Adjunct Professor Magdalena A K Muir is making this presentation on behalf of John Hopkins University’s Energy Policy and Climate Program.

Professor Muir is academically affiliated with two other institutions:
• She is a Research Associate at the Arctic Institute of North America, which is bi-national institution based at the University of Calgary and the University of Alaska Fairbanks.
• She is an External Lecturer at Aarhus University in Denmark and engaged in the Nordic Centre of Excellence for Strategic Adaptation Research.

This presentation and related research in Nigeria is occurring under the Sustainable Energy Development project supported by these academic institutions. Further information is available on this project at arctic.ucalgary.ca/research/sustainable_energy_development.
This slide introduces the opportunities that renewable energy can provide in Nigeria.
The slide lists Nigerian energy resources.
This slide summary some key aspects of Nigeria’s energy systems and energy demand, and the climate implications of these energy systems and demand.
This slide illustrates electricity distribution and transmission in Nigeria.
This slide illustrates electricity transmission infrastructure in Nigeria.
This slide illustrates a possible future electricity grid for Nigeria with enhanced transmission.
This slide discusses renewable energy and energy efficiency.

Renewable Energy & Energy Efficiency
Opportunity for decentralized energy system:
- small hydropower, solar photovoltaic
- wind, biodiesel and biogas—on existing
- or enhanced transmission system, or off grid
- in rural, remote or non-served areas.
Higher cost technology but competitive life
- cycle costs & meet additional energy demand
Scope for rational energy use in Nigeria as
- supply side and demand efficiency low:
  - Transmission/distribution losses > 30 %
  - Demand side—low boiler efficiency.
This slide discusses the connection between renewable energy and water, and introduces the next topics in the presentation.
This slide illustrates major rivers and dams and water developments in the Hadejia-Jama'are-Komatugu-Yobe (HJKY Basin), which is a sub-catchment of the larger Lake Chad Basin.
This slide lists the distribution of potential small hydro sites within Nigeria.
This slide lists existing small hydropower in Nigeria.

<table>
<thead>
<tr>
<th>S/N</th>
<th>River</th>
<th>State</th>
<th>Installed Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bagel (I)</td>
<td>Plateau</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>Bagel (II)</td>
<td>&quot;</td>
<td>2.0</td>
</tr>
<tr>
<td>3</td>
<td>Kurra</td>
<td>&quot;</td>
<td>8.0</td>
</tr>
<tr>
<td>4</td>
<td>Lere (I)</td>
<td>&quot;</td>
<td>4.0</td>
</tr>
<tr>
<td>5</td>
<td>Lere (II)</td>
<td>&quot;</td>
<td>4.0</td>
</tr>
<tr>
<td>6</td>
<td>Bakalori*</td>
<td>Zamfara</td>
<td>3.0</td>
</tr>
<tr>
<td>7</td>
<td>Oyan</td>
<td>Ogun</td>
<td>9.0</td>
</tr>
</tbody>
</table>

Source: Power Sector Master Plan, prepared by USAID and Shell in 1998.
This slide illustrates a case study for small rural hydroelectric facility and transmission system in Nigeria.

This is a 3Kw micro hydropower scheme privately operated by a farmer and village electrician. It is located in Evboro II village, Ovia N.E. LGA, Edo State, 45 km west of Benin City. This is a small farming village with 55 families and 400 people. The Ogbovben River divides the village and provides the water for the impoundment.

As the pictures illustrate, the dam and transmission system are made of inexpensive and locally available materials.

This slide discusses the energy and water nexus for Africa and Nigeria.

Water and Energy Nexus for Africa and Nigeria

Integrating energy and water systems at any scale offers unique opportunities for energy and water security and economic development.

Wind, solar and renewable energy can be combined with desalination facilities for treatment of drinking waste water, or for the extraction and replacement of water in aquifers and dams.

Hydro, solar and wind resources (supported by hydrogen storage, aquifer management, dams and and hydraulic storage) can substitute for coal and hydrocarbons, increasing energy security and decreasing carbon emissions.

Intermittency of renewable energy, energy requirements of desalination and water treatment facilities addressed by design and technologies.
This slide illustrates the complexity and productivity of different types of desalination technology.
This is the most simple renewable energy - desalination technology, and used mostly for emergencies and situations of great water scarcity. It results in very limited water productivity, and does not include any sanitary treatment of the water.
Membrane distillation is a thermal process in which water vapour, driven by a difference in temperature, passes through a hydrophobic membrane and condenses on the opposite side. The modules can be directly connected to a corrosion-free solar thermal collector without heat storage. Offers important advantages for the construction of solar-driven or waste-heat driven, stand-alone desalination systems, including: operating temperature is in the range of 60 - 85 °C; costly chemical pre-treatment of the water supply not necessary; intermittent energy supply acceptable; robust and easy-to-use technology.

Membrane distillation is an intermediate renewable energy–desalination system that can be standalone and includes water treatment. It is suitable for industrial facilities and small communities.
This is one example of a solar energy-desalination-water treatment technology. The technology was tested in the EU MEDGRAS project.
This slide illustrates the solar-desalination technology and a successful implementation of that technology in Tunisia.
This is an example of large scale renewable energy – desalination- water treatment project.
"We wanted to create a comprehensive project that would touch every aspect of their lives," said Robert Freling, Executive Director, SELF. "We provided power for a water-pumping system that pushed clean water into the village. Women can turn on a tap and have fresh water in the town center without walking miles to fetch it. There's a microenterprise center, street lighting, lights for 20 homes, a portable pump that they can take from field to field and water their crops."


This slide provides the motivation behind a successful solar project in northern Nigeria

Three villages in Jigawa State equipped with solar electricity systems which provide:

- Water pumps clean water from deep wells
- Schools where electricity for computers, and lighting for night time adult literacy classes.
- Health clinic where refrigerate drugs and vaccines
- Electric home lighting replaces kerosene lamps.
- Street lights for night markets and safer nights.
- Micro-enterprise centre for six small businesses, providing electricity for tailors and barbers, and use of electric equipment.
- Solar home lighting systems paid with micro-credit.
- Local technicians for solar installation/maintenance.

The slide describe key aspects of the solar project in northern Nigeria.
Thank you for the opportunity to present and share ideas.
Further information available by contacting Magdalena Muir (mamuir@ucalgary.ca), or by contacting the Wil Burns, Associate Program Director, Master of Science in Energy Policy and Climate Program, John Hopkins University (wburns@jhu.edu).