Q. **Reference Revised Evidence, p. 18, lines 4 - 10**
Provide details of the information relied on that currently available broadband PLC is available as a long distance telecommunications transmission technology for high voltage electrical utility applications.

A. Mr. Barreca has been forecasting the evolution of communications technologies for 20 years. He is internationally recognized in this regard and has taught numerous public training courses on technology forecasting, is the technology forecasting instructor for the Society of Depreciation Professionals (and has been for seven years), has conducted, or will conduct later this year, training seminars at professional conferences in the US, Asia, and Canada, and has given executive briefings to major corporations on the evolution of communication technology and markets.

For seven years, Mr. Barreca's duties, while part of BellSouth's Strategic Planning Department, included forecasting the evolution of existing and new communications technologies for the specific purpose of planning and budgeting major capital initiatives. Mr. Barreca currently publishes depreciation tables for communication technologies, which take into account the life-cycle influences of ongoing and future technological advancements. Later this year, Mr. Barreca will publish similar depreciation tables for electric utility technologies.

Mr. Barreca's reference to Broadband PLC becoming commercially available in the next 5 to 7 years is his expert opinion and is based on several factors:

- Past and ongoing evolution of Analog PLC technology.
- The recent shift to Digital PLC technology.
- Very high volume of PLC research currently underway.
- Findings and forecasts of other experts and vendors. (See attached presentation.)
- The fact that here are 75 utilities conducting Broadband PLC pilot projects.

- The expectation that consumer use of PLC in the home will accelerate technology advances, including electric utility applications.

Mr. Barreca does not make the claim cited by Hydro in NLH-4. Mr. Barreca, on page 18, states

> Digital PLC systems are commercially available, and significant research is devoted to improving this technology.
>
> The shift from analog to digital represents a shift from a mature technology, where technological advancements are slow and costly to achieve, to a new technology where technological advancements are fast and accelerating. Early implementations of Broadband PLC will likely be on the market in 5 to 7 years.

High Speed Internet Access by Power Line Carrier

An Overview for RUS Telecommunications Symposia

Steven E. Collier
Vice President, Emerging Technologies
March 10, 2003

Recent Events

- NRECA CRN published a research report in 1997 finding near-term prospects dim for PLC broadband in the U.S.
- NRECA & NRTC co-funded and published an update in 2001 again finding near-term prospects dim for PLC broadband in the US, especially for rural utilities.

Recent Events

- Activity by existing and new PLC broadband developers increased considerably in 2002.
- Many utilities, including cooperatives, are being contacted by developers to solicit $$ for pilot projects.
- In early 2002 the United Telecommunications Council's (UTC) Power Line Telecomm Forum (PLTF), founded in 1998, became and independent arm, the United Power Line Council.

Current Events

- There are ~75 utilities worldwide trying PLC broadband with pilots involving a few hundred to a few thousand customers.
- There are a handful of pilots underway in the U.S. each involving a small number (≤100) of retail customers.
- NRTC and NRECA are undertaking a thorough investigation of the current developers leading to demonstrations of each at a rural utilities.

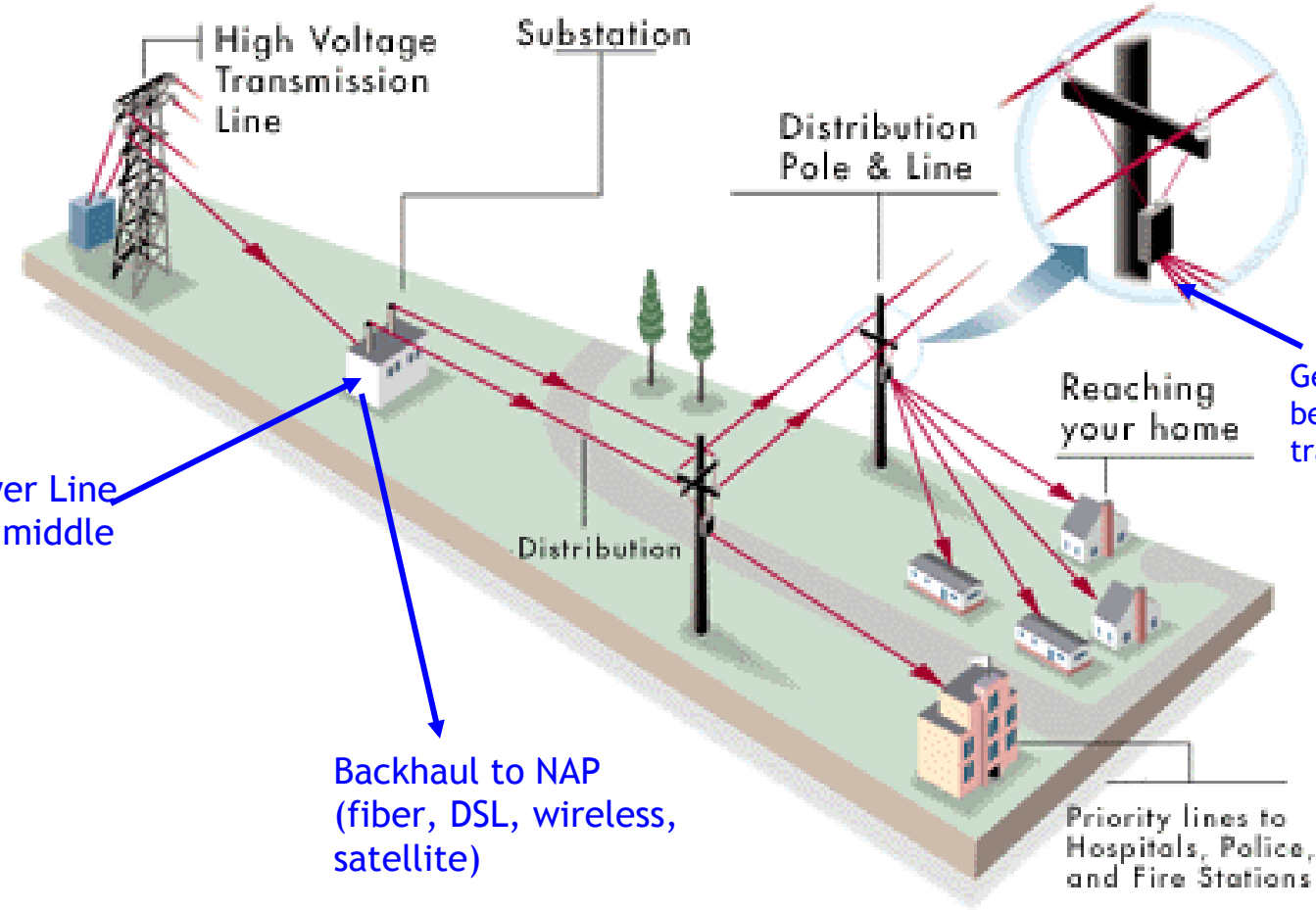
What Is PLC HSI?

- High frequency signal carrying IP on a utility power line.
  - Independent of 60 Hz power waveform, powerline is a waveguide
  - Signals in the 1 to 100 Mhz spectrum
- 25-45 Mbps transfer per substation
  - Individual subscriber speeds of ~2 Mbps

What Is PLC HSI?

- A transmitter/receiver is coupled to middle voltage (< 69 kV) power line, usually at substation, and again at the high side of the distribution transformer
- The signal is communicated at consumer premises via:
  - Bypass distribution transformer with fiber or wireless and re-inject PLC on low side
  - Fixed wireless to premises
  - Transmit PLC through distribution transformer

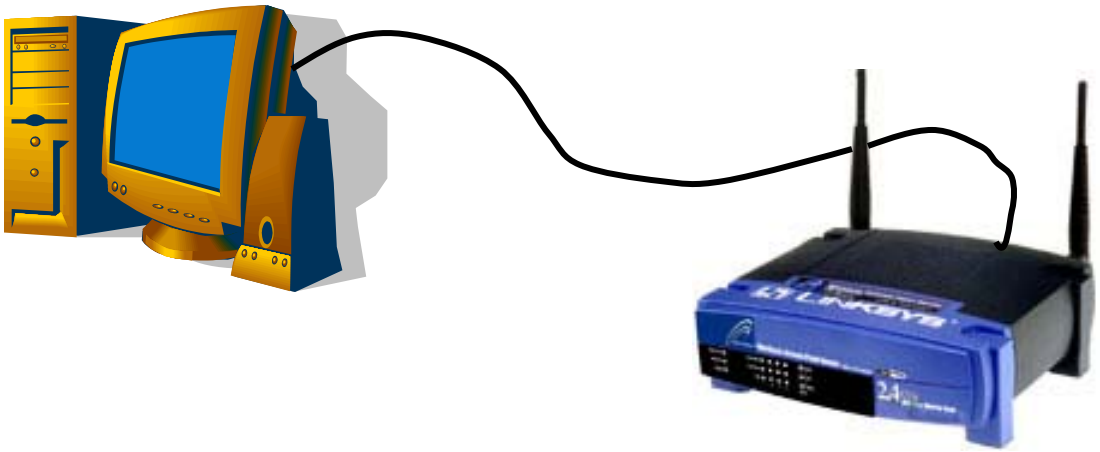
The Distribution System



Inside the Home or Business

Power Line Modem

Inside the Home or Business
Fixed Wireless



PLC HSI Advantages

- Existing power line infrastructure reaches every consumer.
  - Reaches most remote rural consumer
  - Reaches unmanned sites (water wells, oil wells, street lights, etc.)
- With appropriate power line interface, HSI available anyplace on the power line.
  - On end-to-end PLC systems, HSI is available on consumers premises anywhere there is a power plug.

PLC HSI Advantages

- PLC broadband is somewhat scalable
  - (substation = cell)
- PLC broadband can be symmetrical
  - Upload & download speeds can be managed for each individual subscriber
- Speeds comparable to DSL or cable (≥ 1 mbps)

PLC HSI Advantages

- Some systems will have self-configuring LAN and automatic integration of consumer premise access points.
- Can support high quality voice over IP from PSTN.
- Can accommodate streaming video over IP.

PLC HSI Advantages

- For electric utilities:
  - Utility owns and controls the infrastructure.
  - Good opportunity for diversified service.
  - Can support utility applications (AMR, SCADA)
- For telecomm utilities:
  - Electric utility will require access to Internet backbone.
  - Some electric utilities may need network management support.

PLC HSI Challenges

- Technology
- Systems
- Institutional
- Economics
- Economics
- Economics
- Economics
- Economics

PLC HSI Technology Challenges

- Hardware not yet in commercial production
  - Will there be unexpected design & manufacturing issues?
    - Will there be excessive infant mortality in the field?
    - Durability in adverse utility environments?
  - Target hardware costs cannot be reached until adequate quantities are manufactured
  - Technology may become obsolete by the time it is in production as a result of new PLC or other technologies.

PLC HSI Technology Challenges

- Some PLC technologies are not operable at very low or no load.
- High frequency signals attenuates rapidly over power lines
  - FCC “Part 15” makes repeaters necessary every 500 to 2,000 feet for some PLC technologies.
- Physics limits frequency to 30 Mhz, limiting ultimate throughput.

PLC HSI Technology Challenges

- Power line noise may interfere with PLC signal.
- PLC in wide deployment may cause RFI as unintentional radiator.
- Other issues that may be encountered with wide deployment.

PLC HSI Technology Challenges

- Will 45 Mbps per substation be enough?
- Will 2 Mbps per consumer be enough in the mid to long term?

PLC HSI Systems Challenges

- Significant PLC infrastructure must be planned, installed and maintained.
- Requires backhaul from middle voltage injection point to a network access point (NAP).
- Requires telecomm network management.
- ISP business must be planned, managed and operated.

PLC HSI Institutional Challenges

- Utility may not own/control the ISP network.
- Credibility of PLC Industry.
- New standards & codes.
- Regulatory issues
  - Electro-magnetic emissions & radio frequency interference
  - Spectrum utilization
  - Joint use of utility plant

PLC HSI Economic Challenges

- Market
  - Competition from other broadband technologies (fixed wireless, DSL, fiber, cable, satellite)
    - Best alternative internally
    - External threats
  - Market demand for broadband at price point necessary for profitability
  - Value added upstream services

PLC HSI Economic Challenges

- PLC Companies
  - Does the developer have adequate funding to complete development and continue operations until they can cash flow?
  - Can equipment be manufactured at target cost points?
  - Can services be offered at prices that are acceptable to market?
  - Can the developer provide adequate technical support and training?

PLC HSI Economic Challenges

- Utilities
  - Does the utility have adequate funding to launch and continue operations until they can cash flow?
  - Can enough subscribers be signed up to cash flow?
  - Can equipment be procured at target cost points?
  - Can ISP and upstream value-added services be offered at prices that are acceptable to market?
  - Can the utility provide adequate technical support and training?

PLC HSI Economic Challenges

- Cooperatives
  - Number of substations (injection points)
  - Length of lines
    (number of repeaters required)
  - Sparsely populated power lines
    (number of consumers per substation, per repeater)
  - Achievable market penetration
  - Availability of network access near substations

Who Are the Players?

- Europe, South America, Asia
  - M@in.net (Kfar Zaba, Israel)
  - Xeline (Seoul, Korea)

Who Are the Players?

- North America
  - Current Technologies – Germantown, Maryland
    - Est. 2000; Financed by Liberty Associated Partners
    - End-to-end PLC, HomePlug compatible, fiber bypass of distribution transformer
      - May use fixed wireless in portions of the network.
    - Pilots underway with PEPCo & Cinergy
    - Projecting commercial operation by Q4 2003

Who Are the Players?

- North America
  - M@in.net - Kfar Zaba, Israel
    - Est. 1999; Owned by Noga Technologies (TASE: NGTC)
    - End-to-end PLC, transmit signal through distribution transformer
    - Pilots:
      - Multiple pilots overseas
      - Pilots w/ PPL, City of Manassas, VA

Who Are the Players?

- North America
  - Amperion – Chelmsford, Massachusetts
    - Est. 2001; Partners: Cisco, AEP, Redleaf (VC), ABB
    - Middle voltage only
      - Working on solutions all the way to the consumer
    - Beta test with AEP in Dublin, Ohio

Who Are the Players?

- North America
  - Ambient Corporation – Brookline, Massachusetts
    - Est. 1998; Publicly traded (OTCBB: ABTG)
    - Middle and low voltage only
    - Beta test with Con Ed

Who Are the Players?

- North America
  - International Broadband Electric Communications (formerly PowerComm Systems, Inc.) – Huntsville, Alabama
    - Est. 2001; Privately held
    - End-to-end PLC, bypass distribution transformer, HomePlug compatible
    - Pilot with Cullman EC, Alabama

Conclusions

- PLC HSI technologies appear solid
- There are technical, systems, institutional and economic issues.
- PLC hardware is not yet in commercial production or implementation in U.S.
- An economically feasible solution is not certain for electric cooperatives.
- Current Technologies seems to be the closest to commercialization, followed by Amperion and M@in.net.

NRTC Activities

- Closely monitor industry developments.
- Ongoing discussions with existing and new PLC developers.
- Cooperation with NRECA CRN on investigations and pilot projects.
- Monitor utility pilots and demonstrations.
- Commission NRTC Member pilot projects in 2003/2004.
- Become distributor for Members