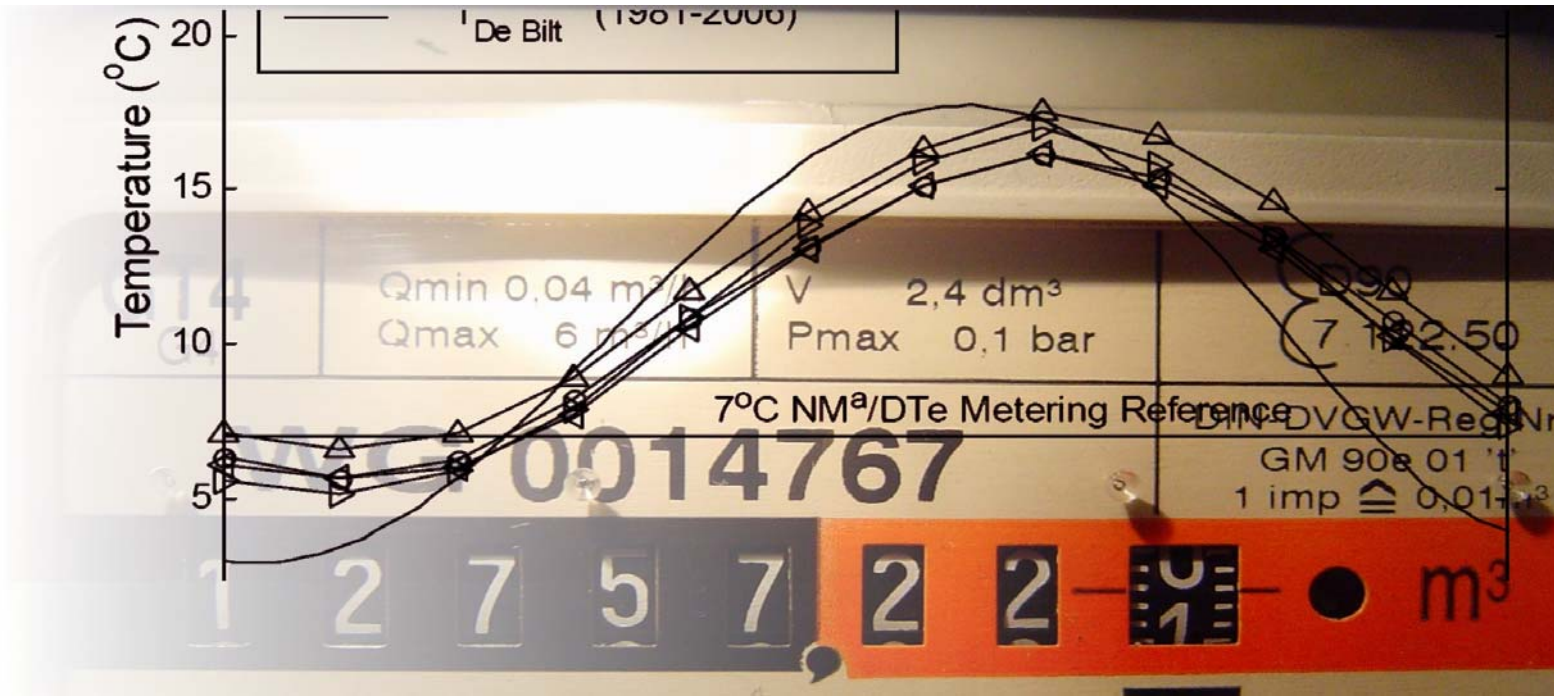
RESIDENTIAL GAS METERING: How good is it?

A Report to the Dutch Minister of Economic Affairs on the quality of billing of residential natural gas energy-usage by bellow meters

AnMar Research Laboratories B.V.



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"Western society has many flaws, and it is good for an educated person to have thought some of these through, even at the expense of losing a lecture or two to tear gas."

Robert B. Laughlin (1950-) Physicist

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Foreword

Energy is a key factor in sustained development of modern society. While energy demands increase, both domestically and across the industrialized countries, our energy infrastructure continues to rely almost exclusively on fossil fuels. This unbalance between modern energy demands is now making itself felt by reaching the physical limits of our atmosphere.

There is no quick fix to the confrontation between our energy needs and its impact on the environment. The development of a clean energy source, by large-scale deployment of a renewable energy source or fusion, will take time, at least several decades. At present, optimizing our use of (fossil) energy sources is a common sense strategy in minimizing environmental impact of greenhouse gas emissions. It requires energy awareness and quality information at all levels of governance, from state to individual residence.

Limiting the impact of greenhouse gas emissions is crucial to preserving the present global climate. Its long-term evolution depends, in particular, on the amount of permafrost, total ice-coverage, and global topology of ocean currents. Their uncertain points of instability pose a major risk in global warming trends.

What we observe in this report is a mechanical energy information infrastructure for residential energy consumption, which is woefully inadequate to meet the challenges of the Kyoto Protocol. In particular, the mechanical metering system for natural gas usage presently in place is a legacy from the 19th century, which provides no information to consumers for optimizing their residential energy needs. It should be no surprise, therefore, that we have a hard time improving home energy efficiencies.

A systematic approach to balancing modern society with the impact on environment requires us to improve in energy efficiency across all layers of society. We first need to understand how we use energy to know how to best improve. Modern technologies are available today that can dramatically improve our understanding of energy in real-time. For example, residential gas energy-usage can be correlated with local weather, for a complete measurement of home energy efficiency. Such information bodes well for informed decision making on improving our energy use.

What we recommend is a transformation of the energy information infrastructure, to be fully on par with modern developments in telecommunications and data-analysis. This demands insight and cooperation between government, industry and consumer. We hope the observations and data presented in this report will be helpful in creating a vision for practical implementation. We think that an informed consumer will think twice about energy consumptions and energy saving measures.

We gratefully acknowledge the participating residents in our field-study. We thank the KNMI, and Reflectivesystems Inc., for stimulating discussions. We gratefully acknowledge Orbi Solutions B.V. for contributing a second independent field-study.

Maurice H.P.M. van Putten Anton F.P. van Putten

Acknowledgments

Weather, soil and natural gas data are from the following sources: *The Royal Netherlands Meteorological Institute* (KNMI, http://www.knmi.nl), *The National Climatic Data Center*, U.S. Department of Commerce, (http://www.ncdc.noaa.gov), *The Energy Information Agency,* U.S. Department of Energy (http://www.eia.doe.gov) and the *Thermophysical Properties of Fluid Systems* online data base of the *National Institute of Science and Technology* (http://webbook.nist.gov/chemistry/fluid).

Data on mountain glacier thickness in Fig. H.II have been kindly provided by M.B. Dyurgerov.

The epigraph to this report is with permission from the Nobel autobiography (1998) of Robert B. Laughlin. Some of the epigraphs in this report are selected from http://www.brainyquote.com.

EXECUTIVE SUMMARY

The Minister of Economic Affairs Maria Van der Hoeven recently agreed to a formal investigation into the quality of billing of residential natural gas-usage by bellow metering in The Netherlands. This decision is in response to parliamentary questions by Halbe Zijlstra MP following an invited ANMAR Report on potentially systematic differences in actual temperatures at metering and *assumed* temperatures at billing by national gas suppliers.

We here report on a comprehensive study on temperatures in the supply and metering process based on KNMI soil and weather data and a novel field-study on temperature measurements in a nation-wide sample of homes. The results are compared with the NMa/DTe-approved 7°C accounting method.

Experimental measurements show that the mean national soil temperature at is 11.0°C at a depth of 100cm below surface. Residential gas-flow is fully turbulent and highly intermittent with a relatively small duty-cycle of 10%. It hereby rapidly equilibrates with the meter body, and hence indoor climate. Soil temperatures are therefore irrelevant to metering inside. The average temperature at metering measured in a sample of over 30 homes is 20.1°C with a standard error in the mean of 0.3°C.

Our findings show a systematic excess payment of 430 million Euros per year, based on the combined systematic error of 4.7% in conversion to normal volume introduced by the 7°C accounting method and a 1.5% metering error in mechanical bellow meters.

We recommend conversion to normal volume based on true temperature correction in the planned transition to smart metering.

The results represent a symptom of a contemporary challenge: to create a digital energy information system for complete transparency in true gas energy-usage to empower government, industry and consumers with the information they need to balance their energy needs with the impact on environment. High-quality data will be crucial to meet the objectives of the Kyoto Protocol in light of the present state of global warming. For residential gas energy-usage, we recommend dual-use smart metering in correlation with the local weather as a tool for saving energy.

Key words: accounting, gas energy-usage, bellow-meter, 7°C-method, Kyoto Protocol

EXECUTIVE SUMMARY (DUTCH)

De Minister van Economische Zaken Maria Van der Hoeven heeft op 3 april 2007 een onderzoek gelast naar de nauwkeurigheid van de gasmeters in Nederlands huishoudens. Dit besluit is genomen als antwoord op Kamervragen van de volksvertegenwoordiger (VVD), de heer Halbe Zijlstra. Deze vragen zijn gesteld naar aanleiding van een door AnMar b.v. op uitnodiging van Zijlstra vervaardigd rapport d.d. 28 maart 2007. De door de gasleveranciers toegepaste volumeherleidingmethode voor het bepalen van het gasverbruik voor de consument, wordt in dit rapport aan een diepgaand onderzoek onderworpen.

Dit rapport doet verslag van een uitgebreid veldonderzoek van de invloed van de temperatuur op de balgenmeter. De resultaten worden vergeleken met de door de Nederlandse Mededingingsautoriteit (NMa) / en de Directie Toezicht Energie (DTe) toegepaste volumeherleidingsmethode. Bij deze individuele volumeherleidingsmethode wordt verondersteld, dat de gastemperatuur 7°C bedraagt en de gasdruk overeenkomt met de nominale leveringsdruk, vermeerderd met 1,01325 bar.

In dit onderzoek is gebruik gemaakt van door KNMI gemeten grondtemperatuur 100 cm beneden maaiveld (daar op deze diepte de gasleidingen liggen) over de afgelopen 20 jaar en de weerdata. In het door AnMar uitgevoerde veldonderzoek is daarnaast de buitentemperatuur, de temperatuur in de balgenmeter en de temperatuur in de meterkast gemeten. Een tweede onafhankelijk veldonderzoek is uitgevoerd door Orbi Solutions b.v. te Aalten en Winterswijk (Gelderland). Het totale veldonderzoek heeft een landelijke dekking en omvat ruim 30 woonhuizen van verschillende typen.

KNMI data geven een gemiddelde landelijke grondtemperatuur van 11.0°C op 100 cm diepte. Gebleken is, dat huishoudelijke gasstromen volledig turbulent zijn en een intermitterend karakter vertonen, met een relatief korte duty-cycle van 10%. Gebleken is verder, dat zich in de balgenmeter een vrijwel instantaan thermisch evenwicht instelt met het binnenklimaat. De grondtemperatuur van het gas blijkt niet relevant te zijn. De gemiddelde metertemperatuur, in een steekproef van ruim 30 huizen, is bepaald op 20.1°C met een standaard fout van het gemiddelde van 0.3°C.

Het onderzoek toont een teveelbetaling aan van 430 miljoen Euros per jaar op het totaal van alle aansluitingen. Deze teveelbetaling bestaat uit de som van een systematische fout van 4.7% bij de conversie naar normaal volume op basis van de 7°C graden methode. De additionele meetfout van 1,5% van de mechanische balgenmeter resulteert in een totale gemeten fout van 6,2%.

De onderzoeksresultaten zijn mede van belang voor de zo noodzakelijke bewustwording van de consument van zijn werkelijke energieverbruik. Hiervoor dient een nieuwe informatie infrastructuur te worden gerealiseerd om regering, industrie en de consument te steunen in het realizeren van de doelstellingen van het Kyoto Protocol, gelet op de geconstateerde klimaatverandering. Voor huishoudelijk gebruik van aardgas wordt aanbevolen dual-use smart metering in correlatie met het weer, om het gasverbruik individueel transparant te maken als middel tot energie besparing.

Key words: accounting, gas energy-usage, bellow-meter, 7°C-method, Kyoto Protocol

1. INTRODUCTION

"Physics is experience, arranged in economical order." Ernst Mach (1838-1916) Physicist

The Netherlands is a major international participant in the natural gas-industry both as a supplier and consumer.[1] It has about 6.8 million households connected to the gas-net. Each household consumes an average of about 1800m^3 of natural gas per year which, at present price levels, is billed at about 6.8 billion Euros per year including transportation costs. With the individual contribution of about 1000 Euros per year, natural gas-consumption is a major economic factor in people's lives.

The financial infrastructure in the gas-industry is highly dependent on measurement technology to facilitate transport, trade and supply. While there is considerable investment in accurate and reliable measurement systems at the side of production and transport, metering technology at the supply side to residences consists of mechanical bellow meters developed in the first half of the *nineteenth* century[2]. At that time, the novelty was new business in introducing natural gas to homes with secondary emphasis on the accuracy of metering itself. While the technology of residential gas-metering has not changed, the world around us has in dramatic ways.

Energy is gradually becoming a scarce commodity with demand increasing more rapidly than supply. This trend is stimulated by globalization of the economy with newly emerging industrialized economies, and a lack in conversion to renewable energy sources. Our increasing dependence on fossil fuels is believed to have initiated the presently observed trend in global warming at the beginning of the industrial revolution. [3] Its environmental impact may have dramatic economic consequences, [4] which poses new challenges in public policy and technology development on renewable energy sources and cost-effective energy savings.

A recent invited ANMAR Report to MP Zijlstra[5] describes a preliminary estimate on systematic errors in billing of residential gas consumption in The Netherlands, based on conversion to normal volume using the NMa/DTe-approved 7°C accounting method.[6] The preliminary estimate of a nationwide excess payment of 350 million Euros per year reflects the inadequacy of a mechanical metering infrastructure, especially given the need for quality information as a tool for saving energy.

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[1] http://www.eia.doe.gov/pub/international/iealf/table24.xls

[2] S. Clegg, 1816, in Luckiesh, M., 1920, Artificial Light, Gutenberg Project e-book 17625; J. Bogardus, 1837, in Gayle, M., & Gillon, E.V., Jr., 1974, Cast-Iron Architecture in New York (Dover Publications: New York), pxi; T. Glover, 1843, in Bluvshtein, I., & Energy, D., 2007, Pipeline & Gas J., 28:1

[3] National Academy of Sciences, 1999, Adequacy of climate observing systems; *ibid.* 2001, Climate change science: an analysis of some key questions; *ibid*. 2006, Surface Temperature Reconstructions for the last 2000 years

[4] Sprott, E., & Bambrough, K., May 2006, Investment Implications of an Abrupt Climate Change (Sprott Asset Management: Toronto).

[5] van Putten et al., March 29, 2007, AnMar Report to VVD-woordvoerder H. Zijlstra (Anmar Research Laboratories B.V.: Eindhoven), Appendix A.

[6] Measurement conditions gas – RNB, part of conditions of Artikel 12b of the Gas Law, published by NMa/DTe.

The preliminary estimate of 350 million Euros per year excess payment is based on a typical 10°C error in the conversion to normal volume[7] in the 7°C accounting method. It includes a metering error of 1.5%, which is representative for the bellow meters currently in use. It should be mentioned that installation of a bellow meter in a warm location inside homes is known to be ill-advised[8].

In response to questions by MP Halbe Zijlstra,[9] the Minister of Economic Affairs Maria van der Hoeven has agreed to a formal investigation on the accuracy of the 7°C method for conversion to normal volume in residential gas metering. As a public issue, it enjoys broad political and public support from MPs Jos Hessels (CDA), Ferd Crone (PvdA), Dion Graus (PVV) and others.[10]

In this Report, a detailed account is given of the original AnMar Report in two parts:

Part I evaluates the 7°C accounting method in conversion to normal volume, based on a comprehensive field-study on temperatures at metering. Included is a review of the available soil and weather data, heat-transfer to natural gas during metering and a temperature error analysis in billing.

Part II discusses a contemporary context of residential gas energy-usage in home energy efficiency and its relevance to the Kyoto Protocol. This discussion takes a global view by analyzing soil and weather data from the weather services of The Netherlands and California. We estimate home energy efficiency by weather-sensitivity analysis.

In the recommendations (Section 12), we highlight the unique opportunity for *dual-use smart metering* to address both the issues of Part I and II in the upcoming transition to smart metering.[11] Specifically, we highlight the opportunity to promote

- Energy awareness, to balance today's energy needs with the environment
- Empower consumers with the information they need to start saving energy
- Reliable billing with safeguards for consumers.

This report thus presents an integrated analysis on measurement of normal volume, energy-usage and energy information technology in today's residential energy consumption. We hope it provides a roadmap for informed decision making on today's investments for the future.

[7]Appendix B
[8]Barkham Burroughs, 1889, Encyclopaedia of Astounding Facts and Useful Information, p368, Gutenberg Project e-book 14091
[9]Appendix C
[10]Mos, B., & Ruempel, J., March 31 2007, Gasmeters Liegen, www.telegraaf.nl; *ibid.* April 1 2007, Onderzoek Liegende Gasmeters; Zijlstra, H., April 3 2007, Deviations in residential gas-metering and the disadvantageous consequences for natural gas billing to citizens (Afwijkingen bij gasmeters en de nadelige gevolgen daarvan voor de energie rekening van burgers), in Question Session, Dutch Parliament (Vragenuur Tweede Kamer der Staten Generaal); ibid. Minister M. Van der Hoeven, April 3, 2007.
[11]NTA 8130:2007 NL, 2007, (NEN: Arnhem)

Statement of interest

This research has been conducted as a public service with no financial support from government or gas-industry. It describes a detailed field-study following a recent invited ANMAR Report by a Member of the Dutch Parliament. Key findings of this research are based on KNMI soil and weather data and temperature measurements on a random sample of 32 residential gas meters in two independent field studies. Some historical data from the Van Putten Gas Energy-Observatory Project are included. The VPGEO Project is a recent initiative on digital energy information to promote the Kyoto Protocol. Its historical data are consistent with and do not influence the conclusions derived from KNMI data and the field-study reported in this publication.