May 14, 2025

Before the House Energy Committee
Pennsylvania State House of Representatives
Informational Meeting

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Good morning and thank you for the opportunity to speak with you today. My name is Diane Holder, and I am the Vice President of Engineering and Strategic Engagement at ReliabilityFirst Corporation (RF). My role involves overseeing our state outreach initiatives and engineering services. I am an electrical engineer with approximately 30 years of experience in the electric utility industry, having held roles in engineering, operations, and external affairs.

RF is one of six North American Electric Reliability Corporation[1] (NERC) Regional Entities responsible for preserving and enhancing the reliability, resilience, and security of the bulk power system (BPS).[2] Our role was created following the 2003 Northeast blackout, which impacted 50 million North Americans across Michigan, Ohio, Pennsylvania, New York and Ontario. This event prompted the Energy Policy Act of 2005, which created the ERO (Electric Reliability Organization). Collectively, NERC and the Regional Entities comprise the ERO Enterprise. With specific authorities under the Federal Power Act and through a delegation agreement with NERC, RF's mission serves the public good and supports health and safety by assuring BPS reliability for over 73 million customers in our 13 states and the District of Columbia.[3]

We are responsible for auditing and enforcing the NERC Reliability Standards for more than 300 registered entities in our footprint, including Regional Transmission Organizations (RTOs) PJM and MISO, utility companies, and generators. We also provide outreach, training, and education to those entities, and technical expertise to state public utility commissions, legislators, and other stakeholders. Our staff includes power system engineers, control area operators, and forensic cyber experts, as well as data analysts, auditors, attorneys, and others. We participate with FERC

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[1] The North American Electric Reliability Corporation (NERC) is a not-for-profit international regulatory authority designated by the Federal Energy Regulatory Commission (FERC) to assure the effective and efficient reduction of risks to the reliability and security of the grid. Through delegation agreements and with oversight from FERC, NERC works with six Regional Entities (including RF) on compliance monitoring and enforcement activities. Collectively, NERC and the Regional Entities comprise the ERO Enterprise. The ERO Enterprise jurisdiction includes users, owners, and operators of the BPS, which serves nearly 400 million people in the continental United States, Canada, and Mexico.

[2] See the NERC Overview for a map depicting the footprints of NERC and the Regional Entities (page 2)

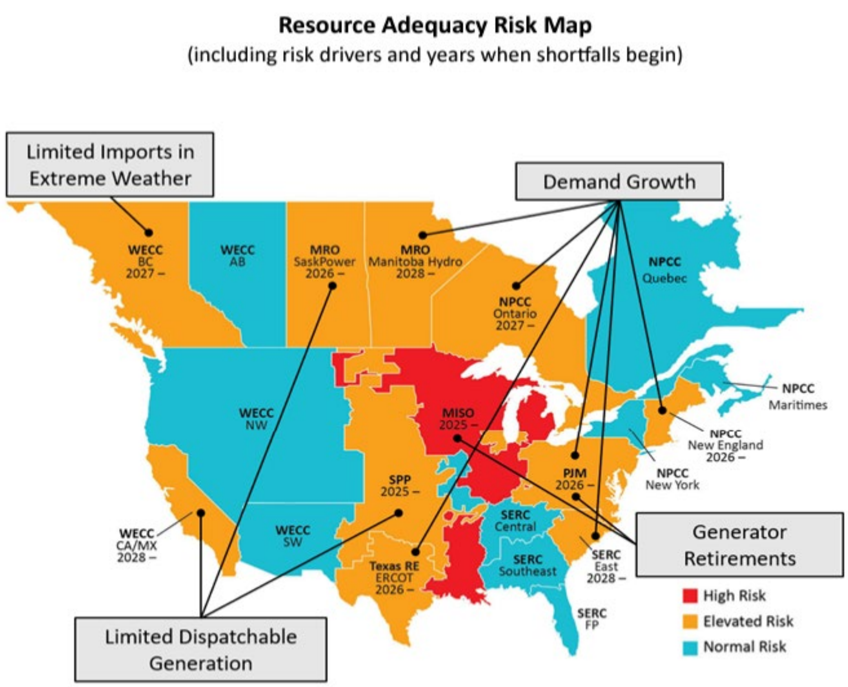
[3] RF does not have jurisdiction over the local distribution of electricity

(the Federal Energy Regulatory Commission) and NERC on inquiries, task forces, and working groups, and have a unique perspective working on these complex challenges.

RF's role in today's discussion is to serve as a technical resource concerning the reliability risks associated with the rapidly changing generation resource mix, and describe actions taken by RF and the ERO Enterprise to help mitigate these risks. While energy policy should appropriately consider and prioritize BPS reliability, our statements are not intended, and should not be interpreted, as advocating for a specific position, fuel source, or policy outcome.

I. Resource Adequacy Reliability Considerations

To provide context for the remainder of the testimony, this section presents an overview of the current state of resource adequacy. Resource adequacy refers to matching supply with demand to ensure that the grid has adequate resources to supply loads 24 hours per day, 365 days per year, during all operating conditions. NERC annually assesses and reports on the adequacy of the Bulk Electric System in the United States and Canada over a 10-year period. This report, the Long-Term Reliability Assessment (LTRA),[4] projects electricity supply and demand and discusses key issues and trends that could affect reliability.



<u>Figure 1</u>: The 2024 LTRA risk map by region[5]

Over a ten-year horizon, the 2024 LTRA finds many areas of North America are at risk of energy shortfalls during extreme weather conditions (designated as "elevated risk" in Figure 1) and even

[4] NERC_Long Term Reliability Assessment_2024.pdf
[5] 2024 NERC LTRA p. 6

during normal peak conditions (designated as "high risk" in Figure 1). From the 2023 to the 2024 LTRA, the PJM region was raised from normal to elevated risk. Reliability concerns discussed in the 2024 LTRA include demand growth, generator retirements (with over 79 GW of fossil-fired and nuclear generator retirements planned through 2034), slower than anticipated new generation, and capacity shortages from limited dispatchable generation. These can all impact reliability margins and reserves, and in some cases, require extensive transmission reinforcement projects to sustain reliability. Additionally, due to the variable nature of renewable generation, more renewable capacity will be needed than the thermal generation that it replaces.[6]

II. Discussion Topic 1: Getting the Most Out of the Grid We Have

The first question raised during today's hearing concerns what actions can be taken to ensure we are maximizing the use of our existing grid. We have outlined several items below in response to this question.

A. Identifying and Addressing Known Risks to the System

An important part of maximizing the grid involves identifying and addressing as many of the well-known risks as we can, to make the grid more reliable and resilient in the face of challenges posed by increased demand and the energy transition.

Our work at RF focuses on risk identification and mitigation. The RF Regional Risk Assessment[7] and the NERC Reliability Risk Priorities Report (RISC Report)[8] provide information on the top risks facing the electric system today and how to manage them. These risks include the grid transformation and the resource adequacy challenges I already discussed, as well as extreme weather events,[9] physical and cyber security risks, and critical infrastructure interdependencies (the ways that different sectors such as gas, water, and manufacturing can impact the electric grid and vice versa). Any one of these risks could be the focus of an entire hearing. Our efforts span various areas; we monitor and enforce the NERC Reliability Standards to reduce risk on the system, plus conduct outreach, training, and education across the industry.

One example of this is RF's voluntary winterization outreach program. While there are new NERC Reliability Standards that help address reliability concerns related to extreme weather, RF also conducts on-site voluntary winterization visits for new generators and generating units that

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[6] In other words, a MW of synchronous, thermal generation retired is not equivalent to a MW of new asynchronous, intermittent generation installed.
[7] RF-Regional-Risk-Assessment-2023-24.pdf
[8] RISC_ERO_Priorities_Report_2023_Board_Approved_Aug_17_2023.pdf
[9] Winter Storm Elliott and its lessons learned demonstrate the risks of generation retirements dovetailing with extreme weather events. Winter Storm Elliott was the fifth major storm with reliability impacts in the last eleven years. There were unprecedented electric generation outages coinciding with winter peak electricity demands, resulting in about 5,000 MW of load shed as rolling blackouts. Presentation | FERC-NERC-Regional Entity Joint Inquiry Into Winter Storm Elliott | Federal Energy Regulatory Commission

experienced freezing issues the previous winter. RF subject matter experts go on-site, visiting with the plant manager and inspecting the facility. This outreach results in recommendations for improvement and lessons learned from other site visits and recent events. Additionally, we document best practices to share on subsequent winterization site visits.

NERC and the Regions also study past events and share lessons learned[10] from those events with the industry. In June 2024, NERC and the ERO released the 2024 CIP Themes Report[11], which unpacks broad themes related to cyber security risks and mitigation strategies. We are also proactive in engaging with other countries to exchange insights on lessons learned from their grid transformations, as well as collaborating with other critical infrastructures to understand the risks and challenges they encounter. For example, we have studied cyber and physical security events impacting natural gas and water to determine if the electric grid may be susceptible to the same threats and vulnerabilities.

Over the past year, NERC and the Regions partnered to perform the Interregional Transfer Capability Study (ITCS), which analyzed total transfer capability (the amount of power that can be transferred between transmission planning regions to improve energy adequacy). It recommends prudent additions to total transfer capability that could strengthen reliability. The complete ITCS has been filed with FERC and recently made available for public comment. The comments are currently under review by FERC prior to presentation to Congress.[12]

Just last month, NERC posted a report[13] summarizing the key findings from its Level 2 Recommendation to Industry: Inverter-Based Resource Model Quality Deficiencies Alert,[14] which was issued in 2024 to Generator Owners, Transmission Planners, and Planning Coordinators. The alert included recommendations for IBR modeling best practices and questions to understand the extent of condition of dynamic modeling deficiencies for IBR. NERC plans to release a follow-up alert in Q2 this year to continue discussion of these risks and help improve system reliability.

Additional reliability risks NERC and the Regions have been working to bring to the forefront include asset management (for assets like substations, transformers, generating facilities, and control centers) and configuration awareness. Reliability depends in part upon an entity's success in tracking, managing, and maintaining significant amounts of data, components, assets, and systems, especially when building new assets. Facility ratings and system limitations also play a key role in modeling the grid as future BPS projects are contemplated to manage load growth and mitigate system constraints. The ERO Enterprise has been actively engaged in identifying and working to mitigate challenges associated with facility ratings programs through outreach,

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[10] NERC Lessons Learned and Event Reports
[11] 2024-CIP-Themes-and-Lessons-Learned.pdf
[12] 20241125-3020_AD25-4-000-NERC ITCS Notice.pdf.pdf
[13] Inverter-Based_Resource_Modeling_Deficiencies_Aggregated_Report.pdf
[14] The aggregated report is posted for awareness to help inform industry what additional actions are necessary to mitigate observed deficiencies, with a comprehensive list of all alerts is also available here: NERC Alerts

education, discussions at Regional Entity and NERC technical committee meetings, and monitoring, enforcement, and mitigation activities. In 2022, NERC and the ERO released the ERO Enterprise Themes and Best Practices for Sustaining Accurate Facility Ratings[15] to document and share with industry.

Asset management and facility ratings will become more impactful as Grid Enhancing Technologies (GETS) such as new sensors and power flow control devices are brought onto the system. Recordkeeping will need to be accurate if we wish to gain additional margins from our existing (and aging) infrastructure. These new devices will also require training and skills development to prevent or reduce errors.

B. Maintaining the Appropriate Amount of Essential Reliability Services

The testimony began with the well-known Resource Adequacy challenges we are facing in the RF region. However, even if we can keep up on the supply and demand of Megawatts to serve the load throughout all hours of the day, essential reliability services[16] must be accounted for to ensure energy policies and market designs can appropriately reflect evolving reliability challenges. These grid attributes are operating features essential for reliability and are typically found in traditional, synchronous machines.[17] Essential reliability services include dispatchable ramping, frequency response, and voltage support.

Dispatchable ramping refers to generation that system operators can easily call upon, that can be reliably turned on, turned off, increased, and decreased to match the corresponding variability of the load. Frequency response is critical to maintain and quickly restore frequency to limit negative effects on equipment and operations. Sufficient ramping capability is also vital to support frequency stability. Voltage control plays a key role to ensure power is delivered where it is most needed.[18]

The essential reliability services I just described help ensure the flexibility of the grid. Flexibility is needed to respond to various circumstances, such as unforeseen rises in demand or generation shortfalls. Fast start-up of generation (and generation availability during peak and off-peak times) is key to ensuring reliability during the energy transition.

It is also important for fuel to be readily available when needed. This has been an issue during extreme weather events. Recommendations coming out of FERC and ERO cold weather inquiry reports suggest having alternate fuel sources, and to forecast and communicate fuel availability

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[15] ERO Enterprise Themes and Best Practices for Sustaining Accurate FR - Final - Oct-20-22.pdf
[16] Read more about Essential Reliability Services from NERC's two-page brief here: ERS Abstract Report Final.pdf
[17] However, with the addition of Grid Enhancing Technology such as smart inverters (or grid-forming inverters), some of the essential reliability services not inherently found in asynchronous machines could be provided by IBR in the future.
[18] NERC resource: The Basics of Essential Reliability Services

to Balancing Authorities. Resources that are tied to a single fuel source can be a risk, which is why NERC and the Regions are looking at critical interdependencies regarding fuel availability.

Finally, blackstart[19] is a category sometimes overlooked, yet critical for reliability and resilience. Generating units with blackstart capability can be started without support or connection to the grid and can provide their own initial power source to restart power flow and restore the grid. The retirement and availability of blackstart resources is an important topic for states to discuss with their RTO and regional reliability organization, such as RF.

Information sharing and collaboration are crucial when working to ensure the proper amount of essential reliability services on the grid. States can consult and work with the RTOs to obtain information on their current and future resource mixes, and when shortfalls are forecast, to discuss where those essential reliability services will come from and how they will be secured. Policymakers must also appropriately prioritize essential reliability services during policy and market design. Regardless of the approach, be it tax credits, siting decisions, or clean energy standards, the critical role of these essential reliability services and growing reliability challenges should remain central to decision-making.

C. Planning for Large Load Growth

The rapid and increasing connection of large commercial and industrial loads to the grid, such as crypto and AI data centers, hydrogen fuel facilities, and manufacturing plants, is creating significant challenges for forecasting and planning. This trend, combined with accelerating electrification, is the primary driver in rising energy demand.[20] The PJM region has seen a rapid connection of large loads, and it is expected that this growth will continue.[21] We are seeing that these loads generally populate faster than new generation to power them can be brought online, creating areas of congestion.[22] Careful consideration of load deliverability, access to transmission, and generation and fuel source location can help reduce reliability risks.

In addition to planning challenges, these large, rapidly connecting loads also raise operational concerns. A system fault could cause several of these loads to disconnect simultaneously, an uncommon scenario in the past, potentially destabilizing the grid.[23] Co-located loads pose unique challenges, as they may or may not be visible to the system operator depending on their operational characteristics and interconnection type. Fluctuations during faults or switching events can also potentially cause issues with voltage support, frequency response, harmonics, the

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[19] NASEO_The Black Box of Blackstart_FINAL.pdf
[20] 2024 NERC LTRA p. 31
[21] 2024 NERC LTRA p. 38
[22] 2024 NERC LTRA p. 92
[23] Incident_Review_Large_Load_Loss.pdf

stability of neighboring resources, or protection system coordination. Additional consideration should be given for system restoration purposes.[24]

The co-location of large energy consumers with power plants presents both opportunities and challenges for system reliability. The overall impact will depend on the specific implementation, technologies used, and regulatory framework. Careful planning, robust fail safes, and thoughtful policy can help to maximize benefits and minimize risk associated with co-located load configuration.

III. Discussion Topic 2: How to Support Expanded Capacity of the Grid So That We Are Prepared for Significantly Higher Levels of Electric Generation and Consumption

A. Grid Transformation and the Energy Trilemma

Before I discuss actions state lawmakers can take, I want to briefly talk about the energy trilemma, which is central to any discussion on energy policy. The transformation of the grid due to demand growth, generator retirements, and increasing extreme weather events presents an "energy trilemma," that is, the need to ensure reliability while also balancing cost and environmental factors. RF's area of expertise, electric reliability, is vital to modern life to ensure the health and well-being of citizens and maintain the economy and national security. Cost also plays a key role, as unaffordable electricity can hinder economic opportunities and disproportionally affects the most vulnerable among us. Finally, it is important for grid transformation solutions to be environmentally sustainable.

Policymakers are tasked with finding the right balance between these three factors. Given the current reliability and risk landscape I've discussed today, it is helpful to think about how to maintain reliability when looking at the other two factors (for example, "how do I decarbonize the grid in a way that also preserves reliability and maintains enough essential reliability services," or "how do I reduce costs in a way that also preserves reliability).

B. Exploring the Optimization and Expansion of Generation and Transmission Infrastructure

Next, I would like to note a few recommendations for state lawmakers from the 2024 NERC LTRA. First, the LTRA states that as ISO/RTOs continue looking for opportunities to streamline transmission planning processes, delays from siting and permitting activities (the most common causes of delayed transmission projects) will need to be reduced. Support from regulators and policymakers at both the federal and state levels to address these delays will help these

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[24] For instance, if the generation is needed to assist in the restoration of the grid, then obligation to serve the co-located load could be suspended until the grid is restored in a manner that can reliably feed the co-located load.

transmission planning processes.[25] Additionally, the LTRA notes that policymakers can also work alongside NERC, the Regions, the RTOs, and industry to implement a framework for addressing the operating and planning needs of the interconnected natural gas-electric energy system.[26]

In addition to the recommendations from the LTRA, it is helpful for lawmakers to continue to work with the RTOs on how to best ensure additional generation resources, a diverse resource mix, and essential reliability services. In support of this, the RTOs in the RF footprint have put forth initiatives to get shovel-ready resources through the interconnection queue more quickly. In PJM, the Reliability Resource Initiative (RRI) has already attracted 94 applications totaling 26.6 GW of nameplate capacity, 47 of which are uprates (existing resources to be modified to generate more electricity).[27] Similarly, in MISO, the Expedited Resource Addition Study (ERAS) proposal[28] that is currently under review at FERC seeks to shorten the length of time projects spend in the generation queue.

C. Considering Effective Load Carrying Capability

As the resource mix evolves to include more variable and limited-duration resources, system planning is shifting from a focus on capacity adequacy, which ensures sufficient capacity to serve the highest expected demand, to energy adequacy, which is the ability to deliver energy across all hours, seasons, and weather conditions. In this context, it becomes increasingly important to move beyond nameplate capacity, which reflects only the maximum potential output of a generator under ideal conditions. Instead, emphasis should be placed on accredited capacity, which is the portion of nameplate capacity that can be reasonably relied upon to contribute to reliability during times of system stress. One of the primary metrics used to assess accredited capacity is Effective Load Carrying Capability (ELCC). PJM defines ELCC as a means to calculate the contribution of all resources to overall system reliability.[29] The higher the ELCC, the more often the generation is available and can be counted on during high load conditions, as seen in Figure 2. Encouraging the development of new resources that improve the overall fleet's ELCC supports system reliability, especially as traditional, higher-ELCC generation retires and is replaced with new intermittent, lower-ELCC generation.

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[25] NERC LTRA at p. 10.
[26] NERC LTRA at p. 10.
[27] Reliability Resource Initiative Draws 94 Applications | PJM Inside Lines
[28] FERC eLibrary | File List
[29] https://www.pjm.com/-/media/DotCom/about-pjm/newsroom/fact-sheets/elcc-measures-capacity-contribution-of-renewable-and-storage-resources.pdf

	2026/2027 BRA ELCC Class Ratings
Onshore Wind	41%
Offshore Wind	69%
Fixed-Tilt Solar	8%
Tracking Solar	11%
Landfill Intermittent	50%
Hydro Intermittent	38%
4-hr Storage	50%
6-hr Storage	58%
8-hr Storage	62%
10-hr Storage	72%
Demand Resource	69%
Nuclear	95%
Coal	83%
Gas Combined Cycle	74%
Gas Combustion Turbine	60%
Gas Combustion Turbine Dual Fuel	78%
Diesel Utility	91%
Steam	73%

Figure 2: PJM ELCC Class Ratings for the 2026/2027 Delivery Year[30]

At the same time, it is important to recognize that a diverse portfolio of resources, one that does not depend on a singular fuel source, supply chain, or common failure mechanism, can enhance overall system reliability and resilience. This is because all types of electrical generators can contribute to reliable electric service, and they all have different strengths and limitations. A balanced resource mix that includes renewables, storage, fossil fuels, nuclear, and hydro power plants helps mitigate the risk of widespread outages. When one technology experiences performance limitations, others may be better positioned to provide support and maintain reliable service.

Grid Enhancing Technologies can also be leveraged using superconductors to mitigate power loss across lines plus Ambient Adjusted Ratings (AAR) and Dynamic Line Ratings (DLR)[31] to appropriately update the calculated limits of existing transmission lines based on real-time and forecasted weather conditions to allow for increased energy transfers.

Additional options are not confined to generation and transmission. There are load-side solutions such as demand response programs and flexible loads that can be shifted – though I will note that in our experience, these have been at a much smaller scale than what would be needed to address massive load growth and numerous generation retirements.

D. Learning from International Events

The risks and challenges I have discussed today are starting to manifest themselves in other regions of the country and across the world. While many are familiar with the Texas Odessa Report, California Moss Landing fire, and the recent Winter Storm Reports (Uri, Elliot,

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[30] 2026-27-bra-elcc-class-ratings.pdf
[31] RM20-16-000-Final Rule | Federal Energy Regulatory Commission

Gerri/Heather, and Enzo), there are some important lessons learned from recent international blackouts that remind us of the risks we are facing.

In early February this year, Sri Lanka experienced an island-wide power outage that was primarily due to low system stability (meaning low system inertia), driven by the "exceptionally high contribution of solar photovoltaic." However, the cause is more complex than simply having a large amount of solar on the system. While Sri Lanka has a capacity of about 4,600 MW, it suffers 40% transmission losses. Additionally, no new power plants were built from 2016-2019, among other factors.[32] The Sri Lanka event shows the importance of pairing storage with renewables, as well as the importance of diverse and flexible generation.

Even more recently, and still under investigation, is the Iberian Peninsula (Spain and Portugal) blackout just a few weeks ago. Just before the collapse, over 70% of the generation in Spain was from renewable resources, approximately 60% of which was solar[33]. While some would rush to say renewables are the sole issue, this generation mix was not unusual in Spain or Portugal, especially on sunny and windy days. Digging deeper, preliminary investigations from Spain's grid operator indicate that two consecutive generation loss events occurred in southwestern Spain, and given the unavailability of conventional spinning generation, led to instability that triggered disconnection from France and ultimately culminated in the power outage.[34] This event helps show how the Essential Reliability Services I have discussed are critical to the grid's reliability, as well as investing in Grid Enhancing Technologies such as grid-forming inverters to help with sudden losses that cause fluctuations in stability.

Planners, policymakers, and industry can look at events like these and use them to initiate important conversations about inertia, transmission planning studies, oscillations, grid-forming inverters, and preserving system strength before, during, and after grid disturbances. As the MISO RIIA report specifies, systems with 30-50% of IBR resources will present some unique challenges[35]. Determining the resources needed while we move through this grid transformation will be vital in our reliability journey.

I will conclude by saying that to successfully address the complex reliability challenges emerging as the grid is transformed, NERC, the Regional Entities, and state and federal policymakers will need continued collaboration, coordination, and thoughtful action. Robust resource adequacy planning that acknowledges the benefits of a diverse resource mix and the threat of extreme weather will help fortify the grid and protect electricity consumers from cascading outages. As states craft policies for a cleaner, more sustainable grid, we are pleased to serve as a resource to help you remain well informed regarding key reliability topics.

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[32] History-Repeating-Itself_Sri-Lanka-Electricity-Crisis_Final.pdf
[33] Real-time electricity demand, generation structure and CO2 emissions
[34] Blackout in Spain and Portugal: What do we know so far?.pdf
[35] RIIA Executive Summary520053.pdf; see starting p. 4