift from fuel wood to LPG: in the Northern governorates, for which we have data from the 1989 HES, LPG consumption has increased from 87,000 tons in 1988 to over 500,000 tons by 2003.[8] This strategy of encouraging household use of LPG was adopted by Yemen on the basis of several considerations, including concerns over deforestation, the heavy time burden on rural women and children for fuelwood collection, the health impacts of using fuelwood for cooking, and the strong preference expressed by all income groups for LPG as the most desired fuel for cooking.

A6.2 LPG consumption from Marib has risen dramatically during the 1990s (Table A6.1) increasing from some 7,433 tons in 1990 to 624,813 tons in 2003.[9]

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[8] The previous Yemen HES covered only the Northern governorates of the former YAR, and therefore comparisons of aggregate amounts require caution. World Bank/ESMAP, *Republic of Yemen, Household Energy Strategy Study, Phase I: A Preliminary Study of Northern governorates,* Washington DC, March 1991.

[9] This historical presentation of LPG use by YGC may be a clue to the reconciliation problems discussed in Annex 10: the HH survey shows greater consumption of LPG than is reported sold by YGC. According to the above table, in 1990 LPG sales were 7,433 tons; yet the 1991 HES (for the Northern Governorates of the former YAR) states LPG consumption at 87,000 tons!

Table A6.1: LPG Salient Statistics

Year	Consumption	Annual growth Rate	Bottling Plants	Annual tons/ bottling station	Primary transport fleet
	[tons/year]	[%]	[#]	[tons]	#trucks
1990	7,433		7	1,062	5
1991	51,771	597%	8	6,471	17
1992	89,200	72%	10	8,920	56
1993	107,067	20%	16	6,692	96
1994	232,815	117%	17	13,695	113
1995	261,106	12%	21	12,434	121
1996	279,790	7%	27	10,363	141
1997	324,011	16%	29	11,173	194
1998	348,856	8%	36	9,690	215
1999	412,894	18%	48	8,602	276
2000	462,783	12%	60	7,713	339
2001	505,823		65		399
2002	587,994		68		418
2003	624,813		71		420

Source: YGC

A6.3 The bulk of LPG use is for domestic cooking, but there are few data on the extent of other uses. Some LPG is delivered to larger establishments (for hotels, or heating chicken broiler houses) in bulk form, and some LPG filling stations offer larger cylinders (also used in restaurants). Over the past year, a significant number of restaurants have converted from cylinders to bulk supply replenished by small road tankers.

A6.4 The largest non-domestic use is likely to be for road transport, as there is high incentive to convert gasoline cars to LPG given the difference in price. LPG consumption of the transport sector is estimated at 10% of the total.[10] This is driven entirely by the present retail price differential between gasoline (35 YR/liter) and LPG (10.25 YR/liter). However, there is no reliable information on the number of conversions that have actually occurred, and the ability to infer LPG consumption from lower than expected growth in gasoline demand is beset with a number of practical difficulties.

A6.5 Based on discussions with officials of the YGC, the composition of LPG consumption for 2003 can be taken as 87% household, 8% transport, and 5% for agriculture, hospitals, restaurants & hotels, government, and military. However, the transport share is increasing, and for 2004 may be taken as 10% of the total. An estimate of 2003 consumption is as shown in Table A6.2.

[10] According to YGC, most car filling stations are owned by owners of LPG bottling stations.

Table A6.2: 2003 LPG Consumption

		1000 tons
Marib		625
Aden refinery		6
Total sales	100%	631
Consumption		
Domestic	88%	555
Transport	7%	44
other	5%	32

A6.6 Table A6.3 shows the cost of energy expressed in terms of cost per unit of calorific value. At present retail prices, LPG is by far the cheapest form of energy in Yemen, to which consumers respond by inventive new applications for LPG: at current retail prices, LPG has a 61% cost advantage per MJ over gasoline (and hence the incentive for conversion of gasoline powered automobiles) and a 13% advantage over diesel.

Table A6.3: Cost per Unit of Energy

		LPG	*Gasoline*	*Kerosene*	*Diesel*	*Fueloil*
cost per liter	[YR/liter]	10.2	35.0	16.0	17.0	31.0
net calorific value	[MJ/liter]	24.5	32.4	34.4	35.4	38.9
cost per MJ	[YR/MJ]	0.42	1.08	0.47	0.48	0.80
advantage of LPG	[YR/MJ]		0.66	0.05	0.06	0.38
	[%]		61%	10%	13%	48%

A6.7 For example, it is reported that farmers are running irrigation pumps with a mix of 30% LPG and 70% diesel. Increasing amounts are used for powering fridges (reflected in the household survey: 0.6% of households use LPG for this purpose). Small gasoline engines (e.g. that power pumps on water bowsers) are being converted to LPG. LPG is also being used for space heating.

The LPG Supply Chain

A6.8 LPG is produced by separating it from the gas produced in association with the crude oil at Marib. The gas treatment plant has a capacity of 2,200 tonnes of LPG per day and presently produces 1,860 tonnes per day. The gas treatment plant is owned by the Government, and operated as part of the Yemen-Hunt oil complex at Marib. The storage capacity is 500 tonnes.

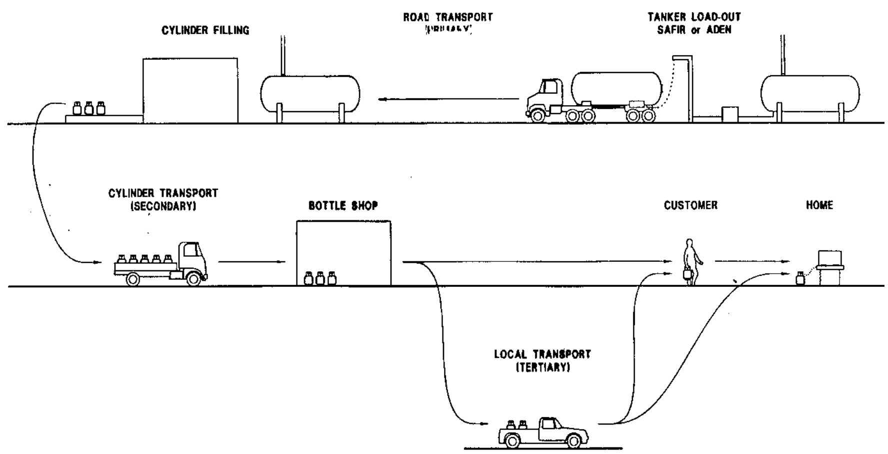
A6.9 The Aden refinery also produces LPG.[11] In 2002 it produced 95,145 tons, of which 90,713 tons were exported, and the balance of 4,432 tons was sold to the domestic market.[12] In 2003, the contribution from the Aden refinery increased slightly to 6,315 tons. The storage capacity at Aden refinery is 50 tons, which is currently under expansion to 100 tons. However, while LPG delivered to YGC at Marib is at no cost to YGC, the cost of LPG sold to YGC by the Aden refinery is still under negotiation (the refinery is requesting payment at the border price).

A6.10 YGC owns and operates the bulk storage and tanker loading facility at Safir. There are presently 420 heavy tankers averaging 23 tons of LPG, and the tanker loading facility has a capacity of 85 tanker-trucks per day. The present rate of loading

[11] LPG is *not* produced at the Marib *refinery* (but only from the Marib gas processing plant).
[12] Oil, Gas and Mineral Statistics, Annual Bulletin 2002, Issue#2.

is 72 trucks/day. The tanker-trucks are privately owned (except for a few tanker-trailers owned by YGC which are leased to private operators).

Figure A6.1: The LPG Supply Chain



A6.11 LPG is delivered to 71 filling stations (of which 64 are privately owned, 7 owned by YGC). The typical filling station has 50 tons of storage, but presently operates at only 40% capacity: as evident from Table A6.1, average throughput has declined from some 13,500 tons/year in 1994 to only 7,700 tons/year in 2000. This follows from the sharp increase in the number of filling stations built by the private sector in response to the prospects for a rapidly growing business and guaranteed returns.

A6.12 YGC is responsible for maintenance of cylinders, for which it receives a margin of 3 YR/cylinder (see Table A6.11). Filling stations are responsible for the return of damaged bottles to YGC, who repair or replace them, as necessary.

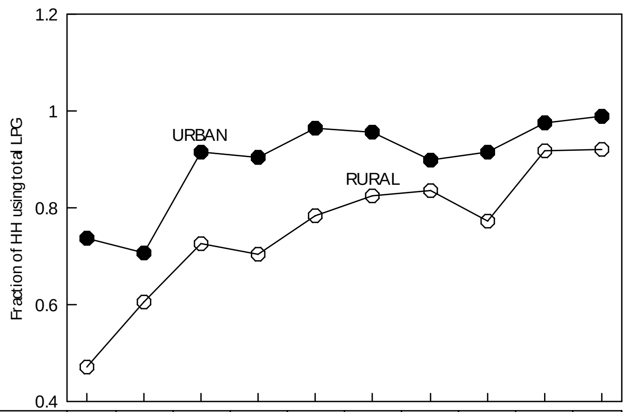
A6.13 Table A6.4 shows LPG use by income decile, which ranges from 50% in the poorest decile, to 94% in the top decile (or 78% of all households).

Table A6.4: LPG use by Income Decile

Income per decile (YR /month)	*%HH reporting use*			*Consumption [Kg/month]*			*Consumption [1000 tons/year]*		
	Urban	Rural	All	Urban	Rural	All	Urban	Rural	All
1 0-9000	74%	47%	50%	21	20	20	4	24	28
2 9001-12000	71%	60%	62%	24	22	22	7	31	39
3 12001-15000	91%	73%	75%	23	22	22	9	41	51
4 15001-19800	90%	70%	74%	21	23	22	9	28	37
5 19801-22500	96%	78%	82%	23	24	24	12	43	55
6 22501-27000	96%	82%	86%	23	24	24	15	41	56
7 27001-33000	90%	83%	85%	24	30	28	17	48	65
8 33001-42700	91%	77%	81%	24	27	26	18	41	58
9 42701-61000	97%	92%	94%	24	32	29	20	54	75
10 61001>0	99%	92%	94%	31	38	36	27	63	91
average	92%	74%	78%	25	26	26	139	415	555

A6.14 Across all income deciles urban access is greater then rural access (Figure A6.2).

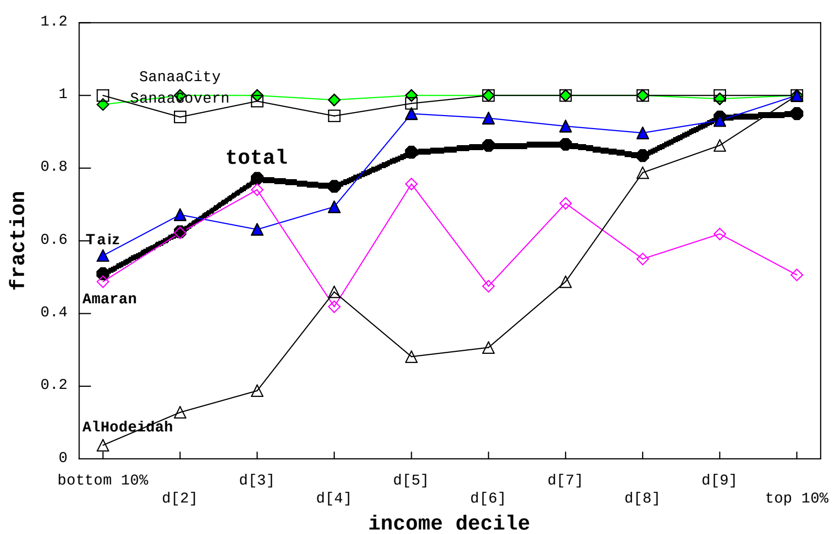
Figure A6.2: Urban v. Rural Access to LPG



	d[1]	d[2]	d[3]	d[4]	d[5]	d[6]	d[7]	d[8]	d[9]	d[10]
● URBAN	74%	71%	91%	90%	96%	96%	90%	91%	97%	99%
⊖ RURAL	47%	60%	73%	70%	78%	82%	83%	77%	92%	92%

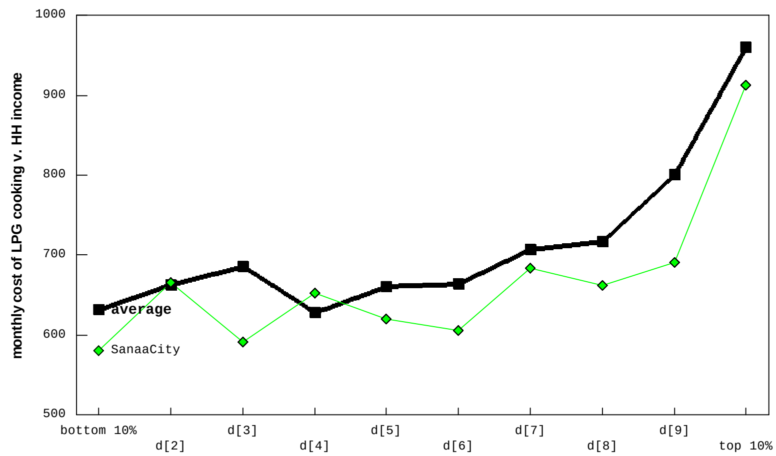
A6.15 In the major urban areas (such as Sana'a and Aden), LPG is used by more than 97% of households even in the poorest income groups (Figure A6.3). Most Governorates exhibit the expected increase in LPG use with income: on average just 50% of households in the poorest income decile use LPG, rising to close to 100% in the top decile. Al Hodeiah has the greatest variation across income deciles, with only 4% of the lowest income decile using LPG.

Figure A6.3: LPG Penetration by Income Decile



A6.16 The corresponding LPG expenditure increases gradually with income, reaching around 700 YR/month in the 8th decile. This then rises sharply in the 9th and 10th income deciles, reaching an average of 961 YR/month in the top decile (Figure A6.4).

Figure A6.4: LPG Expenditure by Income Decile



A6.17 The bulk of LPG is used for cooking, with smaller quantities used for lighting and for fridges (in non-electrified areas). Use of LPG for fridges is concentrated in the three richest deciles. Usage in all but the two lowest deciles is relatively constant, but falls sharply for both lighting and cooking in the two bottom deciles – where the cost of LPG (as well as the initial cylinder cost and LPG device costs) appear to be relatively unaffordable.

Table A6.5: Usage of LPG, as % of Households

	Lighting	*Cooking*	*Fridge*	*Any LPG use*
1 0-9000	13.7%	49.4%	0.0%	50.8%
2 9001-12000	18.8%	62.1%	0.0%	63.3%
3 12001-15000	32.4%	75.7%	0.1%	77.1%
4 15001-19800	30.5%	73.6%	0.2%	75.0%
5 19801-22500	33.3%	82.3%	1.5%	84.9%
6 22501-27000	34.0%	85.7%	0.9%	86.5%
7 27001-33000	35.7%	85.9%	0.5%	86.4%
8 33001-42700	37.2%	82.5%	1.3%	83.7%
9 42701-61000	34.8%	93.9%	0.8%	94.1%
10 61001>0	41.0%	93.4%	1.8%	95.0%
average	31.0%	78.3%	0.7%	79.5%

A6.18 Table A6.6 shows consumption per month in households using LPG for the use in question. There is little difference between urban and rural consumption (in households that use LPG): top decile rural users in fact consume slightly more than their urban counterparts: but on average, urban and rural users consume about the same (30 kg/month, or about 5.5 bottles per month).

Table A6.6: LPG End-uses

	Cooking & Baking		*Lighting*		*Fridge*	
	[kg/month]	*[% of HH]*	*[kg/month]*	*[% of HH]*	*[kg/month]*	*[% of HH]*
Bottom Decile	24	[49%]	9	[13%]		[0%]
ALL income	30	[78%]	9	[30%]	24	[1%]
Top decile	42	[93%]	10	[41%]	21	[2%]
URBAN						
Bottom Decile	26	[73%]	6	[8%]		[0%]
ALL income	30	[92%]	7	[16%]	36	[0%]
Top decile	38	[100%]	7	[19%]	34	[2%]
RURAL						
Bottom Decile	23	[47%]	9	[14%]		[0%]
ALL income	30	[74%]	9	[35%]	22	[1%]
Top decile	44	[90%]	11	[52%]	12	[1%]

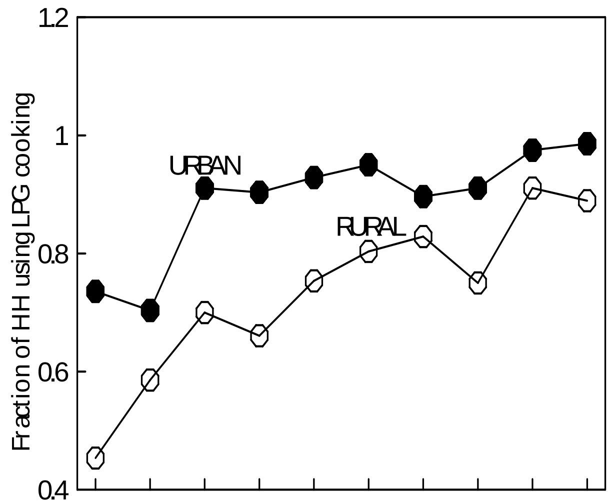
A6.19 However, the big difference between urban and rural values is in penetration rates: only 47% of the poorest decile use LPG for cooking in rural areas, as compared to 73% in urban areas.

A6.20 Tables A6.7 and A6.8 show the details of consumption and expenditure for LPG for the two major uses, cooking (and baking), and lighting. The following may be noted:

- the unit cost of LPG for lighting is substantially higher than for cooking (by over 50%, at 48 YR/kg v. 25 YR/kg), because it is sold in small, non-standard bottles. Households therefore pay very high costs per lumen (discussed further in Annex 8 where the willingness to pay for electricity access is examined).
- even for LPG sold in standard containers, the reported average price is 25 YR/kg. The official price is 18.63 YR/kg (205 YR per 11kg cylinder). The distribution of these markups is discussed below.
- the per household consumption of LPG, between 2 and 3 11kg cylinders/month per household, is high compared to other countries.

Table A6.7: LPG for Cooking

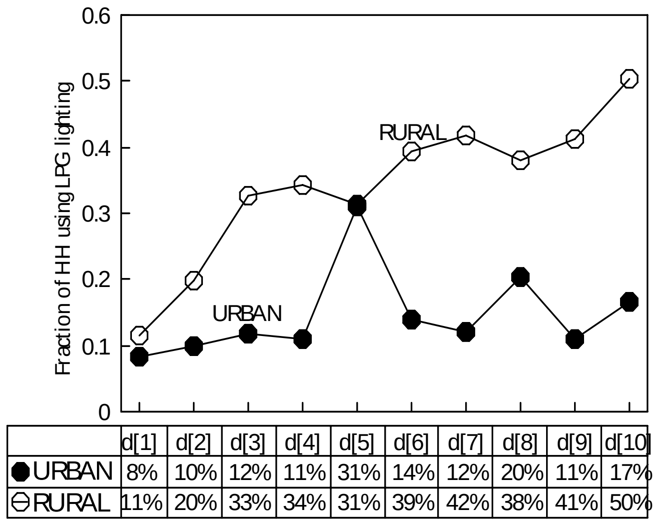
Income per decile (YR/month)		%HH reporting use			Consumption,[Kg/month]			Expenditure, [YR/month]			Reported price,[YR/kg]		
		Urban	Rural	All	Urban	Rural	All	Urban	Rural	All	Urban	Rural	All
1	0-9000	74%	45%	48%	20	18	18	607	630	626	253	293	287
2	9001-12000	70%	59%	60%	23	20	20	684	715	709	267	305	298
3	12001-15000	91%	70%	73%	23	20	20	708	688	692	265	293	288
4	15001-19800	90%	66%	71%	20	20	20	621	722	696	260	309	296
5	19801-22500	93%	75%	79%	22	22	22	645	734	714	253	295	285
6	22501-27000	95%	81%	84%	22	22	22	682	750	731	265	298	288
7	27001-33000	90%	83%	85%	24	26	25	691	886	827	257	281	274
8	33001-42700	91%	75%	80%	24	23	23	673	746	722	246	282	270
9	42701-61000	97%	91%	93%	23	28	27	672	902	824	253	268	263
10	61001>0	99%	89%	92%	29	35	33	853	1077	998	249	268	261
	average	91%	72%	76%	24	24	24	699	792	767	256	288	279



	d[1]	d[2]	d[3]	d[4]	d[5]	d[6]	d[7]	d[8]	d[9]	d[10]
URBAN	74%	70%	91%	90%	93%	95%	90%	91%	97%	99%
RURAL	45%	59%	70%	66%	75%	81%	83%	75%	91%	89%

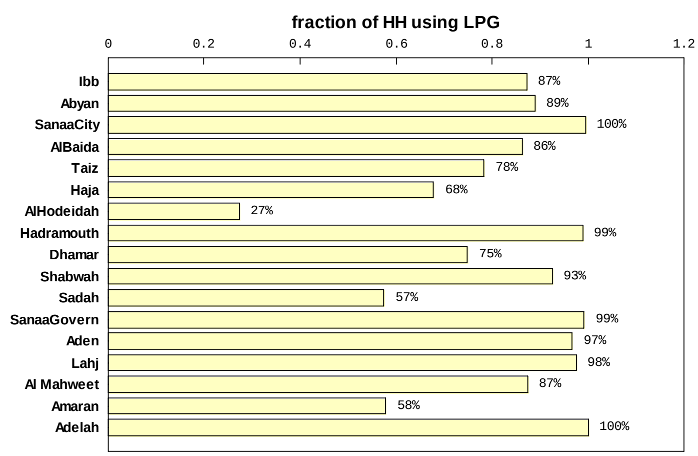
Table A6.8: LPG for Lighting

Income per decile (YR/month)		%HH reporting use			Consumption,[Kg/month]			Expenditure, [YR/month]			Reported price,[YR/2kg cyl		
		Urban	Rural	All	Urban	Rural	All	Urban	Rural	All	Urban	Rural	All
1	0-9000	8%	11%	11%	5	7	7	203	288	282	70	89	88
2	9001-12000	10%	20%	18%	7	7	7	317	316	316	104	96	96
3	12001-15000	12%	33%	30%	3	7	7	184	316	309	109	90	91
4	15001-19800	11%	34%	30%	5	7	7	305	375	369	95	107	106
5	19801-22500	31%	31%	31%	6	8	7	261	329	316	89	89	89
6	22501-27000	14%	39%	33%	5	6	6	345	309	313	110	101	102
7	27001-33000	12%	42%	33%	4	7	7	173	388	366	91	101	100
8	33001-42700	20%	38%	33%	5	7	7	219	347	324	90	101	99
9	42701-61000	11%	41%	32%	6	8	8	259	338	329	96	99	99
10	61001>0	17%	50%	39%	6	8	8	256	368	353	95	94	94
	average	15%	33%	29%	5	7	7	252	342	331	95	97	97



A6.21 Figure A6.5 shows the use of LPG by Governorate. Al Hodeida has by far the lowest LPG penetration, with only 27% of households reporting LPG use: Sa'adah and Al-Amran also have significantly low LPG penetration rates.

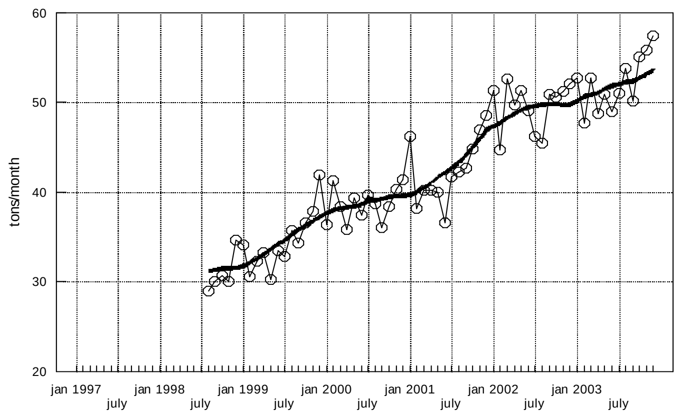
Figure A6.5: Percentage of Households in Each Governorate Reporting LPG Use



A6.22 The demand for LPG shows a distinct winter peak (Figure A6.6), which in recent years has also coincided with Ramadan: many families report usage of an extra cylinder during Ramadan.[13]

Figure A6.6: Monthly LPG Demand

1.1.22



Reconciliation with Supply Side Data

A6.23 The raw data of the 2003 HES suggest annual LPG consumption of 711,000 tons /year, which is considerably higher than that reported by YGC (555,000 tons/year). When one also takes into account that there is likely to have been significant LPG consumption not covered by the survey (LPG for transportation, LPG use in commercial and industrial establishments, and smuggling), and that the YGC figure is likely to be fairly accurate, this discrepancy needs explanation.

A6.24 The survey estimate is based on the following assumptions:

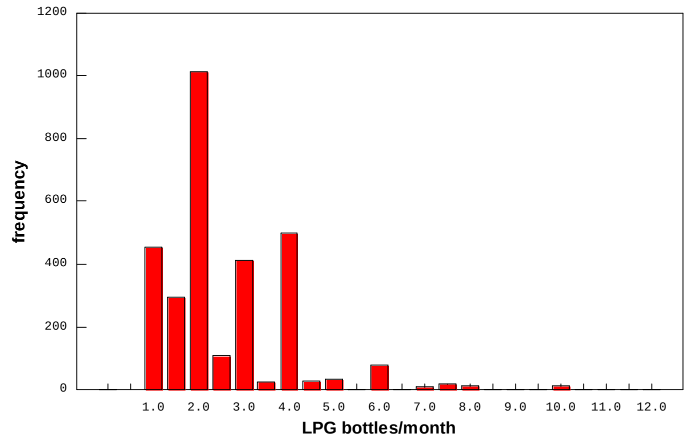
- that each recharge of the standard cylinder contains 11kg of LPG.
- that bottles are empty when refilled.
- that the number of cylinders used on average each month would be answered reasonably well.
- However, there are doubts regarding each of these assumptions:
- There is much anecdotal evidence about short-filling of bottles.
- YGC data suggest that "empty" bottles may contain as much as 0.5kg of LPG when returned for refilling.

[13] This may have had some impact on the survey, which was conducted in the month following Ramadan. Although households were requested to report the number of cylinders bought "on average" each month, recent purchases would inevitably influence their responses. Indeed, the raw data implies a much higher rate of consumption than that inferred from YGC data on actual deliveries to LPG bottling plants. Moreover, a YGC survey of 2002 showed that the average bottle contained 0.5kg of LPG when it was returned for refilling, so that the assumption that each cylinder represented 11kg of consumption leads to a 4.5% overestimate in total LPG consumed by the household sector.

- The answer to the question on average number of cylinders was inevitably influenced by the higher consumption during Ramadan, which immediately preceded the survey[14]

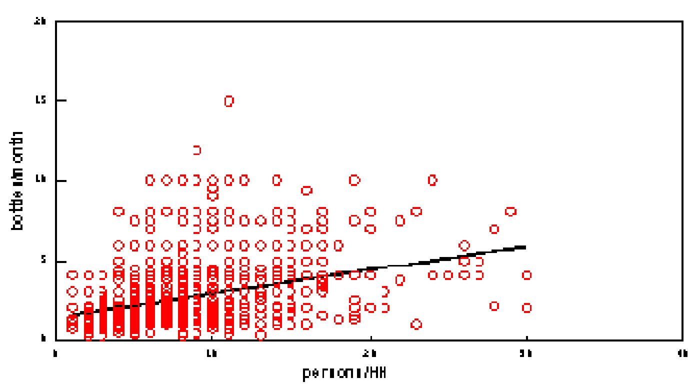
A6.25 The distribution of reported number of LPG bottles used per month is shown in Figure A6.7. The most frequently reported number was two per month.

Figure A6.7: Distribution of Reported Cylinders/month



A6.26 One might suppose that the number of bottles used per month increases with household size, but one would also expect substantial scale economies. That is indeed the case, as shown in Figure A6.8.

Figure A6.8: Bottles per Month v. Household Size



The least squares regression relationship is

$$[\text{LPG bottles/month}] = 1.41 + 0.15\ [\text{persons/HH}];\ R^2=.14$$

[14] The companion question #112 (B3_2 "how many days does one cylinder of LPG last"), which would serve as an independent consistency check, is unhelpful, since the replies are generally consistent (with an implied number of days per month that ranges from 28 to 31.5!) It is not clear (from the data itself) which of the two questions was actually used, and which inferred.

A6.27 Addition of household income (or income decile variable) is not statistically significant. For a family of four this equation yields two bottles per month, which seems reasonable.

A6.28 The data show high variability. For example, as shown in Table A6.9, for a family of four the lowest reported number of bottles per month was 0.5, the highest number eight. The low value is plausible, implying that LPG is used sparingly: According to the PRA, a typical cylinder should suffice for 30 meals in an average (rural) family. However, the highest reported value seems doubtful: a family of four that reports eight bottles a month would need to cook 240 meals, a very unlikely number, unless the individual cooked for others or had a cottage industry.

Table A6.9: Range of Reported Number of Bottles

Persons/HH	*Number of HH*	*Average*	*Lowest*	*Highest*
1	16	1.7	0.8	4.0
2	97	1.6	0.3	4.0
3	153	1.8	0.3	4.0
4	280	2.0	0.5	8.0
5	355	2.1	0.4	7.5
6	406	2.3	0.5	10.0
7	402	2.5	1.0	10.0
8	342	2.6	0.3	10.0
9	278	2.8	0.4	12.0
10	203	3.0	0.7	10.0
11	147	3.0	0.4	15.0
12	106	3.1	1.0	10.0
13	72	3.2	0.3	7.5
14	53	3.6	1.0	10.0
15	41	3.5	1.0	8.0
16	27	3.6	1.0	9.3
17	27	4.5	1.5	8.0
18	4	3.8	1.3	6.0
19	10	4.6	1.3	10.0
20	8	4.7	2.0	8.0
21	4	2.7	2.0	3.0
22	3	5.6	3.8	7.5
23	3	4.5	1.0	8.0
24	3	7.0	4.0	10.0
25	2	4.0	4.0	4.0
26	4	5.0	4.0	6.0
27	4	4.7	4.0	5.0
28	4	5.4	2.1	7.0
29	2	8.0	8.0	8.0
30	3	3.0	2.0	4.0

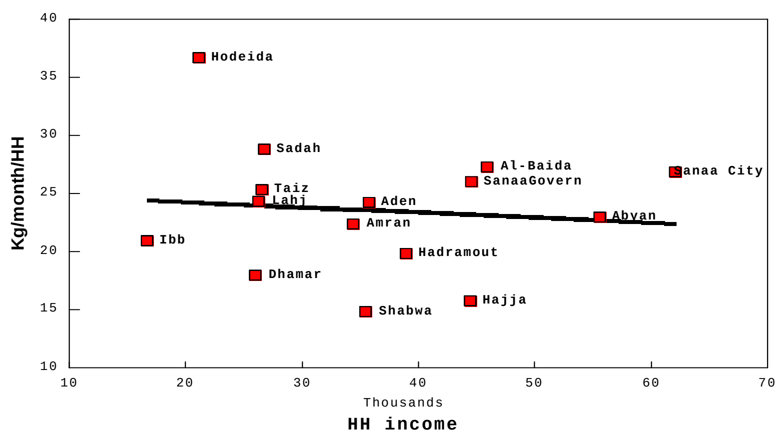
A6.29 Table A6.10 shows LPG sales by governorate as per YGC data. Using the LPG household penetration data, we can calculate from this data the average kg/HH, assuming all LPG is sold to households. The expectation would then be that in provinces where one expects large industrial & commercial use, or diversion to transport, the apparent household consumption average would be high.

Table A6.10: Reconciliation of LPG Use (from YGC Data)

	Population ('000)	*HH (' 000)*	*LPG Use*	*HH using LPG ('000)*	*Ton LPG*	*KG/HH*	*Kg/month*	*Household Income*
Source>	*YGC*	*YGC*	*2003 HES*		*YGC*			*2003 HES*
	[1]	[2]	[3]	[4]=[2]*[3]	[5]	[6]=[5]/4	[7]=[6]/12	[8]
Sana'a Govern	2468	329	99%	326	101980	313	26.0	44523
Sana'a City	617	82	100%	82	26493	322	26.8	62101
Aden	537	72	97%	70	20218	291	24.2	35762
Taiz	2442	326	79%	257	78300	304	25.4	26523
Hodeida	2071	276	29%	81	35726	441	36.7	21104
Lahj	686	91	97%	89	25882	292	24.3	26294
Ibb	2143	286	90%	258	64667	251	20.9	16650
Abyan	447	60	89%	53	14621	276	23.0	55583
Dhamar	1275	170	77%	131	28168	215	18.0	26019
Shabwa	484	65	96%	62	11021	177	14.8	35486
Hajja	1451	193	73%	142	26803	189	15.7	44417
Al-Baida	599	80	86%	69	22604	328	27.3	45933
Hadramout	920	123	99%	121	28872	238	19.8	38889
Sa'adah	635	85	63%	53	18522	346	28.9	26721
Amran	1027	137	59%	81	21624	268	22.3	34429
Meheit	479	64			8580			
Mahara	75	10			2827			
Marib	702	94			6261			
Dhalee	428	57			16177			
total	19486	2598	0.79	24630	559346	273	22.7	32158

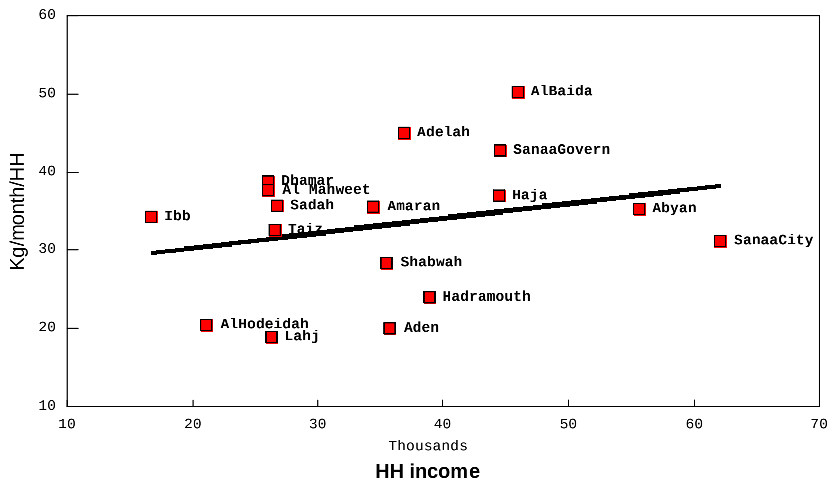
A6.30 When this is plotted against average household income in the various Governorates, the results shown in Figure A6.9 are obtained – with the remarkable result that consumption appears to decline with household income – and that Al Hodeida has by far the highest consumption per household.

Figure A6.9: Apparent 2002 LPG Consumption per Household v. Household Income



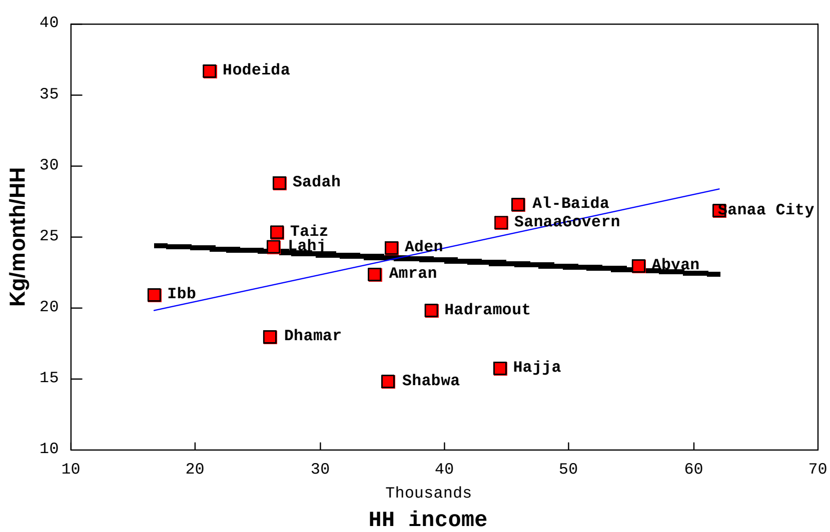
A6.31 However, from the 2003 HES it is known that LPG consumption should *increase* with rising income, as shown in Figure 6.10 – from which we see that LPG consumption in Al Hodeida is only 20 kg/month (per household using LPG) – rather than the 35 kg/HH that can be inferred from the YGC data.

Figure A6.10: LPG Consumption/Household v. Household Income as per 2003 HES



A6.32 In Figure A6.11 the trend-line from the 2003 household survey data is superimposed onto the YGC data for 2002 (though displaced downward to reflect the lower overall 2002 consumption).

Figure A6.11: Expected Household LPG Consumption



A6.33 Four Governorates are seen to lie significantly above the expected trend line: Hodeida, Sa'adah, Taiz and Lahj. Of these, three are coastal provinces from which one might expect some degree of smuggling across the Red Sea (though the LPG filling stations are located far from the coast in Taiz and Lahj, and in these two governorates one might infer a more significant commercial LPG use in the larger cities. However, in the case of Hodeida, the level of LPG cannot reasonably be explained by household consumption, and for which, therefore, smuggling seems the most likely explanation.

The Retail Price of LPG

A6.34 The retail LPG price at the bottling shops in the main urban centers is regulated by the government, and presently stands at YR205 per standard cylinder containing 11kg of LPG.[15] The price structure is shown in Table A6.11.

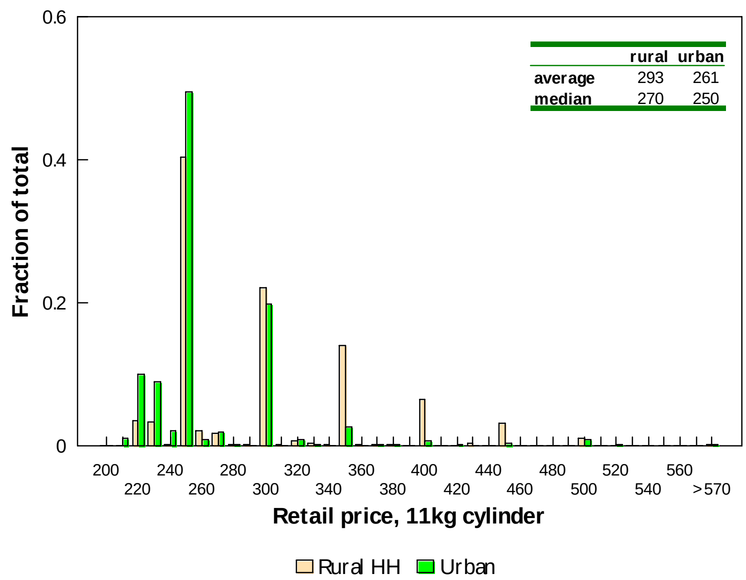
Table A6.11: LPG Price Structure

	YR/11kg cylinder
Input price	0
Primary transportation	41.5
YGC costs	6.0
Depreciation	3.0
Filling station investment return	25.0
Taxes &Royalties	
Central Government	99.0
Local taxes	1.5
Local authority	5.0
Ex-filling station	**181.0**
Bottle shop expenses+ secondary transportation	24.0
Ex-bottle shop	**205.0**

A6.35 The survey shows that the most common price actually paid by the consumer for an 11kg cylinder is YR250, with YR300 and YR350 being other common prices (Figure A6.12). As expected, there are significant differences between rural and urban prices: the overwhelming majority of bottles priced more than YR350 are in rural areas. The price differential reflects tertiary distribution costs (see Figure A6.1). YGC is responsible for monitoring and enforcement of the official price at the bottle shop, which it does by random inspections throughout the country.

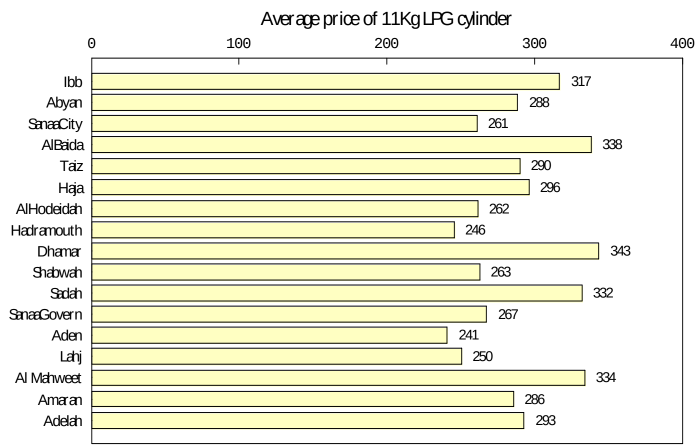
[15] Some sources report the official LPG price per cylinder of 12.5Kg as YR220/cylinder. There are some 7 million LPG cylinders in circulation, made in five different countries as well as in two plants in Yemen (one in Sana'a and one in Aden). Because these have different tare weights (ranging from 14.8 to 15.2 kg) , YGC enforcement of the 11 kg LPG refill is based on an average 15kg tare weight. Although the Ministry of Industry and Trade officially controls prices and weights, enforcement is provided by YGC which conducts random sampling at filling stations to enforce weights, and has introduced coloured caps so that cylinders can be traced to specific filling stations.

Figure A6.12: Distribution of Reported Consumer LPG Prices



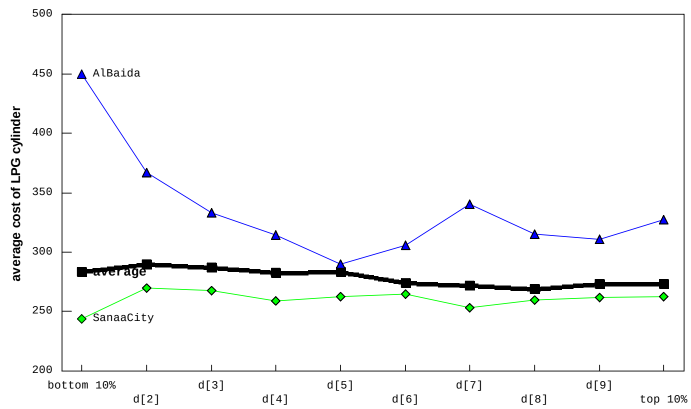
A6.36 Figure A6.13 shows the reported average consumer purchase price of LPG by Governorate.

Figure A6.13: Average Price of 11kg LPG Cylinder, by Governorate



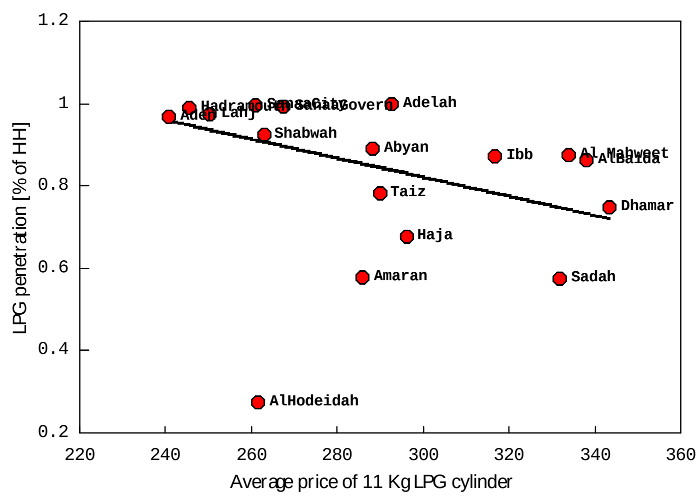
A6.37 With the one exception of Al Baida, the price varies little with income decile (Figure A6.14).

Figure A6.14: Cost of LPG Cylinder as a Function of Income Decile and Location



A6.38 There is however some evidence that price variations affect LPG penetration, as shown in Figure A6.15: higher prices result in lower penetration rates. The simple linear least squares fit has a statistically significant R^2 of 33% (if one excludes Al Hodeida as an outlier).[16]

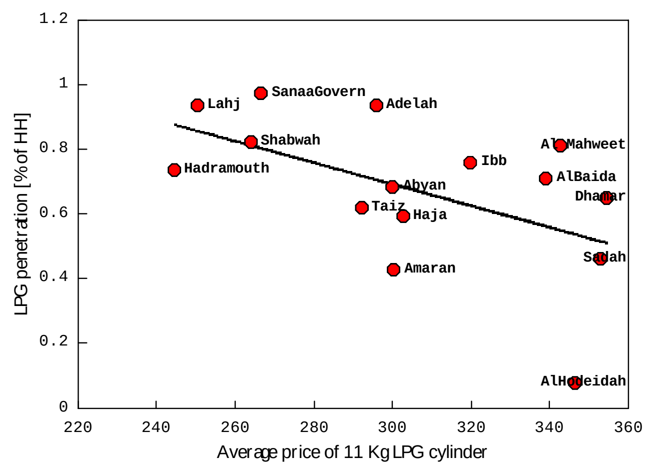
Figure A6.15: LPG Penetration v. Average Price



A6.39 Figure A6.16 shows the same plot for rural households only: the relationship between price and uptake is much stronger. Al Hodeida has an extremely low LPG penetration rate in rural areas of only 8%, by far the lowest in any Governorate.

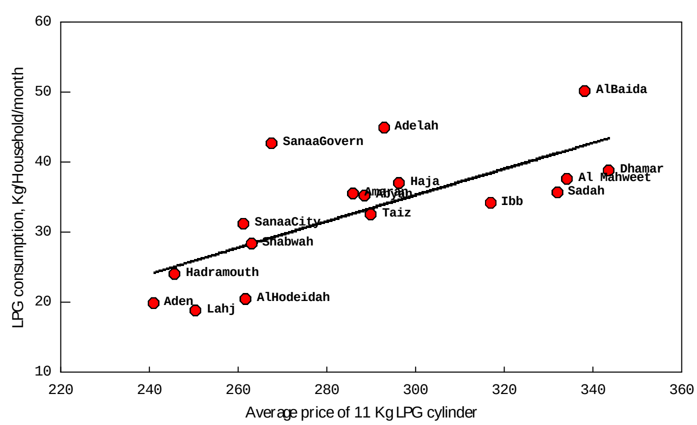
[16] The low rate of LPG consumption in Hodeida has been known to YGC for some time. YGC has been trying to overcome local resistance to the use of LPG in the rural areas of this Governorate, which is apparently grounded in fears about safety.

Figure A6.16: LPG Penetration v. Average Price, Rural Households



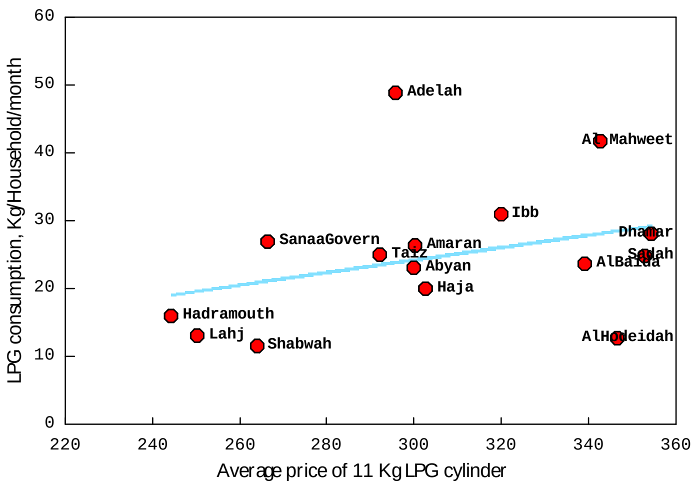
A6.40 However, consumption per household and price are *not* related as one might expect: households consume *more* LPG in Governorates with higher LPG prices, not less, as one might expect (Figure A6.17).

Figure A6.17: LPG Use per Household v. Average LPG Price (all Households and all Income Deciles)



A6.41 Moreover, this is true even when one corrects for income decile and urban/rural location: Figure A6.18 shows the relationship for the bottom quintile of rural households. While the correlation is weak for this income quintile, for *all* rural users (and particularly the high income users), the relationship is statistically significant.

Figure A6.18: LPG Use v. Price, Rural Households, Bottom Income Quintile



LPG Subsidies

A6.42 As noted in the introduction, LPG is the most highly subsidized of all petroleum products: in 2003, the domestic price was only 23% of the import parity price. The LPG subsidy is not included in many of the estimates of petroleum product subsidies (such as that compiled by YPC). Experience in other countries suggests that at the present level of subsidy, conversion of vehicles from gasoline to LPG will accelerate. Attempts to price domestic size bottles at a lower price than at filling stations will unlikely succeed, as again experience elsewhere shows that this simply leads to illicit conversion of vehicles to use domestic bottles.

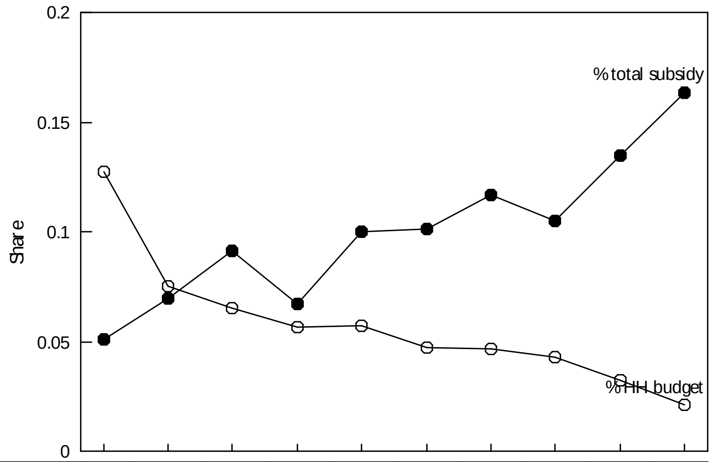
A6.43 Table A6.12 and Figure A6.19 show LPG subsidies by income decile. The top decile captures over three times the subsidy of the bottom decile (16% v. 4%).[17]

Table A6.12: Subsidies by Income Decile

		Subsidy		*For HH reporting use:*		
	consumption	total	captured by each decile	subsidy	total expenditure	subsidy
	[1000 tons/year]	[10^6 YR]	[%]	[YR/month]	[YR/month]	[% of total expenditure]
1 0-9000	28	1123	5%	1080	8481	12.7%
2 9001-12000	39	1537	7%	1209	16021	7.5%
3 12001-15000	51	2006	9%	1206	18389	6.6%
4 15001-19800	37	1474	7%	1213	21365	5.7%
5 19801-22500	55	2203	10%	1318	22990	5.7%
6 22501-27000	56	2227	10%	1309	27591	4.7%
7 27001-33000	65	2578	12%	1529	32867	4.7%
8 33001-42700	58	2315	11%	1422	33326	4.3%
9 42701-61000	75	2965	13%	1607	49248	3.3%
10 61001>0	91	3602	16%	1950	91469	2.1%
Total	555	22029	100%	1415	31997	4.4%

[17] Note that the subsidy shown here of YR30.3 billion relates only to the 88% of total LPG consumption by households, and is therefore correspondingly smaller than the total LPG subsidy shown in Table 5.9, Volume 1.

Figure A6.19: Fraction of Total LPG Subsidy to Households, Captured by Each Income Decile



	d[1]	d[2]	d[3]	d[4]	d[5]	d[6]	d[7]	d[8]	d[9]	d[10]
● % total subsidy	5%	7%	9%	7%	10%	10%	12%	11%	13%	16%
⊖ % HH budget	12.7%	7.5%	6.6%	5.7%	5.7%	4.7%	4.7%	4.3%	3.3%	2.1%

Policy Option: Reduce the Subsidy on LPG

A6.44 Table A6.13 shows the direct effect of raising the LPG price to 60%, 80% and 100% of the economic price. Raising the LPG to the economic price would have significant effects on the poor: the cost of living in the poorest decile would increase 6.5% – as opposed to only 2.0% for the top decile.

Table A6.13: Effect of LPG Price Increases (on Households)

Price level	***[% of economic price]***		***25%***	***60%***	***80%***	***100%***	***Average effect on decile***
Price increase	[YR/liter]		0.0	25.3	40.0	54.6	
Economic price	[YR/liter]		73.26	73.26	73.26	73.26	
Retail price	[YR/liter]		18.6	44.0	58.6	73.3	
Subsidy	[YR/liter]		54.6	29.3	14.7	0.0	
Consumption							
Price elasticity	-0.2						
Consumption	[1000 tons]		555	467	441	422	
Impact on Government							
Subsidy	[YR billion]		30.3	13.7	6.5	0.0	
Net gain to government	[YR billion]			16.6	23.8	30.3	
Impact on households using LPG							
		%HH affected					
Poorest decile	[% of total present HH expenditure]	49.5%	0.0%	6.1%	9.7%	13.2%	6.5%
Middle decile	[% of total present HH expenditure]	83.8%	0.0%	2.5%	3.9%	5.4%	4.5%
Richest decile	[% of total present HH expenditure]	94.2%	0.0%	1.0%	1.6%	2.2%	2.0%

Indirect Effects

A6.45 The indirect uses of LPG are difficult to estimate, as are the related indirect effects of any price increases. Some LPG is used in transportation, replacing gasoline: if LPG prices were to increase, the incentive to convert vehicles would diminish (and in any event this would be to the disbenefit only of the top income deciles who can afford gasoline cars, removing their incentive to convert). As noted, some LPG is used in restaurants and bakeries: again the amounts are unknown, but it would be reasonable to assume that if prices at restaurants were to increase, it is the top income deciles who would be affected.

A6.46 Smuggling of LPG is not likely to occur on a large scale. The need for pressurized cylinders makes smuggling much more difficult than for diesel. An official at YGC believed that no more than 2,000 tons/years were diverted in this way in 2003. In any event, whatever the quantity smuggled, raising the LPG price can only reduce whatever incentives presently exist for smuggling. In short, the *indirect* impacts of LPG price increases are unlikely to constitute a policy constraint for reducing LPG subsidies.

Mitigating the Effect on the Poor

A6.47 Reducing the LPG subsidy would bring a significant revenue gain to the Government, revenue that can be used in whole or in part to mitigate the effects on the poor. One possibility would be to pay every household a flat sum, including the mainly poor households that presently do not use LPG. This has the virtue of simplicity, because it does not require means testing, or who does and does not use LPG. By definition, a flat payment covers a larger share of the cost increase experienced by a poor household than by a large household, and therefore has the desired income redistribution effects. Moreover, for those (poor) households that do not presently use LPG, the flat sum would make a significant contribution to the up-front costs of buying the LPG stove and the first cylinder.

A6.48 The most important feature of the flat sum payment is that the LPG user still experiences a cost increase on fuel purchases, which will motivate more efficient use of LPG for cooking. And therein lies the main gain to the Yemen economy, namely a more efficient use of resources.

A6.49 Table A6.14 illustrates the calculations:

- At 60% of the economic price, LPG would experience an 88% cost increase (over the present level), which accounts for 6.4% of household income of the lowest decile, and 0.7% of the highest decile. Hence the need for returning some of the Government’s additional revenue.
- In row [10] an assumption is made about the own-price elasticity of LPG demand – while there are no studies for Yemen, -0.3 would be a representative value based on experience in other countries.

- With this elasticity, the total quantity consumed decreases from 711,000 to 588,000 tons/year, and the effective cost to Government reduces from YR28.1 billion to YR13.7 billion, a saving of YR14.4 billion, of which it is assumed 65% is returned.
- This results in a flat payment to all households of 4,180 YR /year.

A6.50 For the lowest income decile, this YR4,180 payment [row 16] offsets the additional bill of YR4,965 [row 4], for a net increase of YR785 per year – which represents a tolerable 1% of total household expenditure, as opposed to 6.4% without mitigation. For the highest decile, the YR4,180 payment accounts for a much lower proportion of the increase (because this decile uses much more LPG) – but the net impact of mitigation is much smaller (decreasing from 0.7 to 0.4% of total household expenditure). (Figure A6.20)

Figure A6.20: Net Effect of the Mitigation Scheme

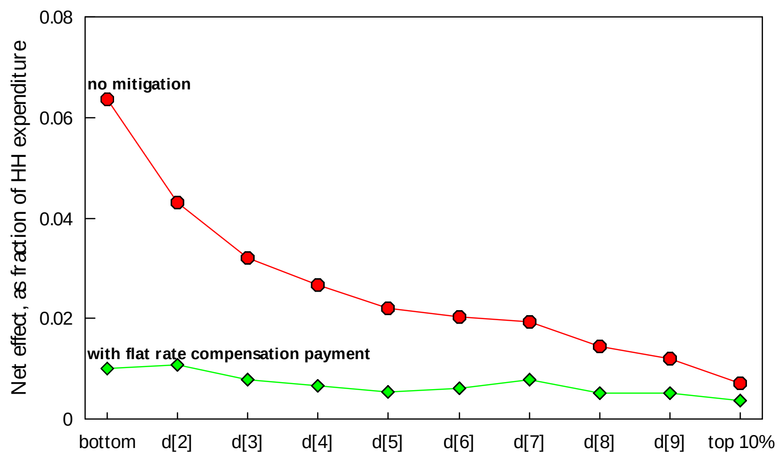


Table A6.14: Impacts of an LPG Price Increase to 60% of the Economic Price

		Monthly income YR/month	*0 -9000*	*9,001 - 12,000*	*12,001 - 15,000*	*15,001 - 19,800*	*19,801 - 22,500*	*22,501 - 27,000*	*27,001 - 33,000*	*33,001 - 42,700*	*42,701 - 61,000*	*61,001 >*	*total*
		decile	*bottom*	*d[2]*	*d[3]*	*d[4]*	*d[5]*	*d[6]*	*d[7]*	*d[8]*	*d[9]*	*top 10%*	*per year*
[1]	present LPG use/HH/year	[Kg/YR]	304	340	340	341	336	369	430	400	452	549	
[2]	LPG expenditure /HH/year	YR	5,664	6,345	6,329	6,365	6,271	6,870	8,024	7,462	8,432	10,241	
[3]	total HH income/year	1000 YR	78	129	173	209	250	297	363	455	614	1,263	
[4]	additional expenditure	Per year	4,965	5,562	5,548	5,580	5,498	6,022	7,034	6,541	7,392	8,977	
[5]	as % of present price	[ ]	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	
[6]	as % of HH income	[ ]	6.4%	4.3%	3.2%	2.7%	2.2%	2.0%	1.9%	1.4%	1.2%	0.7%	
[7]	**Mitigation scheme**												
[8]	old LPG annual consumption	[10^6 kg]	36	50	65	48	71	72	83	75	96	116	711
[9]	old subsidy/ year	[YR mill]	1,442	1,966	2,567	1,885	2,819	2,849	3,298	2,962	3,793	4,604	28,185
[10]	assumed price elasticity		-0.3										
[11]	new total LPG consumption/year	[mill Kg]	30	41	54	39	59	59	69	62	79	96	588
[12]	Subsidy at new consumption/year	[YR mill]	702	957	1,250	918	1,372	1,387	1,606	1,442	1,847	2,241	13,721
[13]	Savings to Govt./year	[YR mill]	740	1,009	1,317	968	1,446	1,462	1,693	1,520	1,947	2,363	14,464
[14]	proportion of revenue returned		0.65										
[15]	revenue returned/year	[YR mill]	9401										
[16]	Flat Payment/HH/year	[YR/HH]	4,180	4,180	4,180	4,180	4,180	4,180	4,180	4,180	4,180	4,180	
[17]	net price increase/HH	[per year]	785	1,382	1,368	1,400	1,318	1,842	2,854	2,361	3,212	4,797	
[18]	as % of present price	[ ]	13.9%	21.8%	21.6%	22.0%	21.0%	26.8%	35.6%	31.6%	38.1%	46.8%	
[19]	as % of HH income	[ ]	1.0%	1.1%	0.8%	0.7%	0.5%	0.6%	0.8%	0.5%	0.5%	0.4%	

A6.51 The proportion of revenue returned has been chosen in this example in such a way that the net impact on the lowest decile is no more than about 1% of total expenditure and that there remains a net price increase (needed to motivate more efficient use). However, as shown in row [18], while the poor household sees a net price increase of 13.9% in LPG purchase, the top decile sees a net LPG price increase of 46.8% – in other words, high income LPG users will have a greater incentive to conserve than low income users who use little LPG. That is another desirable attribute of a redistribution scheme.

A6.52 There are undoubtedly some transaction costs to such a scheme, but even if these were to be in the billion YR range, if 65% of the total is returned, there remains a net fiscal gain to the Government (of some YR4 billion).

Policy Option: Subsidize LPG Cylinders

A6.53 The high start-up costs of LPG (for purchase of the initial cylinder and for an LPG stove) are a significant obstacle to higher access rates among the poor: the initial purchase cost of a cylinder is YR2,500-3,000. And even where poor households do have access, LPG is used sparingly (a rural households in the bottom decile using LPG consumes 24kg/month, compared to 42kg/month in the top decile). Indeed, unlike kerosene, which can be bought in very small quantities, LPG must be bought in 11kg increments, which the poor often find difficult.

A6.54 Therefore it has been proposed that the up front costs of moving to LPG be subsidized. However, private distributors already have a strong incentive to provide credit facilities to families in this situation and for very simple straightforward commercial reasons. According to YGC, most bottling operations presently operate far below capacity. Since the price structure reimburses bottlers according to the number of bottles they sell, recovering the up-front investment is largely dependent upon bottle throughput. It is therefore in the interest of the bottlers to move as many households to LPG as possible, so that they provide a steady stream of bottle purchases, and hence cash flow to the bottler. The costs of providing credit facilities evidently offset the increased income from higher bottle throughput.

A6.55 Even if one could make a case for Government to provide a subsidy of this type to poor families, two questions need answers before such a scheme could be made effective:

- How are the poor to be identified?
- Would the recipients in fact use LPG if given a free cylinder and cook stove?

A6.56 The international experience is relevant to Yemen, for such schemes have been tried elsewhere. The Deepam scheme in India (see Box A6.1) had a reasonably effective mechanism for identifying poor households by registered women's self-help schemes. However, in rural areas where free or cheap biomass is available, LPG was used by the recipients only very sparingly. The average cost of a cylinder refill is 270 Rs. for a 14.3kg cylinder (or about YR 845/11kg cylinder). Yet the maximum monthly household incomes of the recipients is 265 Rs. in rural areas, and 457 Rs. urban areas (YR1,060 and YR1,860, respectively). Thus a cylinder refill in rural areas covered by the Deepam scheme amounts to one month's income – clearly a very significant outlay.

A6.57 Private LPG dealers selling to better-off customers report that the average household consumes about half a cylinder per month, or 7kg/HH/month (a rate that is less than half that observed in Yemen). Deepam recipients used only 2.6 kg/month in rural areas, and 4.8 kg/month in urban areas.[18]

[18] Many recipients of the free cylinder sold them (or even used them as part of dowries). A survey showed that the high cost of LPG was the main reason for discontinuing LPG use.

A6.58 It is thus unclear that such schemes are sustainable, even when, as in the case of the Deepam scheme, qualified beneficiaries could be identified with reasonable certainty. Therefore the first task in Yemen, were such a scheme to be considered by Government, would be to develop a mechanism for identifying beneficiaries. In discussions held in September 2004, both Government officials and NGOs expressed skepticism that the SWF could effectively do so in the more remote rural areas where the need is greatest. Box A6.1: The Deepam Scheme in Andhra Pradesh, India

Box A6.1: The Deepam Scheme in Andhra Pradesh, India

The Government of India has attempted to encourage fuel switching from biomass to cleaner commercial fuels by providing large universal price subsidies to kerosene, sold through the Public Distribution System, and LPG sold in 14.2kg cylinders by dealers belonging to state-owned oil companies. A scheme providing price subsidies, however, does not address one of the barriers to household fuel switching to LPG: the high up-front cost associated with the start-up of LPG service. For example, a new LPG user in the state of Andhra Pradesh must (i) pay Indian Rupees (Rs.) 1,000 (about YR4,050) for an “LPG connection” in order to receive an LPG cylinder and (ii) purchase an LPG stove and associated accessories for a further Rs1,000 (YR4,050) or so. The combined cost of LPG connection and stove purchase makes it difficult for many poorer households to start using LPG as a cooking fuel.

In order to help overcome this barrier, the Government of Andhra Pradesh launched the so-called Deepam scheme in July 1999 whereby the connection fee was paid by the Government for below-poverty-line (BPL) households possessing white ration cards. Those who do not possess white ration cards are also eligible provided that their self-help groups pass a resolution attesting to their BPL status. Deepam recipients still had to purchase their own stove, and were only given the LPG cylinder.

The policy objectives of the Deepam scheme include (i) reducing drudgery among women and children from wood collection and cooking; (ii) improving the health of household members by reducing ambient concentrations of smoke and other harmful pollutants; and (iii) protecting forests from further degradation. The scheme was originally designed to cover one million rural and 0.5 million urban households.

Only members of self-help groups satisfying certain criteria may participate in the scheme. There are more than 373,000 self-help groups in Andhra Pradesh with a total of more than five million members. About 150,000 of these self-help groups are in rural areas. As of February 2002, more than 1.5 million LPG connections had been released through the Deepam Scheme, including 1.2 million in rural areas. The majority of recipients were members of groups under the Development of Women and Children in Rural (or Urban) Areas (DWCRA and DWCUA, respectively).

Source: S. Rajakutty and M. Kojima, *Promoting Clean Household Fuels Among the Poor: Evaluation of the Deepam Scheme in Andhra Pradesh.* World Bank, March 2002.

Annex 7

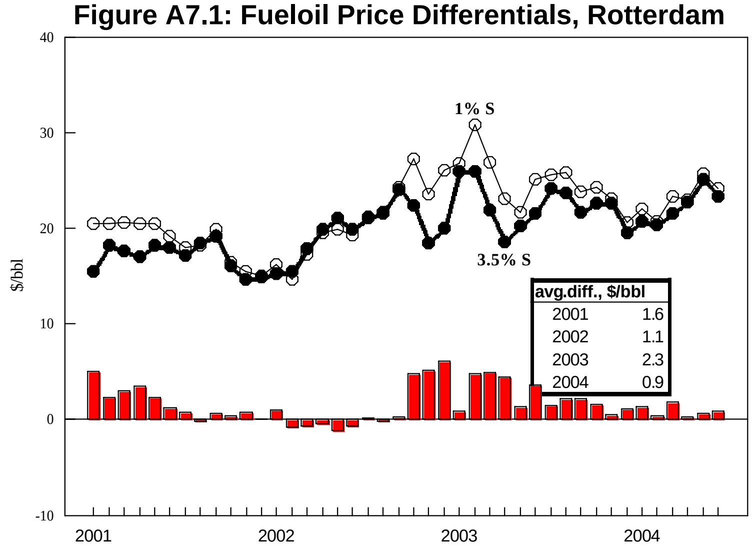
Gasoline and Fueloil

Fueloil

A7.1 Fueloil is not directly used by households. However, it should be included in the comprehensive revision of the system petroleum product pricing, and there are several important features of a pricing system that are well illustrated by fueloil (and that affect the overall household energy bill by virtue of the role of fueloil in electricity generation.

A7.2 The price charged by the refinery to YPC (and its consumers) should bear some relationship to quality. Under the present pricing system, the cost to YPC (and PEC) for heavy fueloil is the same, regardless of sulfur content. However, as shown in Figure A7.1, prices and quality are linked: in Rotterdam, low sulfur fueloil typically trades for 1-2 $/bbl more than high sulfur fueloil (with similar differentials for Italy spot cargoes).

Figure A7.1: Fueloil Price Differentials, Rotterdam



A7.3 PEC in particular has encountered problems with the fueloil that it receives from YPC, since the high sulfur content of some deliveries corrodes equipment. A rational pricing system would price fueloil according to its sulfur content, in accordance with world market differentials.

Box A7.1: Impact on Fisheries

The Implementation Completion Report of the World Bank's 4th Fisheries Development Project includes a detailed analysis of the economics of small-scale fishing operations. The table shows the estimated costs for a six-boat, and a single-boat operation. Small fishing boats are powered by small, gasoline-powered outboard engines, predominantly the 15HP Yamaha engine, for which 1,250 units were imported by the project (of which 815 were in fact sold), in addition to 100 40HP Yamaha engines (all sold), and 350 25HP Selva engines (only seven sold!). At the present retail price of gasoline (35 YR/liter), fuel accounts for 6.9% of the total operating cost (including labor) in the six-boat operation, and 15.8% of the cost of a single-boat operation.
The table also shows the costs if the price of gasoline were increased to the 2003 economic price of 41 YR/liter. Operating costs for the six-boat and single-boat operations increase by 2.4% and 4.0%, respectively.

In YR/year	***Six-boat operation***		***One-boat-operation***	
	at present price	***at 2003 economic price***	***at present price***	***at 2003 economic price***
Gross value of fish landings	16250000	16250000	1848000	1848000
Operating costs				
Cost of fuel, YR/liter	*35*	*41*	*35*	*41*
Cooperative charges (8% of sales)	1300000	1300000	147840	147840
Fuel: 10 gallons/boat/fishing day[100 days/year]	960000	1124571	192000	224914
(as % of total operating costs, including labor)	6.9%	8%	15.8%	18%
Oil: 2 cans@YR200/fishing day	40000	40000	8000	8000
Food: 400 YR/fisherman/day x 36 fishermen	1444000	1444000	64000	64000
Engine spare parts (YR10,000/year/engine x 6)	60000	60000	10000	10000
Net Maintenance	72000	72000	12000	12000
Engine Maintenance	30000	30000	5000	5000
Boat maintenance & replacement	120000	120000	20000	20000
Net replacement (@YR 300,000/year)	300000	300000	50000	50000
Transport of fish (to market)	1625000	1625000	184800	184800
Engine replacement (3year life, YR150,000/engine)	300000	300000	50000	50000
Contingencies, 5% of above	313000	313000	54780	54780
Total operating costs	6564000	6728571	798420	831334
Increase in operating costs		164571		32914
		2.4%		**4.0%**
Gross income (before labor)	9686000	9521428	1049580	1016665
Labor cost	7264512	7264512	418548	418548
Net income	2421488	2256917	631032	598118
Decrease in margin		164571		32914
		7.3%		**5.5%**

Source: World Bank, *Implementation Completion Report: Republic of Yemen Fourth Fisheries Development Project*, Report 20015-YEM, March 6, 2000.

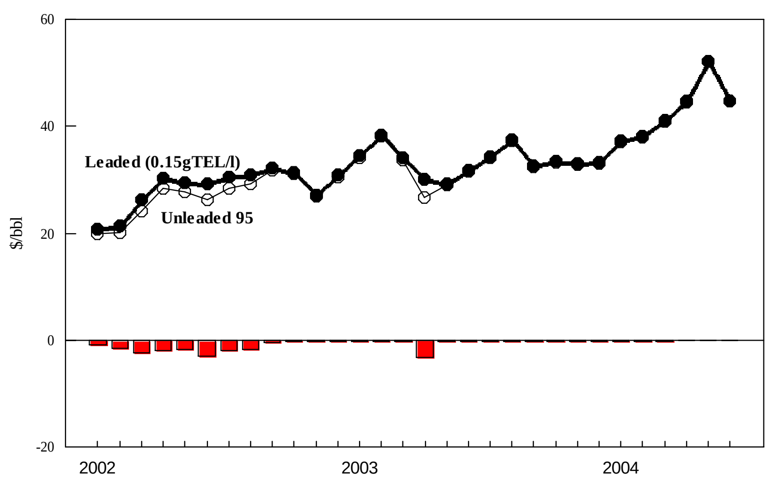
Gasoline

A7.4 Gasoline was also not included in the household survey. But as in the case of fueloil, gasoline should be priced on the same basis as other fuels, and prices adjusted regularly (as discussed in Volume 1).

A7.5 Direct purchases of gasoline do play a role in coastal households dependent on fishing. These households would be (slightly) affected by bringing gasoline to the economic price as well. While it is true that large commercial fishing trawlers may be diesel powered, small-scale fisheries predominantly use gasoline-powered outboard motors. Box A7.1 illustrates the potential impact of a *gasoline* price increase on small-scale fisheries (e.g. cooperatives as may operate small fleets, or single-boat operations). The increase in operating costs were the gasoline price increased by 6 YR/liter (to bring it to the 2003 economic cost) is between 2 and 4%. While this is obviously not trivial, it hardly represents the type of devastating impact on the livelihoods of small fisherman envisaged by popular imagination.

A7.6 As in the case of fueloil, the pricing basis for gasoline should be rational. Notwithstanding that Yemen sells regular leaded gasoline, it is understood that the price basis used by the refinery for sales to YPC is premium unleaded. However, as shown in Figure A7.2, there is little difference between leaded and unleaded gasoline prices in Italy, and in 2003 and 2004 leaded gasoline was slightly *more* expensive than unleaded. This is again a reflection of market conditions in Europe, where there is low demand for *leaded* gasoline. Thus it matter little whether the price basis is a European premium unleaded or leaded; neither is appropriate. Instead, the appropriate pricing basis is Platts *Gulf*.

Figure A7.2: Difference between Leaded and Unleaded Gasoline, Spot Cargoes, Italy



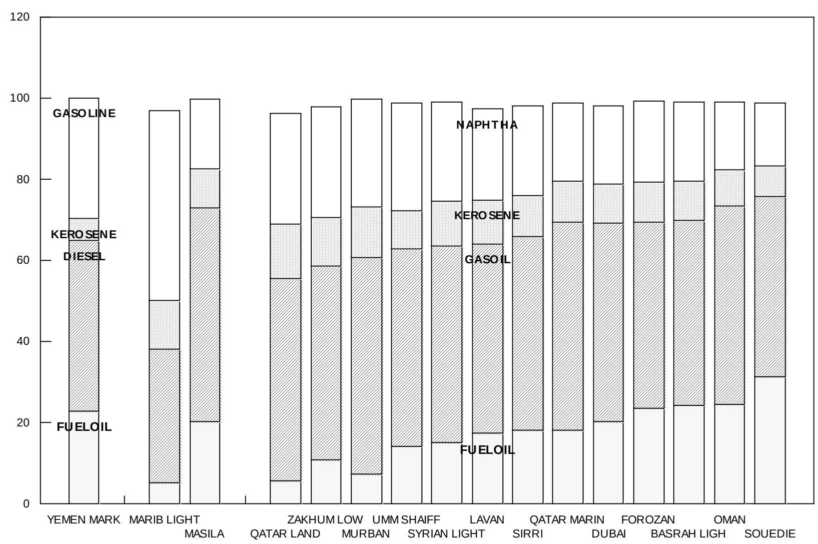
Subsidizing the Refinery

A7.7 The subsidy calculations presented in Volume I suggest that the subsidy as stated in the official Government figures is *over*stated, because it includes subsidies that are in effect provided to the refinery. This is not say that the *entire* amount of the subsidy to the refinery is attributable to uneconomic operations at the refinery *per se* (attributable to negative refining margins that one would normally expect at such an old refinery). Since the refinery accounts were not available this figure cannot be broken down into its actual components. However, three conclusions can be drawn:

- The figure recorded by MoF and MOM as subsidy on petroleum products is significantly overstated if the term subsidy is to be used in its normal meaning: i.e. as the difference that arises between the economic price based on actual border price, and the domestic retail price.

- The corollary is that if domestic prices are raised to the notional economic price as presently defined (i.e. Rotterdam or Italy plus notional freight), then they would be too high: the border price as used in any price formula or price calculations should be based on Gulf prices plus actual freight.
- It is unclear that refining is economic at all. Refining margins at simple hydroskimming refineries are rarely adequate. The rationale for refining Marib crude is unclear, since the domestic product mix is a very poor match to its distillation yields, as shown in Figure A7.3 (resulting in the export of large quantities of naphtha).

Figure A7.3: Crude Yields v. Yemen Domestic Product Market Slate



Annex 8

Electricity

Patterns of Electricity Consumption

Access to Electricity

A8.1 Table A8.1 shows access to electricity by the classification used in the survey. While 91% of urban households report access to electricity (of which 79.3% are served by PEC), only 42% of rural households are electrified, and, of these, only 23% are served by PEC's national grid.

Table A8.1: Electricity Access

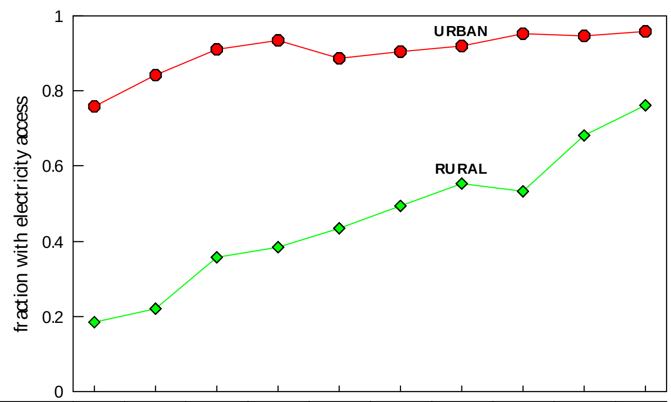
	Urban		*Rural*		*All*	
	[#HH]	*[%]*	*[#HH]*	*[%]*	*[#HH]*	*[%]*
PEC national grid	402,747	79.3%	400,724	23.0%	803,471	35.7%
PEC isolated system	0	0.0%	56,988	3.3%	56,988	2.5%
Cooperative	21,118	4.2%	31,927	1.8%	53,045	2.4%
Private	0	0.0%	2,328	0.1%	2,328	0.1%
Village/community	22,603	4.4%	157,414	9.0%	180,017	8.0%
Relative/neighbor	12,642	2.5%	26,771	1.5%	39,413	1.8%
Family-owned	6,311	1.2%	52,484	3.0%	58,795	2.6%
Other	0	0.0%	6,724	0.4%	6,724	0.3%
Total non-grid	62,674	12.3%	334,636	19.2%	397,310	17.7%
Total with electricity	**465,421**	**91.6%**	**735,359**	**42.2%**	**1,200,781**	**53.4%**
HH with no access	42,665	8.4%	1,005,727	57.8%	1,048,392	46.6%
Total HH	508,086	100.0%	1,741,087	100.0%	2,249,173	100.0%

A8.2 Other notable features of access patterns include:

- widespread interconnection of family-owned systems to neighbors. Of 58,795 family-owned self-generation systems, 67% also serve neighboring households.
- there are very few households served by privately-owned systems; by far the largest number of rural households who do not have grid access are served by village/community-based systems.
- of the total households that do not have access (1,048,392), 96% (1,005,727) are in rural areas. As expected, lack of access to electricity is a *rural* issue.

A8.3 Access to electricity is strongly dependent on income and on the urban/rural divide (Figure A8.1). In the poorest decile, 76% of urban, but only 18.6% of rural households have electricity access. However, in the top decile, the difference between urban and rural is much smaller (95 v. 76%).

Figure A8.1: Access to Electricity by Income Decile



Income decile	1	2	3	4	5	6	7	8	9	10
Urban	75.8%	84.2%	90.9%	93.3%	88.5%	90.4%	92.0%	95.3%	94.7%	95.6%
Rural	18.6%	22.0%	35.8%	38.5%	43.5%	49.5%	55.3%	53.3%	68.1%	76.0%

A8.4 Indeed, access to electricity is strongly correlated to income. Table A8.2 shows monthly household income by type of access. The average monthly income of those with electricity access, some 41,000 YR/month, is almost double that of households without access.

Table A8.2: Electricity Access and Income

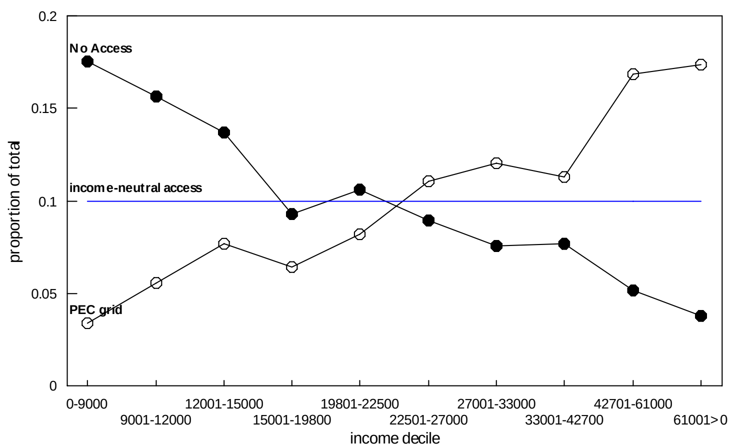
	electricity access		***total HH income***
	[HH]	[%HH]	[YR/month]
PEC national grid	803471	35.7%	43950
In urban areas	402747	17.9%	44573
In rural areas	400724	17.8%	43323
PEC isolated system	56988	2.5%	36428
Coop	53045	2.4%	34684
Private	2328	0.1%	38727
Total grid/minigrid access	**915832**	**40.7%**	**42932**
Village/community genset	180017	8.0%	29379
Relative/neighbor genset	39413	1.8%	27880
Family genset	58795	2.6%	50025
Other	6724	0.3%	47817
Total with electricity access	1200781	53.4%	**40781**
No access	1048392	46.6%	**22282**
Total	2249173	100.0%	

Box A8.1: Inequality of Access

Another way of displaying this income-dependence of electricity access is to examine the distribution of the type of access by income decile, shown in the table. If *access* was income-neutral (as it is in developed countries), one would expect that among grid-connected households, roughly 10% would be in each decile. But of PEC connections, only 3% are to be found in the bottom decile

Distribution of Access

	Income per decile (YR /month)		***No Access***	***PEC National Grid***		***Minigrids***		***Self-Gen***	
				PEC	***Coop***	***Private***	***village***	***relative/ neighbor***	***Family-owned***
1	0-9000	18%	3%	12%	4%	0%	4%	11%	3%
2	9001-12000	16%	6%	3%	7%	9%	10%	3%	0%
3	12001-15000	14%	8%	4%	2%	9%	16%	13%	7%
4	15001-19800	9%	6%	1%	7%	0%	12%	16%	7%
5	19801-22500	11%	8%	11%	10%	18%	12%	18%	11%
6	22501-27000	9%	11%	19%	19%	18%	10%	4%	2%
7	27001-33000	8%	12%	17%	17%	9%	9%	14%	13%
8	33001-42700	8%	11%	14%	18%	18%	11%	7%	20%
9	42701-61000	5%	17%	7%	11%	9%	7%	7%	16%
10	61001>0	4%	17%	13%	7%	9%	8%	7%	21%
	total	100%	100%	100%	100%	100%	100%	100%	100%



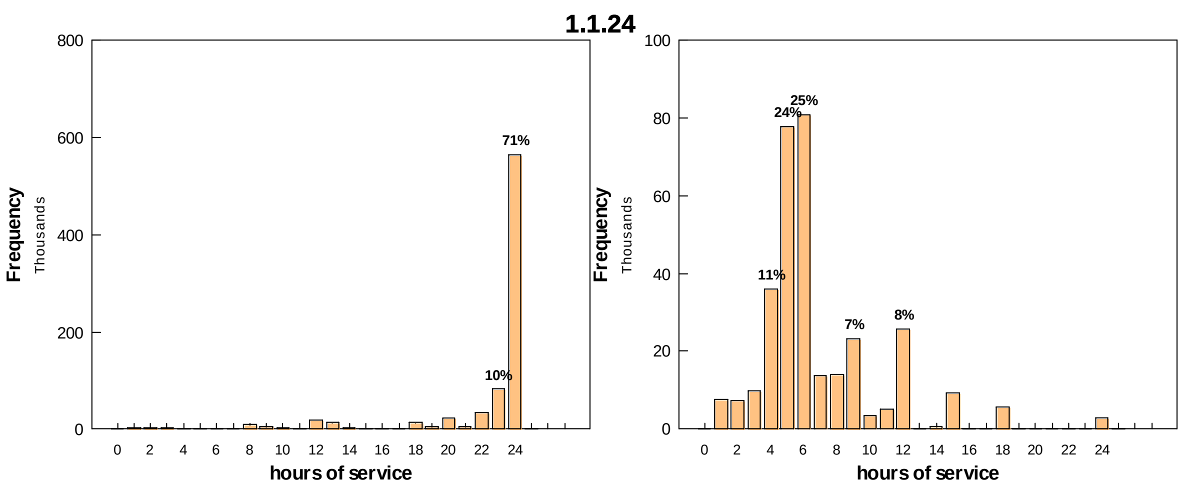
A8.5 As expected, there are significant differences in service quality between grid-connected customers and those connected to isolated systems and self-generation sets. The survey asked households to report on average hours of service per day, whose results are shown in Table A8.3. 83% of grid connected customers report 23-24 hours of service per day, whereas the bulk of self-generation and mini-grid customers report service for 4-6 hours per day. Surprisingly, there are few differences between PEC's urban and rural customers.

Table A8.3: Hours of Service

Hours of service	*PEC grid* Urban areas	Rural areas	total	*Isolated systems* PEC	Coops	Private	Village	Neighbor	*All isolated systems*
1	1%		1%	10%	5%				2%
2		1%		8%	6%			1%	2%
3		1%		7%			3%	1%	3%
4		1%			3%		17%	12%	11%
5				1%	12%		29%	49%	24%
6				34%	21%	100%	23%	23%	25%
7				1%			7%		4%
8	2%		1%	14%	5%		1%	5%	4%
9	1%		1%		30%		5%		7%
10				2%	1%		1%	1%	1%
11				7%	1%			2%	2%
12	2%	3%	2%	5%			13%		8%
13	4%		2%						
14		1%						1%	
15					16%			4%	3%
16									
17									
18	1%	3%	2%	11%					2%
19		1%	1%						
20	1%	5%	3%						
21	1%	1%	1%		1%				
22	2%	6%	4%						
23	6%	14%	10%						
24	77%	64%	71%				1%		1%

Figure A8.2: Hours of Service, All Isolated Systems and Self-gen Sets

PEC national grid **Isolated systems and self-generation**



Consumption Of Electricity

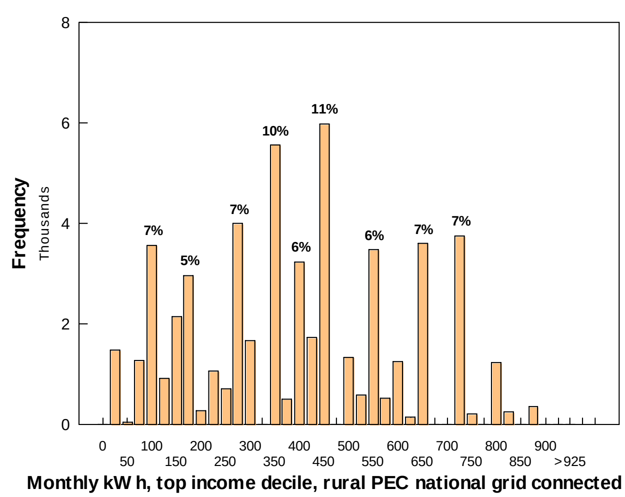
A8.6 The average urban household with electricity access consumed 274 kWh/month, as opposed to only 101 kWh/month in rural households. As shown in Table A8.4, consumption patterns are strongly dependent upon the type of access: consumption in the PEC national grid is typically double that of isolated systems (whether PEC or cooperative).

Table A8.4: Average Monthly Consumption, kWh/HH

	Urban	*Rural*
PEC national grid	274	101
PEC isolated system		74
Coop	91	44
Private		45
village/community genset	No data	No data
relative/neighbor genset	No data	No data
family genset	No data	No data
other	No data	No data

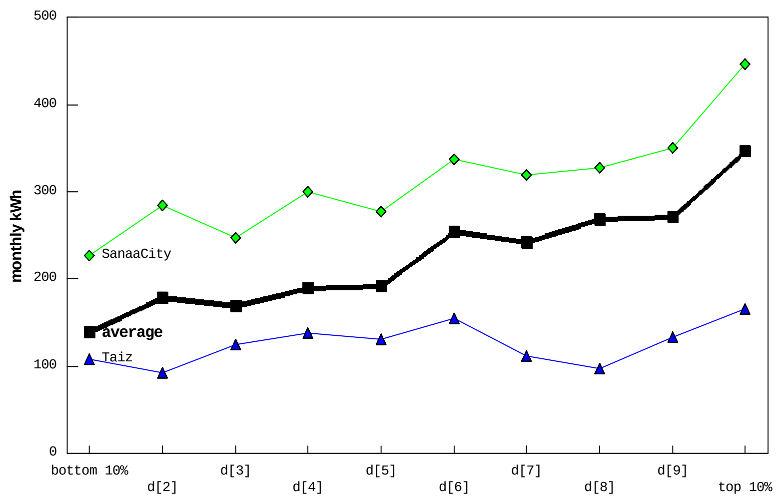
A8.7 However, there is large variation in individual household consumption rates, even within narrowly defined categories. For example, as shown in Figure A8.3, monthly consumption among PEC national grid connected customers varies from less than 20 kWh to over 800kWh/month.

Figure A8.3: Electricity Consumption, kWh/month (Top Income Decile, Rural PEC Grid Customers)



A8.8 Most governorates follow much the same patterns of consumption by income level as the national average (though the *level* of consumption across governorates varies more, see Figure A8.4).

Figure A8.4: Electricity Consumption v. Income



Tariff Structure

A8.9 PEC has two domestic tariffs; one for its grid-connected customers, and one for its "rural" customers, which in fact does not mean rural (in its normal administrative or practical definition), but customers in its isolated systems. Box A8.2 shows provides the details of the structure. Therefore, of PEC's total number of customers (see Table A8.1), only 56,000, or 7%, pay the rural tariff.

A8.10 The existing tariff structure raises several questions:

- to what extent the tariff recovers PEC's costs
- to what extent does the 1st least-cost tariff block serve as an effective "lifeline" rate for the poor?
- to what extent do the differences in rural and grid tariffs reflect differences in actual economic costs of the two types of service?
- to what extent does the high connection charge discourage formal connections?

Cost Recovery

A8.11 PEC does not cover its present costs, notwithstanding the subsidy on diesel fuel. At this point it is not possible to make recommendations on the structure of the tariff because this requires, as a first step, an understanding of the actual economic costs of supply at different voltage levels, properly reflecting the economic costs of generation, transmission and distribution. It is recommended such a study be undertaken as soon as possible (perhaps as one of the background studies for the proposed Rural Electrification Project).

Lifeline Rate

A8.12 As shown in Table A8.5, the first block in the PEC tariff for urban customers, whose purpose should be to provide a first tranche of low cost power to poor households, is set at 200 kWh/month. This is substantially higher than in other countries, and there is no evidence that it effectively serves this role.

Table A8.5: International Comparisons of the First Tariff Block

	kWh
Indonesia	20
India (Gujrat, GSEB)	20
India (Ahmedabad, Kolkata)	25
Egypt	50
Pakistan	50
Laos	50
India (Bombay, BSES)	100
Bangladesh (BPDB/DESA)	100
Yemen: Isolated systems	100
National grid	200

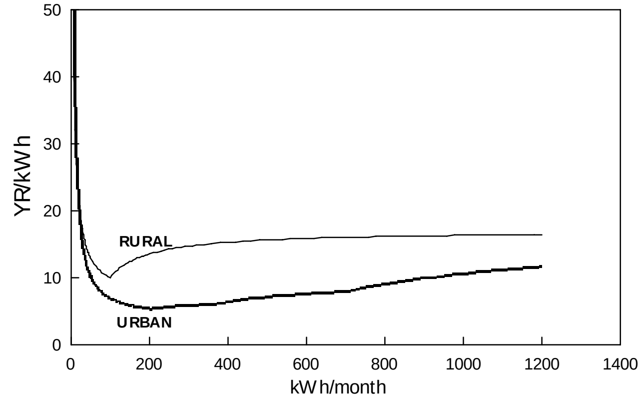
Source: World Bank, *Energy Sector Performance Improvement and* Future Development: The Way Forward, Washington, D.C, 2002.

Box A8.2: PEC Tariff

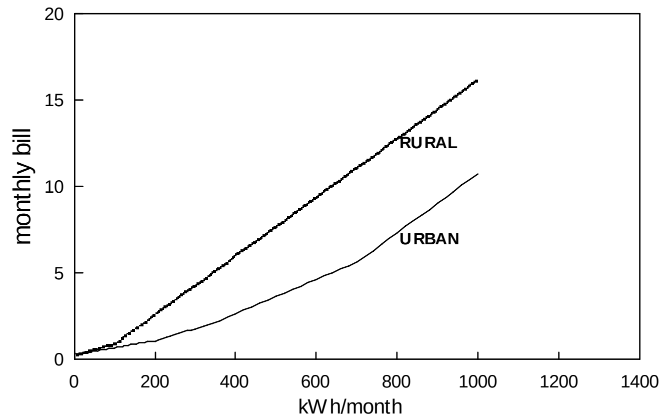
The current PEC tariff for domestic customers is as shown in the table below

		Urban	*Rural*
Fixed charge (1 phase)	YR/month	300	300
Variable charge			
0-100	YR/kWh	4	7
101-200	YR/kWh	4	17
201-350	YR/kWh	7	17
350-700	YR/kWh	10	17
‘>700	YR/kWh	17	17

The corresponding average cost per kWh, as a function of monthly consumption, therefore follows as shown below:



and the total monthly bill as a function of consumption follows as



A8.13 Yet as shown in Table A8.6, the average monthly consumption in rural areas is 101 kWh, and even the top decile consumes only 137 kWh. The average consumption of the bottom decile is 94 kWh, which would argue for a first block of no more than 100 kWh per month, and certainly not 200 kWh per month as at present.

Table A8.6: Monthly Consumption, PEC Grid Customers

Income per decile (YR / month)	*%HH reporting use*			*Consumption, [kWh/month]*		
	Urban	Rural	All	Urban	Rural	All
1 0-9000	51%	8%	12%	157	58	94
2 9001-12000	74%	8%	19%	228	64	174
3 12001-15000	79%	16%	25%	188	65	123
4 15001-19800	74%	16%	28%	258	94	182
5 19801-22500	72%	19%	29%	228	77	144
6 22501-27000	81%	25%	39%	264	95	181
7 27001-33000	82%	28%	43%	275	106	191
8 33001-42700	81%	24%	41%	283	81	171
9 42701-61000	90%	46%	60%	291	114	196
10 61001>0	83%	52%	63%	388	137	237
average	79%	23%	36%	273	101	183

Note: Rural refers to HH in rural areas, not HH paying the REC rural tariff!

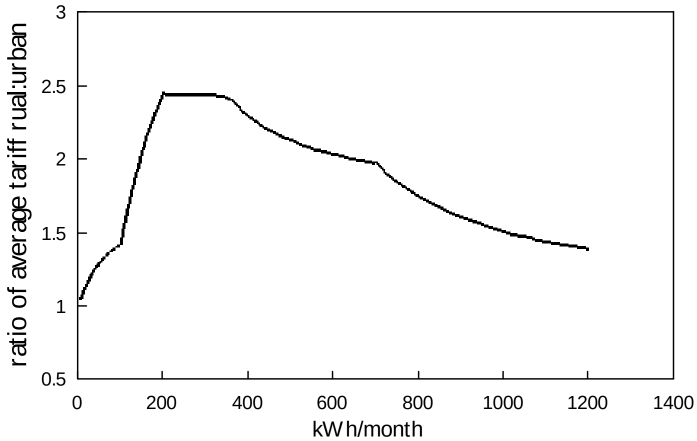
A8.14 In the absence of a cost study it is difficult to make specific suggestions for a residential tariff structure. However the HES data do suggest that the present structure requires revision, and that (as with petroleum product subsidies), the first block results in poor targeting of the implied subsidy.

PEC Rural Tariff (For Isolated Systems)

A8.15 As in the case of the PEC grid system, the extent of subsidy to customers of the isolated systems is not transparent, and again the economic costs of service to isolated systems need to be clearly established. The available data (see Box A8.3) suggest very high connection costs for these systems. Although many isolated systems appear to have benefited from grant aid, the value of this assistance is not included in the PEC database: this should be corrected in any proper assessment of economic costs.

A8.16 Figure A8.5 shows the ratio of monthly household bills of the rural (isolated system) and normal PEC tariffs, as a function of the kWh consumed. The rationale for the very different relative block structure is quite unclear, reaching a peak of 2.5 times the normal tariff for consumption between 200 and 350 kWh/month.

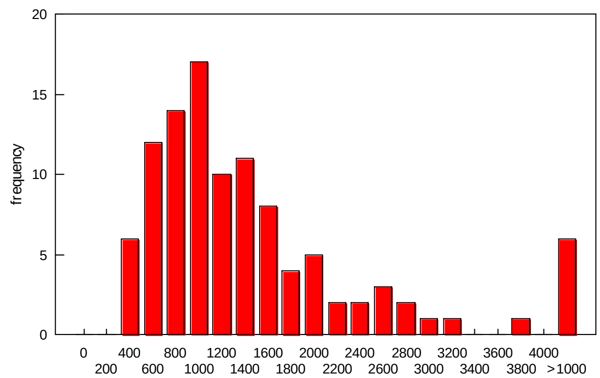
Figure A8.5: Ratio of Monthly Bills, Rural to Urban, as a Function of kWh



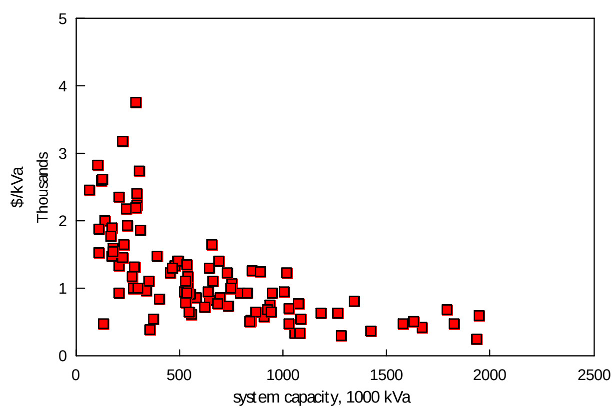
Box A8.3: Costs of Isolated Systems

PEC data highlight the high cost of isolated rural systems. A PEC database contains data on 410 isolated systems implemented over the past 15 years, and includes total project cost (including meters and the cost of house connections), system capacity (as kVA), and the number of households connected. The total cost of each scheme given in this database excludes the value of grants (mainly from the Govt. of Japan), and such systems are not therefore included in this analysis. The data on number of households are doubtful; when summed, it shows over 800,000 households, whereas we know from more reliable data from the commercial accounts division of PEC that the number of systems in PEC rural (isolated) systems is around 56,000. Therefore the costs per household connection are quite low (the mean is less than $400/HH).

The figure given for installed capacity (as kVA) is probably more reliable: the figure below shows the frequency distribution of $/kVA.



The data exhibit the classic expected economies of scale, with falling $/kVA as system size increases. The median cost is $1,072/kVA. (The average of $1,720 is distorted by a few outliers that have costs in excess of $10,000/kVA).



Thus, given an average demand per connected household of 300 watts, the cost per connection may be estimated at over $3,573/HH (including the cost of house connections and meters).

Source: Engineer Waheeb, *Rural Electric Projects in the Republic of Yemen*, PEC, 2004

Electricity Expenditure

A8.17 The distribution of household electricity expenditure closely tracks that of consumption, which follows from the single national tariff structure in the PEC grid. Thus the frequency distribution of Figure A8.6 (expenditure) follows closely that of Figure A8.3 (kWh consumption).

Figure A8.6: Distribution of Household Electricity Expenditure

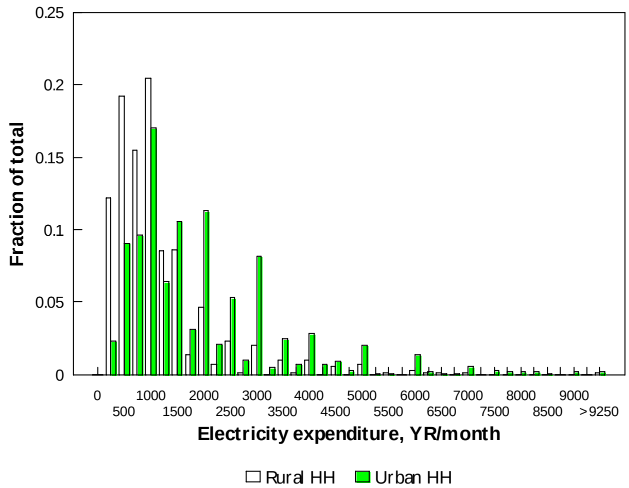
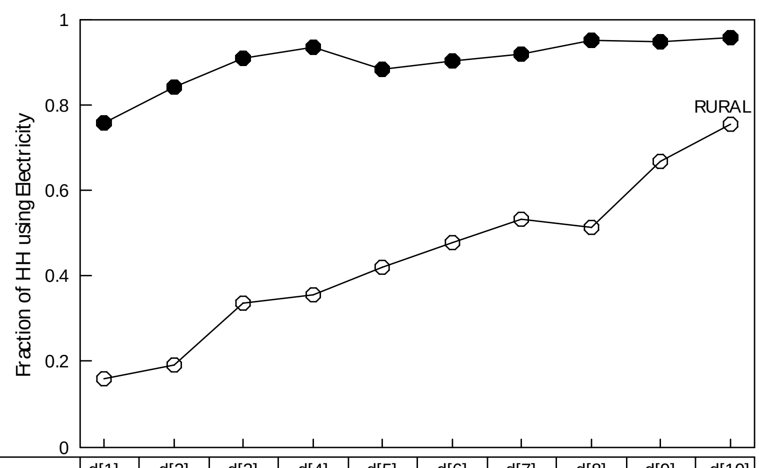


Table A8.7: Electricity Consumption and Expenditure Data

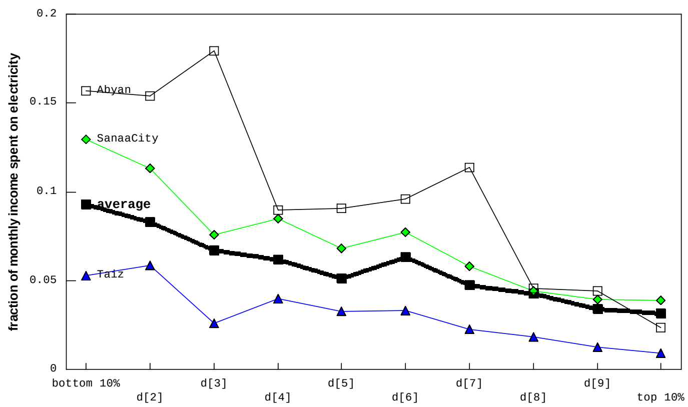
Income per decile (YR / month		%HH reporting use			Consumption,[kWh/month]			Expenditure, [YR/month]			Reported price,[YR/kWh]		
		Urban	Rural	All	Urban	Rural	All	Urban	Rural	All	Urban	Rural	All
1	0-9000	76%	16%	22%	157	58	94	939	577	719	8	15	12
2	9001-12000	84%	19%	30%	228	64	174	1437	740	1201	8	15	10
3	12001-15000	91%	34%	42%	188	65	123	1186	804	978	7	20	14
4	15001-19800	93%	36%	47%	258	94	182	1674	1060	1374	7	15	11
5	19801-22500	88%	42%	51%	228	77	144	1386	811	1058	7	13	11
6	22501-27000	90%	48%	59%	264	95	181	1675	973	1291	8	15	11
7	27001-33000	92%	53%	65%	275	106	191	1724	1213	1470	7	13	10
8	33001-42700	95%	51%	64%	250	81	171	1591	889	1242	7	16	12
9	42701-61000	95%	67%	76%	291	114	196	1907	1325	1583	7	13	10
10	61001>0	96%	75%	82%	388	137	237	2662	1758	2122	7	16	12
	average	92%	42%	53%	273	101	183	1754	1154	1433	7	15	11



	d[1]	d[2]	d[3]	d[4]	d[5]	d[6]	d[7]	d[8]	d[9]	d[10]
● URBAN	76%	84%	91%	93%	88%	90%	92%	95%	95%	96%
⊖ RURAL	16%	19%	34%	36%	42%	48%	53%	51%	67%	75%

A8.18 Note that rural customers pay very high prices per kWh (as a consequence of low kWh use), and therefore the monthly fixed charge of YR300 dominates the monthly bill. The fraction of monthly income spent on electricity is also as expected, as shown in Figure A8.7: as income increases, the fraction of total household expenditure spent on electricity declines.

Figure A8.7: Fraction of Income Spent on Electricity

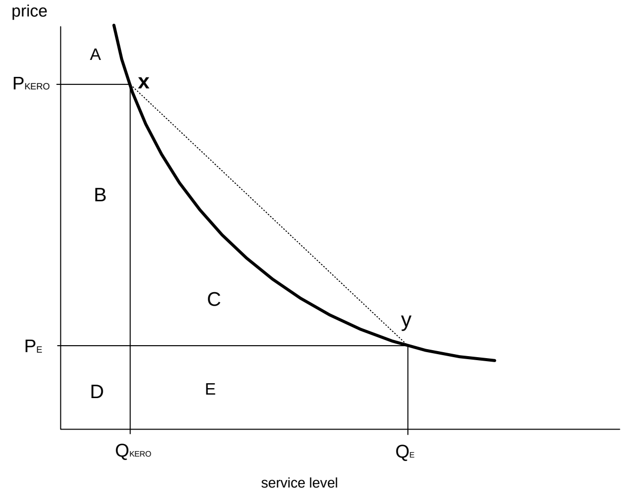


Willingness to Pay for Electricity

A8.19 Benefit-cost analysis of rural electrification requires (obviously) some measure of the *benefits* of electrification. If a demand curve were available, then the total economic benefits of some level of consumption, $\boldsymbol{Q}$, follow as the area under the demand curve (i.e. the total willingness to pay), and the net benefits as the consumer surplus (which is total willingness to pay less the actual cost of consuming $\boldsymbol{Q}$ units at price $\boldsymbol{P}$).

A8.20 Thus, in Figure A8.8, a demand curve for lighting (as lumens) is depicted. Two points are shown. The first point, $\boldsymbol{x}$, represents the demand for lumens in an unelectrified household that uses kerosene for lighting; for the kerosene consumption of the household (as revealed in a survey) and given knowledge of the type of lamp employed, one may derive the number of lumen-hours provided ($\boldsymbol{Q}_{KERO}$), and the cost per lumen hour ($\boldsymbol{P}_{KERO}$). At this point the household enjoys a consumer surplus equal to the area $\boldsymbol{A}$.

Figure A8.8: Demand for Lighting Service



A8.21 The second point, ***y***, represents that same household after electrification; this household consumes a far greater number of lumens ($\boldsymbol{Q_E}$) at the much lower price of the grid tariff $\boldsymbol{P_E}$. Now the consumer enjoys a surplus of the area ***A + B + C***. From this follows that the economic benefit of electrification to this household is the change (*increase*) in consumer surplus, namely ***B + C***.[19]

A8.22 This approach works best in longitudinal surveys, where information is available from a household before and after electrification, and has been used in a number of recent World Bank studies in Vietnam (for electrification by mini-hydro), the Philippines (for electrification by diesel mini-grids), and Sri Lanka and Indonesia (for electrification of rural households in remote areas by solar homes). The method is easiest to apply for solar systems, because the quantity of electricity provided is small, and therefore gets used just for lighting and TV-viewing, for which deriving demand curves is tractable.

A8.23 In the case of the Yemen energy survey, although the derivation of such demand curves is difficult, valuable insights about household behavior and preferences may still be drawn. Table A8.8 shows spending on fuels that are in theory substitutes for electricity – LPG and kerosene for lighting, candles, dry cells and battery charging. For example, the table shows that households connected to the PEC grid that use kerosene for lighting spend 134 YR/month on kerosene; but households with no access to electricity spend 332 YR/month on kerosene. Overall, households with access to electricity spend 418 YR/month on items (that could be replaced by electricity), as opposed to 779 YR/month in households that have no access.

[19] Because the prices seen by consumers are *financial* prices, they must be adjusted for taxes and subsidies implicit in both the price of kerosene, and in the price of grid supplied electricity. These adjustments can be complex because the final price may simultaneously embody both taxes (e.g. VAT on electricity) as well as subsidies (e.g. in subsidies for rural electrification)

Table A8.8: Spending on Electricity Substitutes (all Households)

	total	kerosene		batterycharging		dryCell		LPG lighting		LPGfridge		candles	
	[YR/m]	[YR/m]	[%HH]	[YR/m]	[%HH]	[YR/m]	[%HH]	[YR/m]	[%HH]	[YR/m]	[%HH]	[YR/m]	[%HH]
PEC national grid	307	134	36%	212	1%	224	53%	204	18%	594	0%	119	58%
at PEC urban tariff													
at PEC rural tariff													
PEC isolated system	499	149	64%	353	1%	304	71%	265	48%		0%	84	28%
Coop	407	191	66%	314	1%	257	58%	244	19%	484	6%	98	19%
Private	1043	162	91%		0%	607	100%	198	100%		0%	141	64%
total grid/minigrid access	**328**	**141**	**40%**	**226**	**1%**	**234**	**54%**	**215**	**20%**	**512**	**0%**	**117**	**54%**
village/community genset	488	156	57%	314	4%	308	68%	247	31%	1159	1%	149	33%
relative/neighbor genset	575	257	41%	277	12%	372	66%	245	35%	1250	1%	185	25%
family genset	1365	306	43%	332	20%	716	80%	421	52%	918	2%	760	30%
other													
total with electricity acce	**418**	**160**	**42%**	**309**	**3%**	**287**	**58%**	**245**	**24%**	**703**	**1%**	**141**	**49%**
no access	**779**	**332**	**78%**	**354**	**8%**	**439**	**64%**	**401**	**34%**	**492**	**0%**	**197**	**22%**

A8.24 Households that have access to electricity still use substantial quantities of the alternative fuels, presumably because the cost of kerosene (and LPG) is so cheap that electricity is used sparingly for lighting (because of the perception of high cost): electricity is used for services for which there are no (or no cost-effective) substitutes – such as TVs, fans, and other appliances.

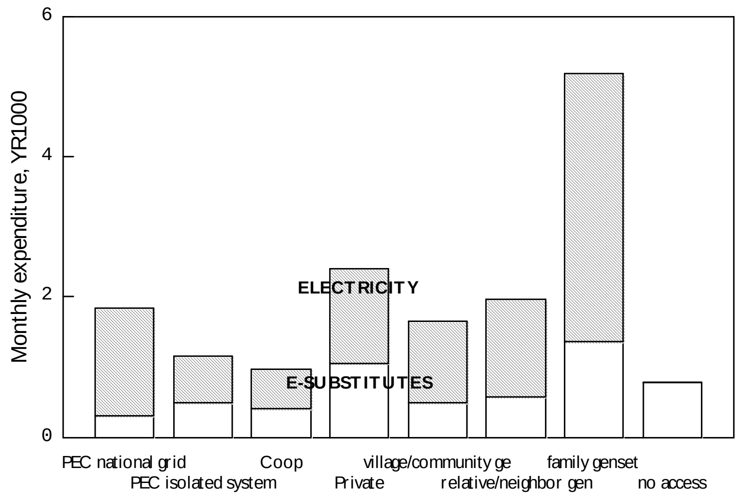
A8.25 Table A8.9 shows the incremental expenditures. Column [1] shows electricity expenditure, and column [2] expenditure on substitutes; column [3] is the total expenditure (=[1]+[2]). The incremental expenditure for electricity in column [4] is relative to households with no access: for example, in households connected to the PEC national grid, the incremental expenditure (for electricity) is 1,072 YR/month.

Table A8.9: Incremental Expenditure

	Electricity expenditure	*Non- electricity expenditure*	*Total expenditure*	*Incremental expenditure*
	[1]	[2]	[3]	[4]
PEC national grid	1543	307	1850	1072
PEC isolated system	663	499	1162	383
Coop	570	407	977	198
Private	1355	1043	2397	1618
Village/community genset	1166	488	1654	875
Relative/neighbor genset	1386	575	1962	1183
Family genset	3822	1365	5187	4409
No access	0	779	779	

A8.26 The most interesting finding of these data is highlighted in Figure A8.9: households with the highest expenditure for electricity are those connected to private mini-grids, or own gensets – but these households spend *more* on electricity substitutes than those with no access at all, and more than those connected to the PEC grid. Evidently these households place great value not just on electricity, but on the entire bundle of energy services.

Figure A8.9: Expenditure on Electricity and Electricity Substitutes, by Type of Electricity Access



Productive Use of Electricity

A8.27 The extent of productive use of electricity in rural households is one of the enduring themes of the rural electrification debate. In Yemen, 7.6% of rural households reported some form of home business: as shown Table A8.10, small food/groceries (1.8%) and crop processing (2.3%) were the two most commonly reported business types.

Table A8.10: Home Business in Rural Households by Electricity Access

	#HH reporting	*as % of all HH*	*PEC grid access*		*With non-grid access*		*With no access*	
Food/beverage grocery	31105	1.8%	14062	45%	8210	26%	8834	28%
Retail sales shop, pharmacy	1544	0.1%	0	0%	1544	100%	0	0%
Storage space	9504	0.5%	2921	31%	1544	16%	5038	53%
Repair shop	1271	0.1%	572	45%	699	55%	0	0%
Handicraft production/sales	18763	1.1%	5878	31%	8303	44%	4582	24%
Furniture making, carpentry	0	0.0%	0		0		0	
Hair salon/barbershop	1349	0.1%	0	0%	0	0%	1349	100%
Crop processing, milling	39948	2.3%	21628	54%	3168	8%	15152	38%
Laundry	0	0.0%	0		0		0	
Bakery	3295	0.2%	1362	41%	1934	59%	0	0%
Other	26334	1.5%	3785	14%	10013	38%	12535	48%
Total	133114	7.6%	50208	38%	35415	27%	47490	36%
total HH	1752551		40348 6	23%	33228 9	19%	1016777	58%

A8.28 Such home businesses are indeed concentrated in homes with electricity access. 23% of all households have PEC grid access, but 38% of households with home businesses have PEC access. Similarly, 19% of all households have non-grid access (mini-grids, self generation) but 27% with home businesses have non-grid access.

A8.29 Pharmacies are a good example of a home business that is only possible with some form of electricity access (for refrigeration) and no household without electricity reports such a business. On the other hand, barber shops (as a home business) apparently are reported only in households with no access.

A8.30 Interpretation of these data requires caution: obviously there are many barbershops and pharmacies in areas served by the grid. However, in such areas these are commercial establishments and therefore not included in the HES. Nevertheless, the data do show that households that have electricity access have a higher incidence of home business than those without.

Annex 9

Biomass

A9.1 Four types of biomass fuel were examined in the survey: fuelwood, charcoal, crop residues, and dung. Despite the large-scale uptake of LPG, a surprising 74% of all households report use of firewood (Table A9.1). The rate of decline with increasing income is modest: while 80% of households in the lowest income decile report fuelwood use, this declines only to around 70% in the middle deciles, and 66% in the top decile.

Table A9.1: % of Households using Biomass Fuels

Decile	*Fuelwood*	*Charcoal*	*Crop residue*	*dung*
1	80	8	24	12
2	82	12	24	19
3	84	11	31	27
4	82	15	30	22
5	70	11	22	19
6	71	18	18	13
7	70	24	19	15
8	71	19	22	18
9	59	20	19	18
10	66	30	20	21
All deciles	74	17	23	18

A9.2 Dung and crop residues are overwhelmingly collected (at no money cost, though at the cost of family time), while substantial fractions of fuelwood are purchased (Table A9.2).

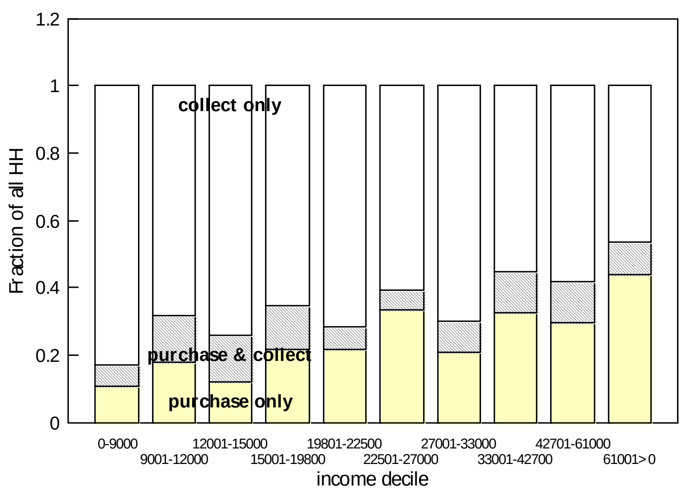
Table A9.2: How do Households Obtain Biomass Fuels, as % of Households Using Fuels?

Decile	Fuelwood			Crop residue			Dung		
	Purchase only	Purchase and collect	Collect only	Purchase only	Purchase and collect	Collect only	Purchase only	Purchase and collect	Collect only
1	11	6	83	1.4	98.6	0		200	
2	18	14	68	2.6	93	5		94	6
3	12	14	74	0.7	93	7		96	4
4	22	13	65		94	6	1	98	1
5	22	7	72	0.5	89	11	5	91	5
6	34	6	61	0.1	100		3	96	2
7	21	9	70		97	3		99	1
8	33	12	55		98	2		95	5
9	30	12	58	0.5	91	9		98	2
10	44	10	47	2.2	89	9	2	98	
All deciles	24	10	66	1	94	5	1	96	3
Rural	19	11	70						
Urban	61	7	32						

As percentages of households who use the fuel in question

A9.3 As expected, the extent to which fuelwood is purchased is strongly dependent upon income (Figure A9.1). In the bottom decile, only 17% purchase fuelwood, as opposed to 54% in the top decile.

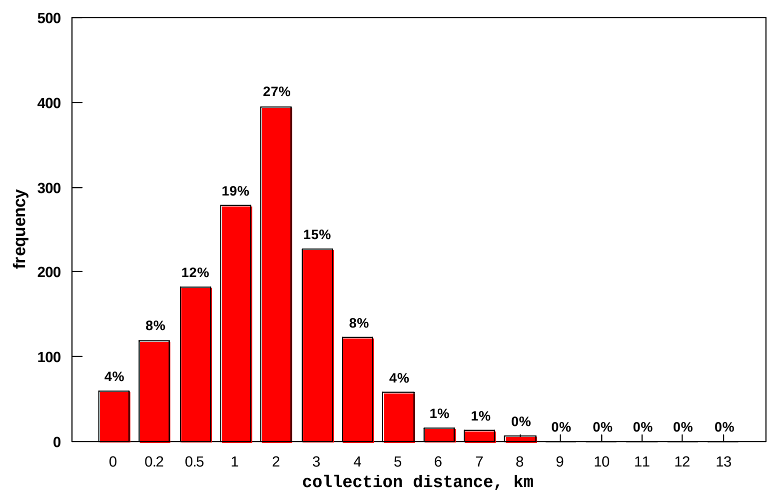
Figure A9.1: Method of Obtaining Fuelwood



Fuelwood Collection

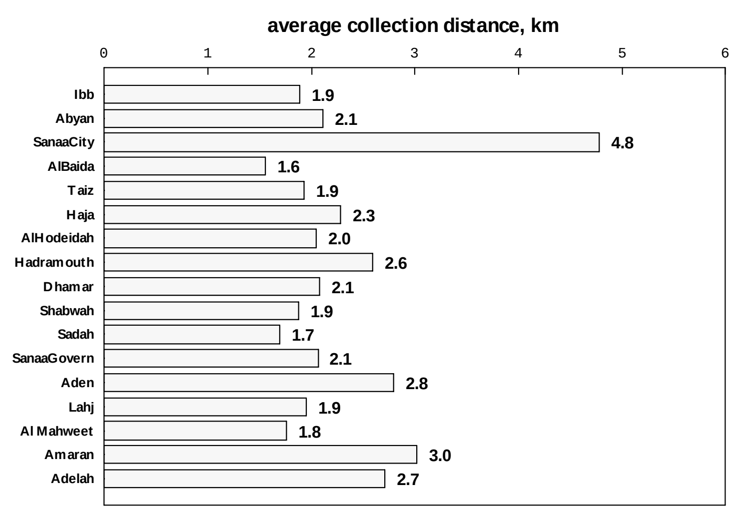
A9.4 Figure A9.2 shows the distribution of fuelwood collection distances: the average is 2km. However, 30% of households report collection distances more than 3km.

Figure A9.2: Distribution of Fuelwood Collection Distances



A9.5 There is surprisingly little variation across governorates (Figure A9.3). Sana'a City is the outlier, with an average reported distance of 4.8km – though this is certainly unsurprising given the situation in the capital and its surroundings. However only 18 sample households reported collecting fuelwood in Sana'a city.

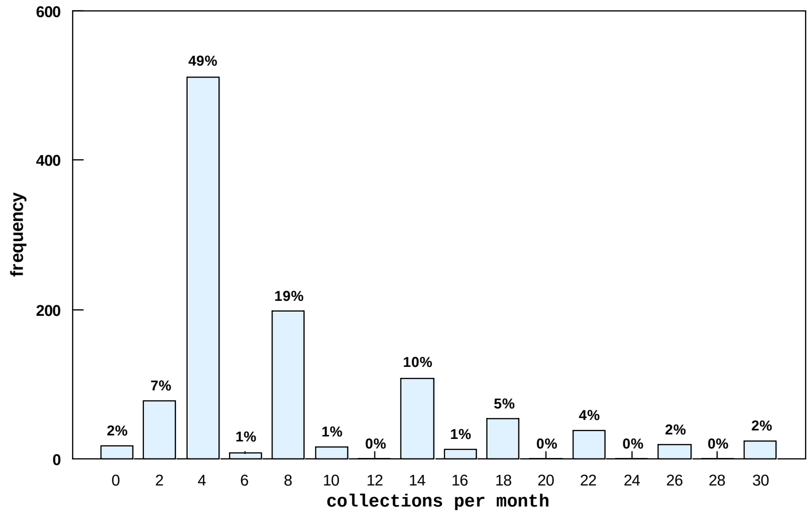
Figure A9.3: Average Fuelwood Collection Distances by Governorate



A9.6 Simple tabulations of the time reported by each gender/group on fuelwood collection can be misleading: indeed, given that an adult woman collects fuelwood, the average time spent per collection (3.8 hours) is in fact *less* than the average time spent by adult males (4.6 hours).[20] But this says little about the proportion of men and women engaged in collection. There is also large variation in the number of collections per month, as shown in Figure A9.4: while 50% of households collect once a week, small numbers collect once a month, and yet others collect daily.

[20] This apparent anomaly is explained below: there is a greater propensity for men to participate in fuelwood collections when distances are great (or perhaps if the fuelwood collected is sold).

Figure A9.4: Frequency Distribution of the Number of Collections per Month

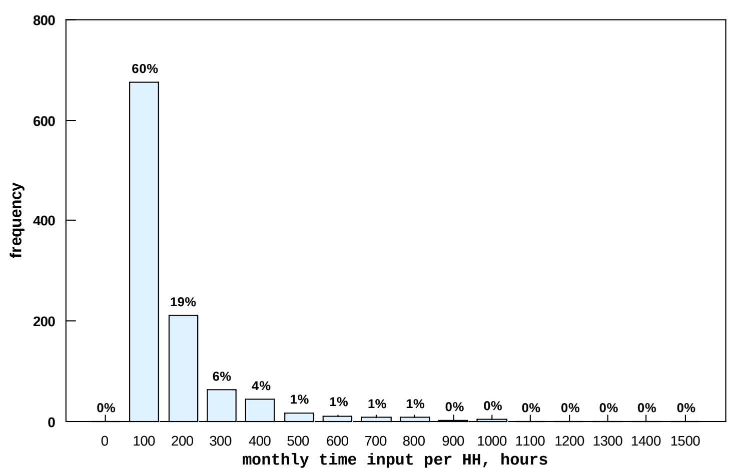


A9.7 Thus it becomes necessary to bring everything to a common basis. This is done by calculating for each household that reports fuelwood collection a total monthly family time budget, ***B***, calculated as

$$\boldsymbol{B = N_c\,(H_w\,N_w + H_m\,N_m + H_g\,N_g + H_b\,N_b)}$$

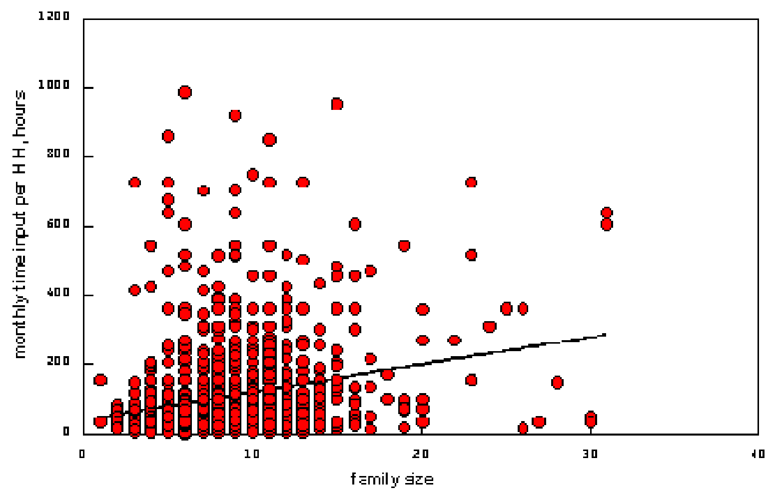
A9.8 Where N_c is the number of collections per month, H_W is the hours per collection reported by women, and N_W the number of women (in the household) who on average participate in each collection, and correspondingly for adult men (subscript ***m***), boys (***b***) and girls(***g***). The resulting frequency distribution of the monthly time budget is shown in Figure A9.5.

Figure A9.5 Monthly Household Time Budget for Fuelwood Collection



A9.9 This monthly time budget is *not* correlated with collection distance, though it is weakly correlated to family size (Figure A9.6), as one would expect (scale economies in cooking mean that the heat input to cooking is not linear to the number of persons participating in each meal).

Figure A9.6: Relationship between Monthly Collection Time Budgets and Family Size

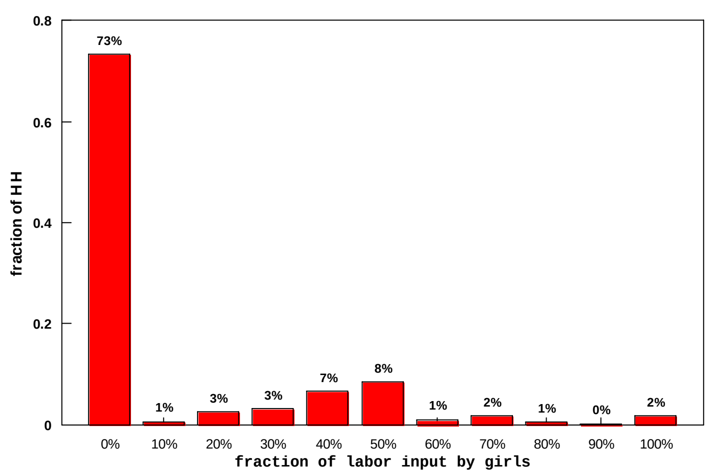


A9.10 Interestingly, the time budgets are also *not* correlated with income: though the regression coefficient has the correct sign (higher income brings lower time budgets), it is not statistically significant.

Labor Inputs

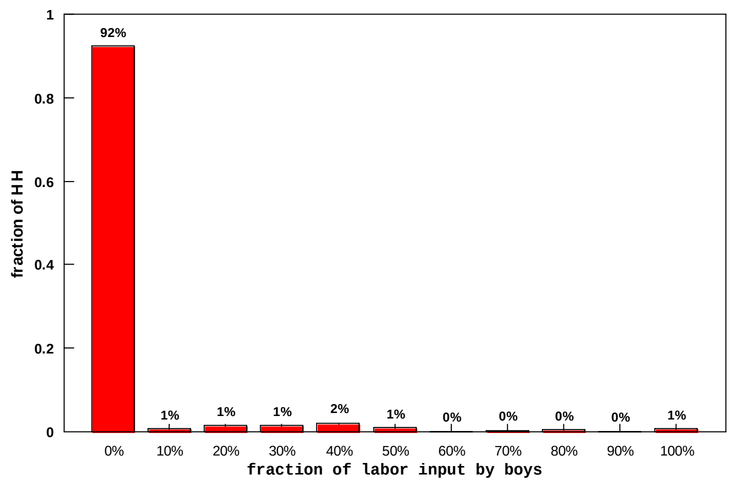
A9.11 With time budgets in hand, the input of each to the collection effort can be calculated. Figure A9.7 shows the fraction of households in which girls provide a given fraction of the labor input. For example, we see that in 73% of all households (that collect fuelwood), girls do not participate at all; in 8% of households girls provide 50% of the total labor and in 2% of households, girls provide 100% of the collection effort. There is no correlation of the labor input of girls to collection distance.

Figure A9.7: Labor Input of Girls



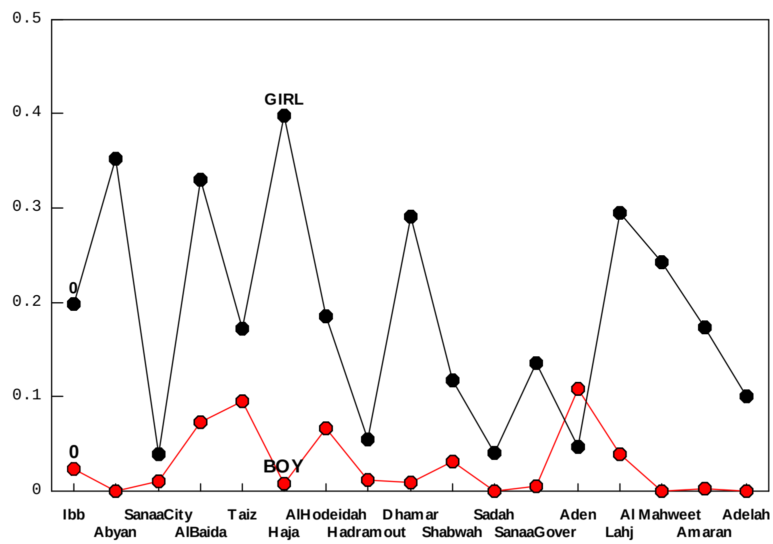
A9.12 Figure A9.8 shows the corresponding labor input of boys: they contribute no labor to fuelwood collection in 92% of all households, and only in very few cases do they make significant contributions.

Figure A9.8: Labor Input of Boys



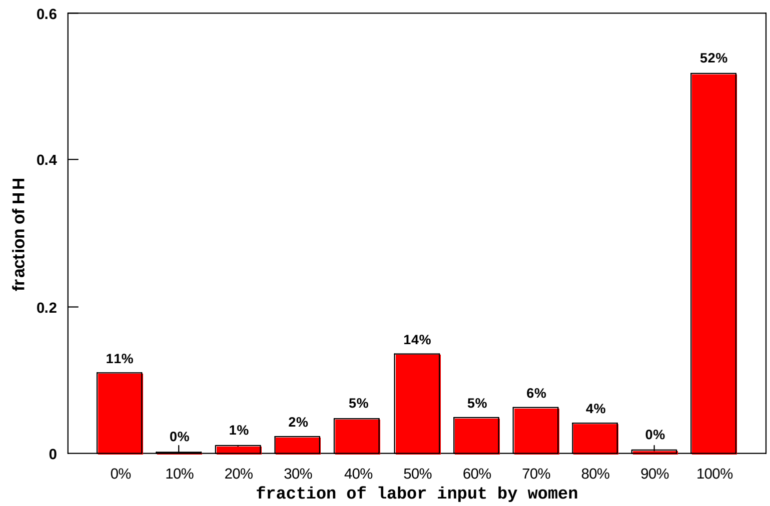
A9.13 There are some significant differences across Governorates, as shown in Figure A9.9: in fact in one Governorate, Aden, the input of boys is greater than that of girls.

Figure A9.9: Comparison of Labor Inputs by Governorate



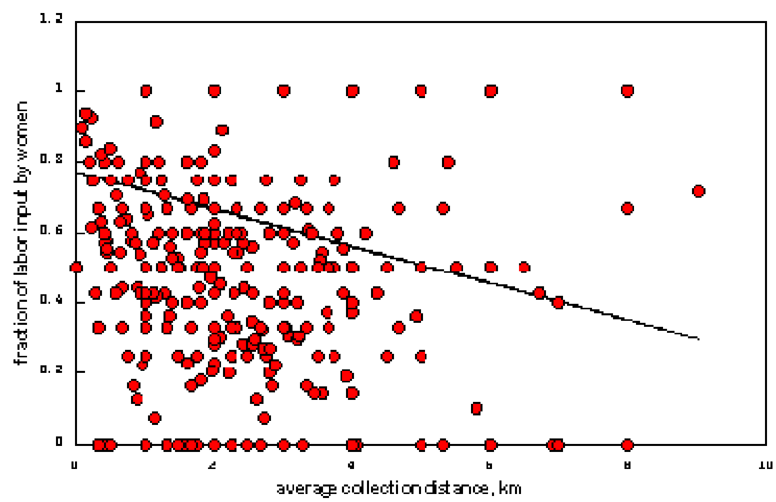
A9.14 The labor input of adult women is shown in Figure A9.10. In 52% of all households (that collect firewood), adult women provide 100% of the collection labor. However, in 11% of households, they contribute no labor and in 14% they contribute 50%.

Figure A9.10: Labor Input of Women



A9.15 However, as shown in Figure A9.11, there is a statistically significant relationship between the labor contribution of women and collection distance: as collection distances increase, the contribution of women *decreases*. This confirms the anecdotal evidence of men wishing to accompany women where collection distances are long.

Figure A9.11: Labor Input of Women as a Function of Collection Distance



A9.16 Finally, Figure A9.12 shows the labor input of men. The pattern is very similar to boys, with 75% of households reporting no contribution of (adult) men.

Figure A9.12: Labor Input of Men

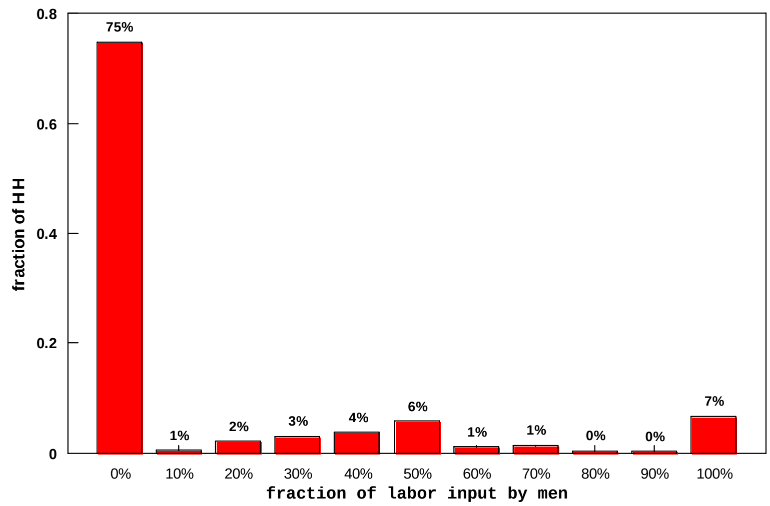
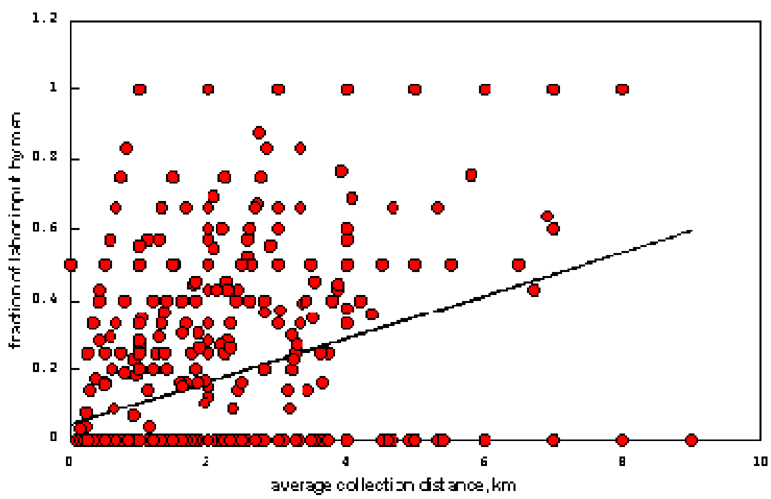
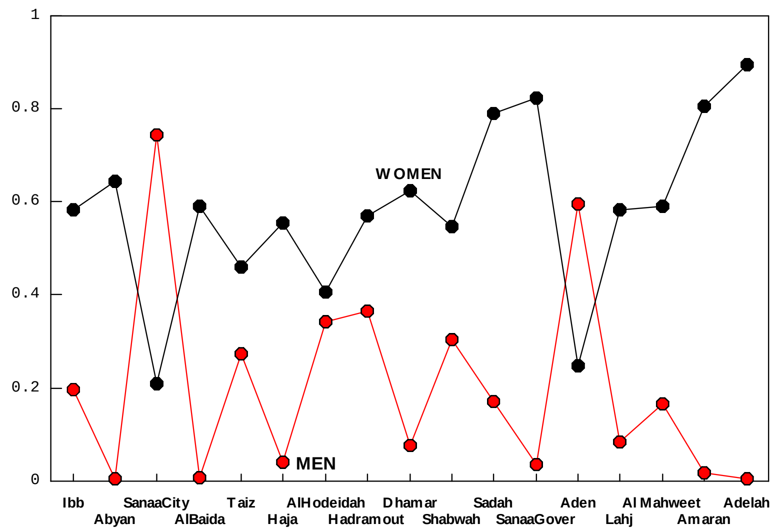


Figure A9.13: Labor Contribution of Men as a Function of Collection Distance



A9.17 Figure A9.14 compares the labor inputs of adult men and women by Governorate. That of men exceeds that of women in only two Governorates, Sana'a city, and Aden.

Figure A9.14: Comparison of Labor Inputs, Adult Men v. Adult Women



Fuelwood Consumption

A9.18 Table A9.3 shows the total consumption of fuelwood by Governorate and income decile. Note that the top income deciles account for the largest total quantity of fuelwood use – yet these are also the deciles that consume the bulk of the LPG.

Table A9.3: Calculated Monthly Purchased Fuelwood Usage by Decile and Governorate (1000kg)

Monthly income	*0 -9000*	*9,001 - 12,000*	*12,001 - 15,000*	*15,001 - 19,800*	*19,801 - 22,500*	*22,501 - 27,000*	*27,001 - 33,000*	*33,001 - 42,700*	*42,701 - 61,000*	*61,001 >*	
decile YR/month	*Bottom*	*d[2]*	*D[3]*	*d[4]*	*d[5]*	*d[6]*	*d[7]*	*d[8]*	*d[9]*	*top 10%*	total/ month
Ibb	1027	2595	669	679	103	831					5904
Abyan	239		120		120	5	239	5	419	168	1315
Sana'aCity		18				4	3	9	30	17	82
Al-Baida						3		14	23	24	64
Taiz	81	712	227	195	129	334	300	233	201	214	2627
Hajjah	214	97	62	90	452	58	298	566	540	1517	3895
Al-Hodeida	733	1724	190	359	258	1260	273	397	69	225	5489
Hadramout	6	144	676	334	728	1001	416	879	3236	1772	9193
Dhamar	802	462	587	407	252	160	14	947	87	347	4065
Shabwah	4	2	9	6	90	478	578	104	107	0	1378
Sa'adah	162	400	181	376	374	280	248	60	349	164	2594
Sana'aGovern	20	121	278	612	226	2097	2782	997	712	2331	10175
Aden	319	401	13	17	22	69	32	12	15	4	904
Lahj			353	102	90	183	28	27	6		789
Al Mahweet			827			16				135	977
Amaran	939	21	137	302	108	326	64	3570	1716	168	7351
Adelah							154		417		571
	4547	6700	4328	3478	2953	7104	5429	7818	7928	7088	57373

A9.19 Table A9.4 shows the uses of fuelwood in households reporting wood use. The dominant use is cooking, but a significant number also use fuelwood for heating, even in the big cities (where 31% use fuelwood for heating, compared to a national average of 24% of households).

Table A9.4: Uses of Fuelwood

		For HH reporting use % reporting use for:			
	% HH using fuelwood	*cooking*	*heating*	*Home business*	*other*
Sanna City	5	85	31		3
Aden	23	82	19		3
All urban HH	36	92	18	5	4
Rural Sa’adah,Sana’a	90	82	31	2	9
Rural Al Hodeida, Hajjahh	91	91	23	1	4
Rural Ibb&Taiz	82	94	20		2
Rural Abyan, Lahj Adalah	62	86	34	2	1
Rural Shabwah&Haramout	94	94	17	1	2
All Rural	85	90	24	1	4
All HH	74	90	24	1	3.8

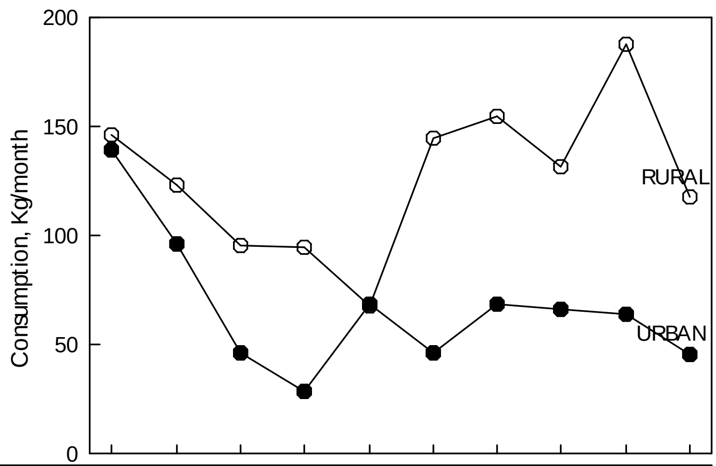
A9.20 The corresponding monthly consumption per household is shown in Table A9.5.

Table A9.5: Average Monthly Consumption in Households using Purchased and Collected Firewood (kg/month)

Monthly income	*0 -9000*	*9,001 - 12,000*	*12,001 - 15,000*	*15,001 - 19,800*	*19,801 - 22,500*	*22,501 - 27,000*	*27,001 - 33,000*	*33,001 - 42,700*	*42,701 - 61,000*	*61,001 >*
decile	***bottom***	***d[2]***	***d[3]***	***d[4]***	***d[5]***	***d[6]***	***d[7]***	***d[8]***	***d[9]***	***10%***
bb	510	320	230	480	49	218				
Abyan	160		240		240	10	480	10	143	72
Sana’a City		33				20	20	33	33	22
Al Beida						5		24	20	14
Taiz	86	140	33	38	94	96	59	38	112	29
Hajjah	45	50	25	45	99	32	84	116	135	99
Al Hodeida	64	69	26	37	35	93	61	42	35	55
Hadramout	80	44	89	55	74	92	131	94	218	103
Dhamar	115	117	122	103	81	32	5	186	80	78
Shabwah	4	8	10	5	43	93	133	28	44	7
Sa’adah	100	76	52	67	144	83	211	51	168	126
Sana’aGovern	60	135	68	223	97	561	263	147	94	166
Aden	661	219	13	14	12	42	17	8	11	14
Lahj			122	29	22	40	16	22	24	
Al Mahweet			300			30				260
Amaran	4000	44	49	123	61	246	34	473	303	112
Adelah							400		225	
Total	145	118	86	77	68	118	130	134	159	100

A9.21 The patterns of consumption per decile are noteworthy: the poorest deciles consume larger quantities (much of it collected) than the middle deciles; consumption increases again in the upper deciles of rural areas (Figure A9.15). Evidently there is a cultural preference for wood, which the upper deciles manage by purchase (rather than spending time for collection).

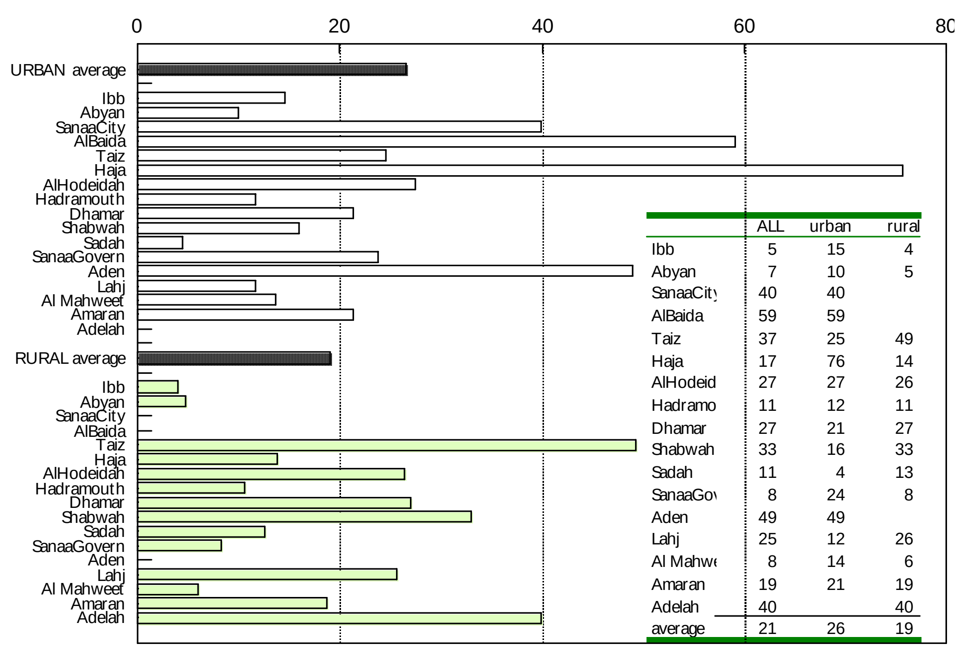
Figure A9.15: Consumption of Fuelwood By Decile, kg/HH/month



	d[1]	d[2]	d[3]	d[4]	d[5]	d[6]	d[7]	d[8]	d[9]	d[10]
● URBAN	139	96	46	28	69	46	68	66	64	46
⊖ RURAL	146	123	96	95	68	145	155	131	188	117

A9.22 As expected, urban fuelwood prices are higher than in rural areas (Figure A9.16). However, these differences are far smaller than the variation across Governorates.

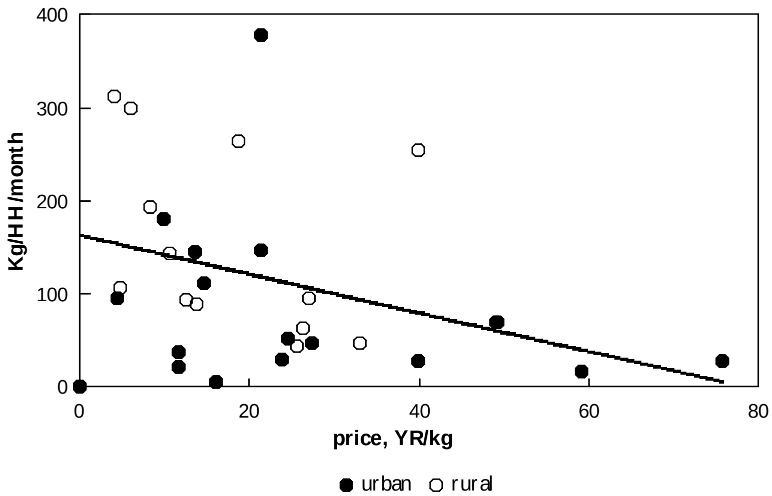
Figure A9.16: Fuelwood Prices, YR/kg



	ALL	urban	rural
Ibb	5	15	4
Abyan	7	10	5
SanaaCity	40	40	
AlBaida	59	59	
Taiz	37	25	49
Haja	17	76	14
AlHodeid	27	27	26
Hadramo	11	12	11
Dhamar	27	21	27
Shabwah	33	16	33
Sadah	11	4	13
SanaaGov	8	24	8
Aden	49	49	
Lahj	25	12	26
Al Mahwe	8	14	6
Amaran	19	21	19
Adelah	40		40
average	21	26	19

A9.23 These price variations have the expected impact on consumption rates, as shown in Figure A9.17: the higher the price, the lower the monthly consumption per household. However, price explains only about 15% of the total variation in consumption rate across Governorates,[21] suggesting that the dominant determinant of consumption rates is resource availability.

Figure A9.17: Fuelwood Consumption v. Price



Charcoal

A9.24 18% of all households report uses of charcoal (Table A9.6). The dominant use is neither for heating nor cooking, but for pipes (recorded in the survey as "other").

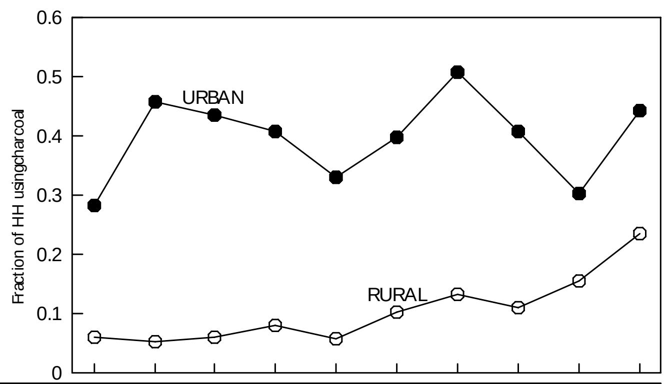
Table A9.6: Charcoal Use

		For HH reporting use, % reporting use for:				
	% HH using charcoal	*cooking*	*heating*	*ironing*	*Home business*	*Other (Pipes)*
Sanna City	54	1	16			80
Aden	54	2	19	1.5		90
All urban HH	43	14	15		2.7	77
Rural Sa'adah,Sana'a	3	16	66		2	43
Rural Al Hodeida, Hajjahh	17	36	14	2	3	58
Rural Ibb&Taiz	2	35	0		4	39
Rural Abyan, Lahj Adalah	15	10	38	3	2	61
Rural Shabwah&Haramout	30	81	20	2	6	6
All Rural	11	41	22	1	3	45
All HH	17	27	18	1	3	62

A9.25 As shown in Figure A9.18, there are sharp differences between urban and rural charcoal use. Particularly in the low rural deciles, charcoal use is very low.

[21] As captured by the R^2 in a simple linear model. Addition of second and third order polynomial terms, or a log form, did not significantly improve the explanatory power.

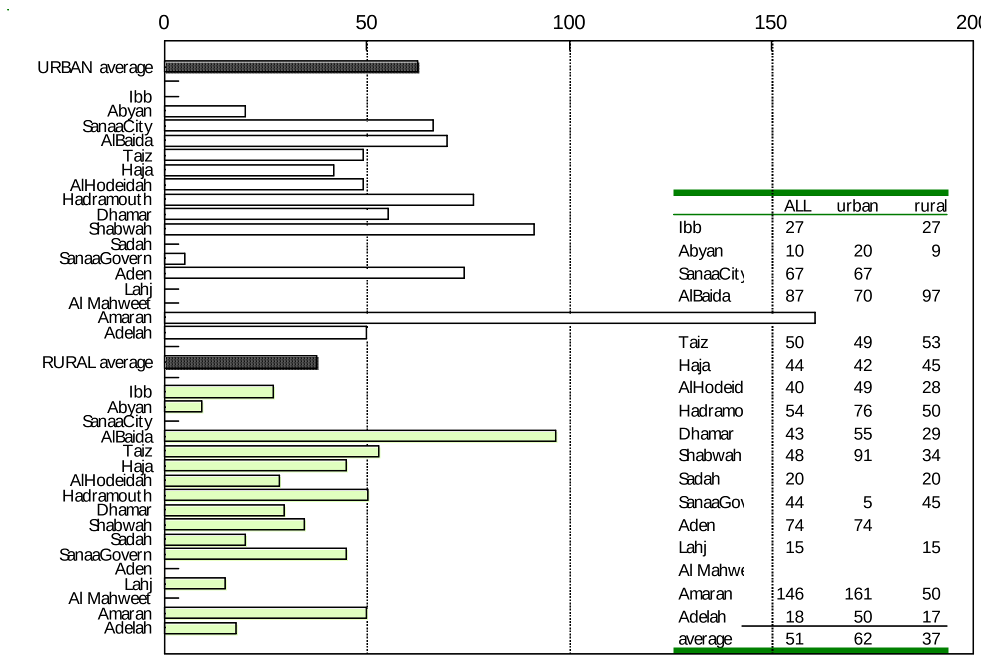
Figure A9.18: Use of Charcoal by Income Decile



	d[1]	d[2]	d[3]	d[4]	d[5]	d[6]	d[7]	d[8]	d[9]	d[10]
● URBAN	28.3%	45.9%	43.5%	40.7%	33.0%	39.7%	50.8%	40.8%	30.2%	44.4%
⊖ RURAL	5.9%	5.1%	6.0%	8.0%	5.7%	10.2%	13.3%	10.8%	15.5%	23.5%

A9.26 As expected, there are again significant differences in urban and rural prices. As shown in Figure A9.19, the average urban price is 62 YR/kg, as opposed to 37 YR/kg in rural areas.

Figure A9.19: Charcoal Prices, YR/kg

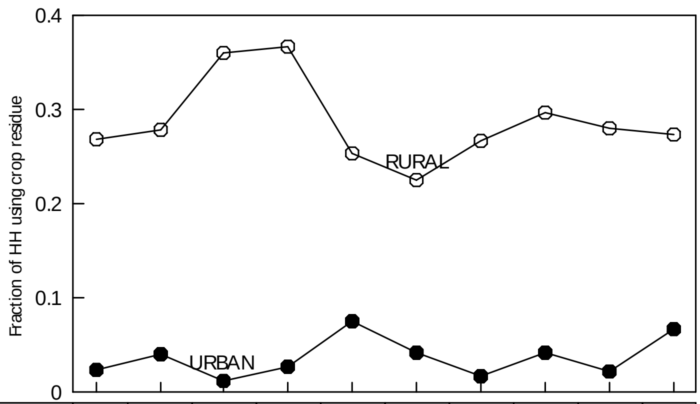


	ALL	urban	rural
Ibb	27		27
Abyan	10	20	9
SanaaCity	67	67	
AlBaida	87	70	97
Taiz	50	49	53
Haja	44	42	45
AlHodeid	40	49	28
Hadramo	54	76	50
Dhamar	43	55	29
Shabwah	48	91	34
Sadah	20		20
SanaaGov	44	5	45
Aden	74	74	
Lahj	15		15
Al Mahwe			
Amaran	146	161	50
Adelah	18	50	17
average	51	62	37

Crop Residues

A9.27 The use of crop residues is largely confined to rural areas and, as noted above, little is purchased. There is little variation in use by income decile (Figure A9.20).

Figure A9:20: Use of Crop Residues



	d[1]	d[2]	d[3]	d[4]	d[5]	d[6]	d[7]	d[8]	d[9]	d[10]
● URBAN	2.3%	4.0%	1.1%	2.6%	7.4%	4.2%	1.6%	4.2%	2.1%	6.5%
⊖ RURAL	26.8%	27.9%	36.0%	36.6%	25.4%	22.6%	26.6%	29.6%	28.0%	27.3%

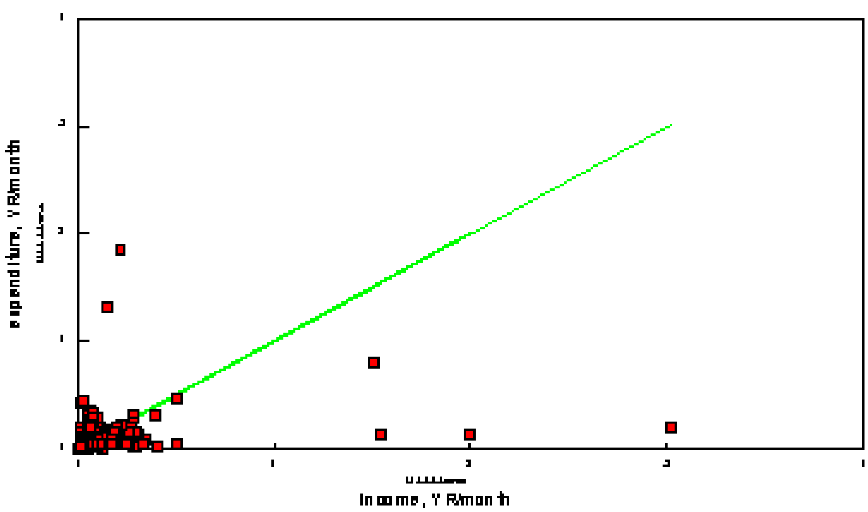
Annex 10

Survey Data Reconciliation

Expenditure and Income Data in the HES Survey Data

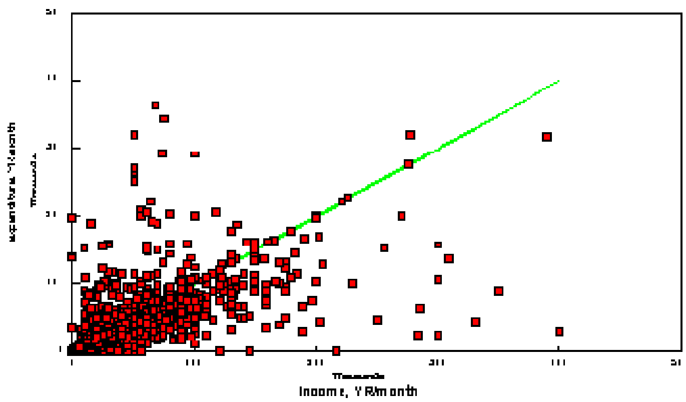
A10.1 Figure A10.1 plots expenditure vs. income for all observations in the 3540 households in the 2003 household energy survey (2003 HES). Four households appear with monthly income greater than YR1 million; and two households show expenditures of more than one million (though these are not in households reporting corresponding income!) These outliers were removed from the dataset.

Figure A10.1: Expenditure v. Income



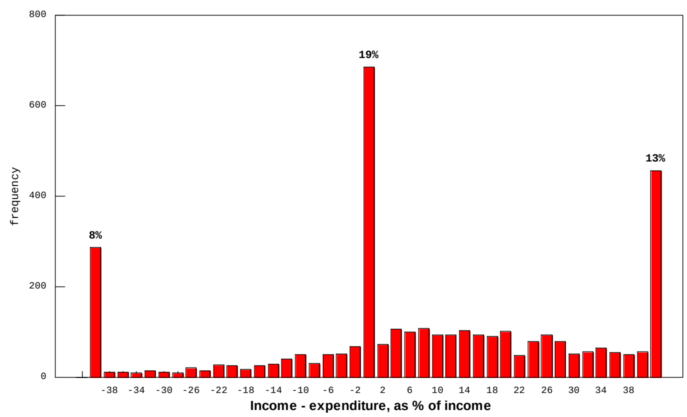
A10.2 The result is shown in Figure A10.2. But this figure raises a different question. In theory, the difference between expenditure and income of a household in any given month is either an addition to savings, or a draw-down from savings. But does this explain the level of variation in the case of the Yemen survey? Given that the implied draw-down or addition to savings is a multiple of expenditure in many cases, this seems an unlikely explanation.

Figure A10.2: Expenditure v. Income, Outliers Removed



A10.3 The frequency distribution of discrepancies (Figure A10.3) is odd. In just 19% of the records do expenditure and income match to within 1%.

Figure A10.3: Frequency Distribution of Income v. Expenditure Discrepancies



A10.4 But in 8% of households, expenditure exceeded income by more than 40%, and 13% of households' income exceeded expenditures by more than 40%. Under-reporting of income in household surveys is a well-documented phenomenon – which would explain the negative entries in Figure A10.3.[22] But here there is a preponderance of over-reporting incomes (or under-reporting expenditures) – represented by the positive entries in Figure A10.3.

A10.5 The problem of the inconsistency between income and expenditure data becomes apparent when one looks at the data for individual Governorates. For example, Figure A10.4 shows the household expenditure profile for Al Hodeida. Since the definition of deciles in the 2003 HES is by income, as revealed in this survey, and the sum of expenditures does not match that income figure, the total expenditure curve is not smooth (e.g. total expenditure in the 3rd decile is less than that in the 2nd decile).

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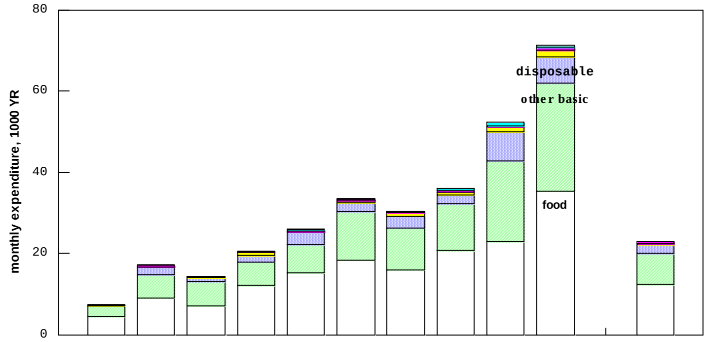
22 World Bank, *Sri Lanka Energy Services Delivery Project, Implementation Completion Report*, May 2003.

Figure A10.4: Al Hodeida [Monthly Expenditure Per HES]



	bottom 10%	d[2]	d[3]	d[4]	d[5]	d[6]	d[7]	d[8]	d[9]	top 10%		average
food	4513	8999	7238	12217	15370	18391	16092	20769	22956	35542		12359
other basic	2533	5838	5815	5751	6777	12107	10219	11580	19833	26373		7753
disposable	196	1795	1081	1704	3163	2043	2962	2062	7222	6625		2073
electricity	62	203	137	744	87	363	806	873	1139	1632		391
LPG	114	339	142	238	360	522	269	383	376	614		299
other energy	11	53	4	0	267	183	0	369	878	492		122

"Other basic" is the sum of expenditure on housing, education, medical water and transportation.

Calculation of Income Deciles

A10.6 The definition of income deciles is survey-based and designed so that the weighted number of households is roughly equal. With a total estimated number of households being 2,249,173, each decile should contain roughly 225,000 households. This is true of all deciles except 3 and 4, as shown in Table A10.1. In the view of the CSO and the survey consultant, a readjustment was not deemed necessary.

Table A10.1: Income Deciles

	Income range	*Households*
1	<9000	234,560
2	9,001-12,000	233,535
3	12,001-15,000	247,273
4	15,001-19,800	185,532
5	19,801-22,500	227,267
6	22,501-27,000	226,015
7	27,001-33,000	223,618
8	33,001-42,700	223,603
9	42,701-61,000	224,887
10	>61,000	222,882
total		2,249,173

A10.7 With deciles defined by income, the average expenditures of each decile may not necessarily fall within the income range of each decile: as shown in Table A10.2, in four out of six deciles, average expenditure lies out of the income range (in three cases below and in one case above).

Table A10.2: Income and Expenditure by Income Decile

	total expenditure	*Expenditure outside income range*
	[YR/month]	
1 <9,000	8,179	No
2 9,001-12,000	15,592	YES
3 12,001-15,000	17,882	YES
4 15,001-19,800	20,869	YES
5 19,801-22,500	22,427	No
6 22,501-27,000	26,976	No
7 27,001-33,000	32,166	No
8 33,001-42,700	32,751	YES
9 42,701-61,000	48,479	No
10 61,001>0	90,548	No

Comparison with the Last Household Expenditure Survey

A10.8 The expenditure data may be compared to that of the previous 1998 Household Expenditure Survey. Table A10.3 shows the expenditure data by income decile, as reported by the World Bank in the 2002 Poverty Update.[23]

Table A10.3: 1998 Household Expenditure Survey

Income decile	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*All HH*
persons/HH	9.4	8.6	7.8	7.6	7.7	7.9	7.4	7.2	7.1	5.6	7.1
***per capita, annual** (1998)*											
Food	9814	14191	17374	20101	23197	25696	29973	35347	42471	63922	28209
Housing	2608	3725	4470	5259	5733	6600	7459	8263	10246	19269	7363
Clothing	1137	1715	2190	2566	3006	3491	3921	4945	5874	9899	3874
Health	196	450	587	654	902	1082	1232	1494	2707	5834	1514
Education	150	166	188	229	274	374	313	361	476	1175	371
Transport	361	536	700	977	1237	1643	2125	2686	4370	9981	2462
Leisure	1225	2148	3058	4135	4781	6085	7504	9117	11683	23087	7282
Other	206	392	659	833	1220	1482	1755	2231	3447	9600	2183
Total	15697	23323	29226	34754	40350	46453	54282	64444	81274	142767	53257
per household, per month											
Food	7717	10226	11299	12676	14812	16855	18530	21269	25029	29772	16663
Housing	2051	2684	2907	3316	3661	4329	4611	4972	6038	8975	4349
Clothing	894	1236	1424	1618	1919	2290	2424	2975	3462	4610	2289
Health	154	324	382	412	576	710	762	899	1595	2717	894
Education	118	120	122	144	175	245	194	217	281	547	219
Transport	284	386	455	616	790	1078	1314	1616	2575	4649	1454
Leisure	963	1548	1989	2608	3053	3991	4639	5486	6885	10753	4302
Other	162	282	429	525	779	972	1085	1342	2031	4471	1289
Total	12342	16806	19007	21917	25765	30471	33558	38777	47896	66494	31459
2003 Energy Survey	**8405**	**15978**	**18020**	**21135**	**22698**	**27474**	**32406**	**32780**	**48215**	**90640**	**31598**
delta	**-3937**	**-828**	**-987**	**-782**	**-3067**	**-2997**	**-1152**	**-5996**	**319**	**24146**	**139**
	-32%	**-5%**	**-5%**	**-4%**	**-12%**	**-10%**	**-3%**	**-15%**	**1%**	**36%**	**0%**

Source: World Bank, Republic of Yemen Poverty Update, *op. cit.*, Volume 2, Table 29.

[23] World Bank *Republic of Yemen Poverty Update*, Report 24422-Yemen, Dec. 2002

A10.9 In all the lower income deciles (1-8), the 2003 HES gives smaller expenditures than the 1998 Survey; but in the highest decile expenditure is 36% higher. Overall the average household expenditure is essentially identical! One would have expected higher expenditures in 2003 than in 1998, given an increase in the CPI of some 55% over this same period.

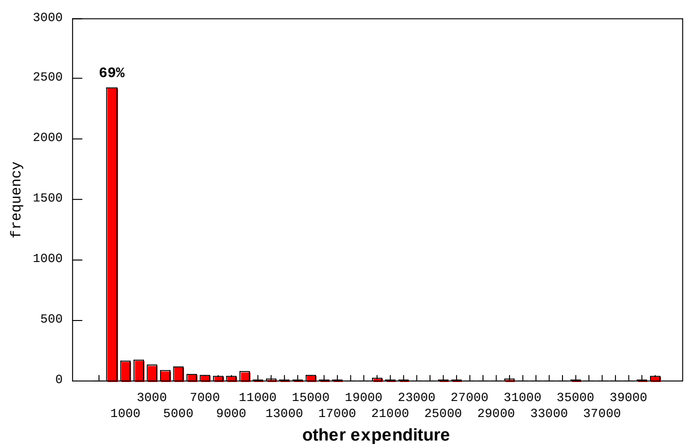
A10.10A comparison by expenditure category is instructive: the 2003 HES shows 20% lower food expenditure, but significantly higher expenditures in health and education (Table A10.4). The definition of “housing” is obviously different.

Table A10.4: Comparison by Expenditure Categories, All Households

	Expenditure Survey 1998	*HES 2003*	
Food	16663	13843	-20%
Housing	4349	586	-643%
Water		1616	
Clothing	2289	2168	-6%
Health	894	2929	+69%
Education	219	1437	+85%
Transport	1454	1620	+10%
Leisure	4302		
Agriculture & livestock		2373	
Other	1289	2995	
Total	31459	29567	
Energy (including electricity)		*2431*	
Total	31459	31998	

A10.11However, the problem with inclusion in “other” is that 69% of the households report ***zero*** “other expenditure” (Figure A10.5), while only five households report zero energy expenditure.

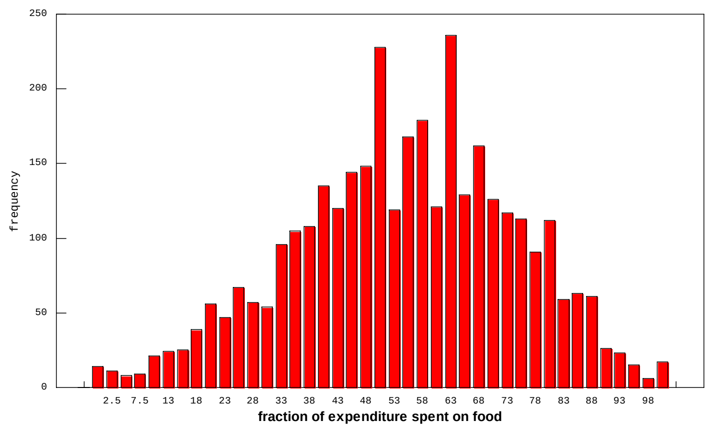
Figure A10.5: Frequency Distribution of “Other Expenditure”



Food Expenditure Data

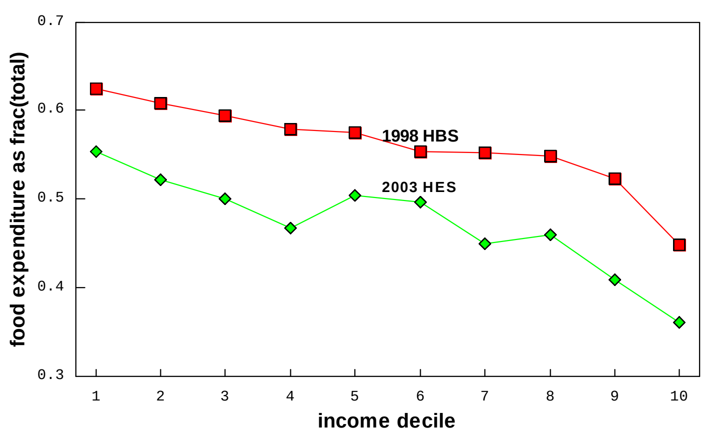
A10.12Food accounts for the largest single expenditure: the average household spent 43% of its expenditure on food, distributed as shown in Figure A10.6.

Figure A10.6: Distribution of Food Expenditure Fractions



A10.13The proportion of total household expenditure accounted for by food declines as expected with increasing household income (Figure A10.7). However, the food shares of total expenditure in the 2003 HES are significantly lower across all income deciles: this would be expected given the increase in household incomes over the five years that have elapsed since the 1998 Expenditure Survey.

Figure A10.7: Food Expenditure as Fraction of Total Household Expenditure



General Patterns of Income Distribution

A10.14Much of the difference can also be explained by the distribution of poverty, which is largely a rural phenomenon. As shown in Table A10.5, 91% of households in the bottom income decile are in rural areas, as opposed to an overall average of 77% of all households being in rural areas. Similarly, 33% of the households in the top decile are in urban areas, as against 23% of all households.

Table A10.5: Distribution of Households by Income Decile

	d[1]	*d[2]*	*d[3]*	*d[4]*	*d[5]*	*d[6]*	*d[7]*	*D[8]*	*d[9]*	*d[10]*	*average*
Urban HH	22,13	38,27	36,03	37,73	44,01	57,31	64,67	64,60	72,65	73,82	511,266
	6	2	0	5	3	7	3	7	8	4	
	9%	16%	15%	20%	19%	25%	29%	29%	32%	33%	23%
Rural HH	212,4	195,2	211,2	147,7	183,2	168,6	158,9	158,9	152,2	149,0	1,737,90
	24	62	44	97	54	98	45	96	28	58	7
	91%	84%	85%	80%	81%	75%	71%	71%	68%	67%	77%
Total HH	234,5	233,5	247,2	185,5	227,2	226,0	223,6	223,6	224,8	222,8	2,249,17
	60	35	73	32	67	15	18	03	87	82	3

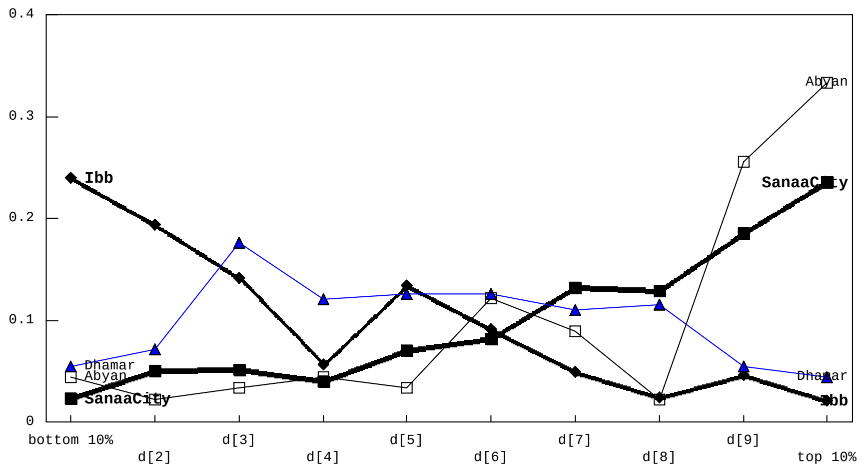
A10.15Table A10.6 shows the distribution of sample households (i.e. before weighting).

Table A10.6: Distribution of Households by Region and Income Decile

Monthly	***0***	***9,001***	***12,001***	***15,001***	***19,801***	***22,501***	***27,001***	***33,001***	***42,701***	***61,001***	
income	***-9000***	-	-	-	-	-	-	-	-	>	
		12,000	***15,000***	***19,800***	***22,500***	***27,000***	***33,000***	***42,700***	***61,000***		
decile	***bottom***	***d[2]***	***d[3]***	***d[4]***	***d[5]***	***d[6]***	***d[7]***	***d[8]***	***d[9]***	***top***	
YR/month										***10%***	
Ibb	68	55	40	16	38	26	14	7	13	6	283
Abyan	4	2	3	4	3	11	8	2	23	30	90
Sana'aCity	14	30	31	24	42	49	79	77	111	141	598
Al-Baida		3	7	2	8	15	5	18	21	26	105
Taiz	32	30	32	29	38	30	31	36	21	21	300
Hajjah	10	8	11	15	10	11	23	13	16	15	132
Al-Hodeida	54	79	21	23	27	23	26	13	9	12	287
Hadramout	4	7	20	27	29	52	31	38	51	23	282
Dhamar	10	13	32	22	23	23	20	21	10	8	182
Shabwah	3	2	2	6	10	27	13	19	23	13	118
Sa'adah	1	8	9	13	15	16	13	10	7	8	100
Sana'aGovern	16	13	29	14	24	17	24	21	24	38	220
Aden	8	28	26	29	38	41	51	67	78	33	399
Lahj	2	9	22	25	25	23	17	15	11	11	160
Al Mahweet	5	3	3	6	2	4	6	15	1	2	47
Amaran	9	12	21	13	15	9	15	30	14	11	149
Adelah		3	5	5	6	11	11	14	26	7	88
Total	240	305	314	273	353	388	387	416	459	405	3540

A10.16According to the HES, Abyan has the highest proportion of high income households (see Figure A10.8): almost a third of its households fall into the (national) top decile.

Figure A10.8: Income Distribution, Selected Governorates



A10.17It follows from the bottom row of Table A10.7 that each sample household in the lowest decile represents more households than in the top decile. In other words, the sampling rate in the bottom decile is 240/234560, about 1 per 1000, while the sampling rate in the top decile is 405/222,882, about 2 per 1000.

Poverty Distribution and Comparison with the Poverty Update Report

A10.18The Poverty Update notes[24]:

> *The distribution of the poor across the governorate of Yemen suggests marked disparities in poverty rates across the national territory. About half of the poor live in four governorates: Taiz (with 18.7 percent of the total poor), lbb (16.2 percent), Sana'a region (11.9 percent) and Al-Hodeida (10.2 percent).*
>
> *The number of poor people as a percentage of the governorate population is highest in Taiz (56 percent), Ibb (55 percent), Abyan (53 percent), and Laheg (52 percent), but is also high in Dhamar (49 percent), Hadramout, Al-Mahrah and Shabwah (43 percent). The incidence of poverty is lowest in Al-Baida (15 percent) and Saddah (27 percent) and in the two major urban centres, Sana'a city (23 percent) and Aden (30 percent).*

A10.19The distribution of the poor across governorates is largely a function of the general distribution of population. Table A10.7 shows the number of households by decile in each Governorate (as per the 2003 HES), and Table A10.8 as a percentage of the total number of households in Yemen (estimated at 2.25million).

[24] World Bank *Republic of Yemen Poverty Update*, Report 24422-Yemen, Dec. 2002

Table A10.7: Number of (Weighted) Households in Each Governorate and Decile

Monthly income	*0 -9000*	*9,001 -12,000*	*12,001 -15,000*	*15,001 -19,800*	*19,801 -22,500*	*22,501 -27,000*	*27,001 -33,000*	*33,001 -42,700*	*42,701 -61,000*	*61,001 >*	
***decile* YR/month**	***bottom***	***d[2]***	***d[3]***	***d[4]***	***d[5]***	***d[6]***	***d[7]***	***d[8]***	***d[9]***	***top 10%***	*total*
Ibb	84,561	60,552	40,198	14,286	39,354	29,065	8,027	6,077	14,122	2,420	298,662
Abyan	1,992	964	1,109	902	1,617	5,281	2,346	931	13,621	19,323	48,086
Sana'aCity	2,594	6,886	7,282	4,853	8,938	13,032	19,839	16,889	27,182	32,988	140,483
Al-Baida		2,378	4,092	750	3,167	6,952	3,396	9,152	12,523	14,252	56,661
Taiz	37,569	32,999	39,941	28,300	35,709	27,040	27,635	27,921	19,094	18,383	294,591
Hajjah	18,860	8,798	12,729	15,964	12,838	9,061	18,348	15,410	15,067	28,720	155,796
Al-Hodeida	51,450	65,806	20,351	21,969	31,280	22,412	23,696	13,276	6,531	10,870	267,641
Hadramout	1,792	3,784	13,232	10,536	15,896	21,292	14,737	18,053	28,306	21,151	148,779
Dhamar	16,706	11,561	40,398	31,311	19,129	19,535	26,646	23,042	9,089	14,077	211,494
Shabwah	1,495	822	1,827	1,837	3,753	14,019	4,425	8,170	6,530	3,793	46,671
Sa'adah	1,620	7,439	7,763	11,563	8,828	9,402	6,619	5,452	3,931	5,284	67,901
Sana'aGovern	6,066	5,513	18,670	5,762	14,198	11,582	23,801	17,750	24,632	26,737	154,711
Aden	907	4,613	3,659	4,575	7,009	6,345	8,578	9,810	13,583	6,572	65,651
Lahj	786	3,775	13,722	13,375	13,975	13,699	9,089	7,268	7,384	3,466	86,540
Al Mahweet	2,603	6,086	8,268	7,809	1,094	4,369	12,118	14,086	519	1,039	57,990
Amaran	5,978	10,171	11,833	9,196	7,900	6,140	8,182	22,316	8,898	10,081	100,694
Adelah		1,389	2,199	2,545	2,582	6,788	6,138	7,999	13,874	3,308	46,822
Total	234,980	233,535	247,273	185,532	227,267	226,015	223,618	223,603	224,887	222,463	2,249,173

Table A10.8: As Percent of the Total Households

Monthly income	*0 -9000*	*9,001 - 12,000*	*12,001 - 15,000*	*15,001 - 19,800*	*19,801 - 22,500*	*22,501 - 27,000*	*27,001 - 33,000*	*33,001 - 42,700*	*42,701 - 61,000*	*61,001 >*	
***decile* YR/month**	***bottom***	***d[2]***	***d[3]***	***d[4]***	***d[5]***	***d[6]***	***d[7]***	***d[8]***	***d[9]***	***top 10%***	*total*
Ibb	3.8%	2.7%	1.8%	0.6%	1.7%	1.3%	0.4%	0.3%	0.6%	0.1%	13.3%
Abyan	0.1%	0.0%	0.0%	0.0%	0.1%	0.2%	0.1%	0.0%	0.6%	0.9%	2.1%
Sana'aCity	0.1%	0.3%	0.3%	0.2%	0.4%	0.6%	0.9%	0.8%	1.2%	1.5%	6.2%
Al-Baida	0.0%	0.1%	0.2%	0.0%	0.1%	0.3%	0.2%	0.4%	0.6%	0.6%	2.5%
Taiz	1.7%	1.5%	1.8%	1.3%	1.6%	1.2%	1.2%	1.2%	0.8%	0.8%	13.1%
Hajjah	0.8%	0.4%	0.6%	0.7%	0.6%	0.4%	0.8%	0.7%	0.7%	1.3%	6.9%
Al-Hodeida	2.3%	2.9%	0.9%	1.0%	1.4%	1.0%	1.1%	0.6%	0.3%	0.5%	11.9%
Hadramout	0.1%	0.2%	0.6%	0.5%	0.7%	0.9%	0.7%	0.8%	1.3%	0.9%	6.6%
Dhamar	0.7%	0.5%	1.8%	1.4%	0.9%	0.9%	1.2%	1.0%	0.4%	0.6%	9.4%
Shabwah	0.1%	0.0%	0.1%	0.1%	0.2%	0.6%	0.2%	0.4%	0.3%	0.2%	2.1%
Sa'adah	0.1%	0.3%	0.3%	0.5%	0.4%	0.4%	0.3%	0.2%	0.2%	0.2%	3.0%
Sana'aGovern	0.3%	0.2%	0.8%	0.3%	0.6%	0.5%	1.1%	0.8%	1.1%	1.2%	6.9%
Aden	0.0%	0.2%	0.2%	0.2%	0.3%	0.3%	0.4%	0.4%	0.6%	0.3%	2.9%
Lahj	0.0%	0.2%	0.6%	0.6%	0.6%	0.6%	0.4%	0.3%	0.3%	0.2%	3.8%
Al Mahweet	0.1%	0.3%	0.4%	0.3%	0.0%	0.2%	0.5%	0.6%	0.0%	0.0%	2.6%
Amaran	0.3%	0.5%	0.5%	0.4%	0.4%	0.3%	0.4%	1.0%	0.4%	0.4%	4.5%
Adelah	0.0%	0.1%	0.1%	0.1%	0.1%	0.3%	0.3%	0.4%	0.6%	0.1%	2.1%
Total	10%	10%	11%	8%	10%	10%	10%	10%	10%	10%	100%

A10.20Table A10.9 shows the distribution of the poor (defined as income in the bottom 30%) – and compares the survey distribution with those of the poverty assessment.

Table A10.9: Distribution of the Poor (Defined as the Bottom 30% of all Yemeni Households)

	Survey	*Poverty assessment*	*Total Households*
Ibb	26%	16%	13%
Abyan	1%		2%
Sana'aCity	2%		6%
Al-Baida	1%		3%
Taiz	15%	19%	13%
Hajjah	6%		7%
Al-Hodeida	19%	10%	12%
Hadramout	3%		7%
Dhamar	10%		9%
Shabwah	1%		2%
Sa'adah	2%		3%
Sana'aGovern	4%	12% (including Sana'aCity	7%+6% in Sana'a City=13%
Aden	1%		3%
Lahj	3%		4%
Al Mahweet	2%		3%
Amaran	4%		4%
Adelah	1%		2%
total	100%	100%	100%

A10.21Table A10.10 shows the proportion of the poor (again defined as households in the bottom three deciles) by Governorate, comparing the survey result with that of the Poverty Assessment. For several governorates the difference is significant (notably Abyan, Hadramout, Shabwah and Lahj).

Table A10.10: Share of Poor by Governorate

	Survey	*Poverty assessment*	*Difference*
	[1]	[2]	[3]
Ibb	62%	55%	7%
Abyan	8%	53%	-45%
Sana'a City	12%	23%	-11%
Al-Baida	11%	15%	-4%
Taiz	38%	56%	-18%
Hajjah	26%		
Al-Hodeida	51%		
Hadramout	13%	43%	-30%
Dhamar	32%	49%	-17%
Shabwah	9%	43%	-34%
Sa'adah	25%	27%	-2%
Sana'aGovern	20%		
Aden	14%	30%	-16%
Lahj	21%	52%	-31%
Al Mahweet	29%		
Amaran	28%		
Adelah	8%		8%

A10.22One possible explanation of the differences lies in the use of households in the 2003 HES rather than population. But since the deciles (in the 2003 HES) are defined by household, that does seem the logical unit. Table A10.11 shows the number of persons per household in each income decile and Governorate

Table A10.11: Number of Persons per Household

Monthly income	***0 -9000***	***9,001 - 12,000***	***12,001 - 15,000***	***15,001 - 19,800***	***19,801 - 22,500***	***22,501 - 27,000***	***27,001 - 33,000***	***33,001 - 42,700***	***42,701 - 61,000***	***61,001 >***	*Governorate average*
decile YR/month	***bottom***	***d[2]***	***D[3]***	***d[4]***	***d[5]***	***d[6]***	***d[7]***	***d[8]***	***d[9]***	***top 10%***	
Ibb	4.8	6.2	6.0	6.7	6.2	6.1	8.4	8.0	7.2	8.4	6.0
Abyan	7.3	5.9	7.6	6.5	5.7	6.8	9.6	9.0	7.0	10.7	8.6
Sana'aCity	6.6	7.3	7.0	6.1	7.0	7.6	7.1	7.2	7.6	9.9	7.9
Al-Baida		4.4	4.9	6.0	4.7	6.8	5.9	7.1	8.9	8.5	7.3
Taiz	5.7	7.1	8.3	6.9	7.1	7.9	8.3	7.4	8.8	8.7	7.5
Hajjah	7.0	7.3	7.1	8.0	6.7	9.6	8.2	9.2	13.1	12.5	9.2
Al-Hodeida	5.6	5.7	6.2	5.8	6.1	6.0	7.2	6.4	9.7	10.9	6.3
Hadramout	6.3	4.8	5.7	6.2	6.8	6.8	8.5	9.1	9.2	11.0	8.1
Dhamar	7.1	4.9	6.0	7.2	7.7	6.6	7.0	7.0	9.4	13.1	7.2
Shabwah	6.0	3.6	6.5	4.9	7.2	6.9	7.3	6.8	7.0	5.9	6.7
Sa'adah	8.0	6.2	7.4	6.4	5.5	6.9	7.7	7.3	7.9	10.1	7.1
Sana'aGovern	4.5	6.6	7.4	6.8	7.6	8.3	10.5	9.8	11.1	13.1	9.7
Aden	3.0	6.7	6.0	7.5	7.0	5.6	6.9	6.8	6.5	7.7	6.7
Lahj	7.1	3.1	5.0	6.5	6.5	7.3	6.5	8.6	8.0	8.5	6.6
Al Mahweet	5.7	10.5	5.0	11.4	6.2	9.1	8.0	7.3	7.0	16.0	8.2
Amaran	4.7	7.4	8.6	9.9	6.2	11.5	11.3	13.6	10.8	12.2	10.2
Adelah		4.3	6.8	9.0	7.5	6.7	9.0	8.4	9.3	10.4	8.4
Total	5.6	6.3	6.6	7.1	6.7	7.2	8.1	8.4	9.0	10.8	7.5

A10.23Note the increase in household size with income decile, which suggests that households in the top decile have high income (at least in part) because these are the households with most wage earners. Fortunately there is a question in the 2003 HES survey that asks how many "income earners" there are in each household (#538), with results as shown in Table A10.12.

Table A10.12: Wage Earners in Each Household, By Governorate and Household Income Decile

Monthly income YR/month	*0 -9000*	*9,001 - 12,000*	*12,001 - 15,000*	*15,001 - 19,800*	*19,801 - 22,500*	*22,501 - 27,000*	*27,001 - 33,000*	*33,001 - 42,700*	*42,701 - 61,000*	*61,001 >*	*Governorate average*
decile	***bottom***	***d[2]***	***d[3]***	***d[4]***	***d[5]***	***d[6]***	***d[7]***	***d[8]***	***d[9]***	***top 10%***	
Ibb	0.8	1.4	0.8	1.7	1.0	1.2	1.2	1.7	1.9	2.7	1.1
Abyan	1.0	1.0	1.0	1.2	1.0	1.2	1.6	2.5	1.5	2.4	1.8
Sana'aCity	1.8	1.3	1.3	1.3	1.3	1.4	1.5	1.6	1.6	2.3	1.7
Al-Baida		1.2	1.4	1.8	2.2	1.1	1.2	1.9	2.0	1.9	1.7
Taiz	0.7	0.7	1.3	1.3	1.4	1.2	1.5	1.4	1.1	2.1	1.2
Hajjah	1.0	1.4	1.3	2.1	1.6	2.1	1.7	3.0	2.3	2.9	2.0
Al-Hodeida	1.2	1.2	1.4	1.5	1.2	1.5	2.0	1.7	2.8	4.0	1.5
Hadramout	1.0	0.8	0.9	1.5	1.5	1.4	1.8	2.5	2.5	3.8	2.1
Dhamar	1.4	1.3	1.2	1.3	1.3	1.4	1.8	1.7	1.7	2.8	1.5
Shabwah	1.2	1.0	1.0	1.5	1.2	1.1	1.4	1.4	1.8	1.9	1.4
Sa'adah	0.0	1.5	1.9	2.6	2.5	3.2	4.4	3.5	3.5	2.6	2.7
Sana'aGovern	1.0	0.9	1.3	1.5	1.7	1.3	2.0	1.6	2.8	2.7	1.9
Aden	0.4	1.0	1.0	1.2	1.3	1.3	1.7	2.0	2.1	3.0	1.7
Lahj	0.9	1.1	1.3	1.5	2.0	1.6	2.2	2.2	1.9	1.7	1.7
Al Mahweet	1.8	1.0	1.0	1.1	2.1	1.3	1.5	1.4	1.0	2.5	1.3
Amaran	1.0	1.6	1.3	1.3	1.4	1.3	1.7	1.7	2.0	2.3	1.6
Adelah		0.7	0.9	2.0	1.1	1.8	1.5	2.4	2.4	3.2	2.1
Total	1.0	1.2	1.2	1.5	1.4	1.4	1.8	1.9	2.1	2.7	1.6

A10.24 Indeed, this is exactly as expected: the poorest households have on average one wage earner (and a family size of 5.6 – i.e. one wage earner for 5.6 persons) – while the top income decile has 2.7 wage earners and 10.8 persons per household (i.e. one wage earner for 4 persons).

A10.25 However, this question does not appear to have been answered (or asked) consistently. In some cases one can infer that the response is equal to the number of wage earners, while in others it appears to be the number of individuals contributing to income.